



Monitoring Stream Ecosystems in the Central Alaska Network

Standard Operating Procedures Version 1.0



ON THE COVER

Stream sampling at Little Stony Creek, Denali National Park and Preserve
Photograph by: Trey Simmons/NPS

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Standard Operating Procedures Version 1.0

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Contents

	Page
Tables.....	xiii
Figures.....	xvi
Abstract.....	xviii
Acknowledgments.....	xxi
List of Acronyms	xxiii
SOP 1: Field Season Preparation	26
General Preparation and Review	26
Scheduling Field Work.....	27
Logistics.....	28
References.....	31
SOP 2: Sampling Design and Site Selection.....	33
Survey Design.....	33
<i>Rationale for survey design selection</i>	<i>33</i>
<i>Stream population to be sampled.....</i>	<i>35</i>
<i>Construction of sampling frame for synoptic sites</i>	<i>36</i>
<i>Stream selection</i>	<i>36</i>
<i>Reach selection</i>	<i>38</i>
<i>Sampling frequency and rotation schedule.....</i>	<i>38</i>
Planning Annual Sampling.....	39
SOP 3: Continuous Monitoring of Temperature.....	71
Introduction.....	71
Required Equipment	71
Procedures.....	72

<i>Testing HOB0 loggers</i>	72
<i>Launch HOB0 data loggers</i>	72
<i>Site selection</i>	74
<i>Deploy HOB0s</i>	74
<i>Mark logger location</i>	75
<i>Retrieval</i>	75
References.....	77
SOP 4: Training	78
Introduction.....	78
Required Safety Training.....	78
Training Program for Stream Monitoring.....	79
<i>Orientation</i>	79
<i>Skill Development</i>	80
<i>Practical Testing</i>	82
References.....	83
SOP 5: Field Trip Mobilization	84
General Preparation and Review	84
Prior to Leaving the Office	85
References.....	85
SOP 6: Using the GPS	86
Purpose	86
Prior to Deployment	86
<i>Notes:</i>	88
In the Field.....	89
<i>Point Positioning</i>	90

<i>Feature Logging</i>	90
After Field Work.....	90
<i>Metadata</i>	90
<i>Upload/processing</i>	91
<i>Archive</i>	91
Using the Trimble GeoXH Unit	91
<i>Scheduling Field Days</i>	92
Data Dictionaries – Feature Logging with Terrasync.....	93
<i>Creating and Editing Data Dictionaries</i>	93
<i>Pathfinder Office Data Dictionary Editor</i>	93
<i>System Settings – Feature Logging with Terrasync</i>	95
File Transfer.....	98
Navigation.....	99
Map Display.....	100
Differential Correction.....	100
Exporting to Shapefiles.....	101
GeoXH ICONS	102
References.....	102
SOP 7: Multiparameter Sonde Calibration and Maintenance	104
Introduction.....	104
Calibrating Sondes using MDS 650	104
Turbidity Probe	106
<i>Calibration Procedures</i>	106
Calibration using StreamlineENV	108
<i>Adding Sondes to the Device Manager</i>	108

<i>Calibrating Sondes</i>	108
<i>DO sensor</i>	109
<i>Conductivity sensor</i>	110
<i>pH sensor</i>	110
<i>Review the Calibration Results</i>	111
Updating Firmware.....	112
Configuring Sondes for Deployment.....	112
600 XLM.....	112
6920.....	115
6920 V2	116
Activating the Sondes for Deployment.....	116
Downloading Sondes	117
<i>Stop Logging</i>	117
<i>Download Data</i>	118
Preparing Sondes for Longterm Storage.....	118
<i>Sonde Preparation</i>	118
<i>Special Treatments and Considerations</i>	120
References.....	120
SOP 8: Field Methods.....	122
Introduction.....	122
Outline of data collection workflow	122
Before leaving for the field.....	123
Required gear:.....	123
Field Operations.....	125
<i>Site evaluation and reach selection</i>	125

<i>Establishing the Reach Monument.....</i>	126
<i>In Situ Water Chemistry.....</i>	126
<i>Collecting and Processing Water Samples.....</i>	127
<i>Collecting and Processing Macroinvertebrate Samples.....</i>	129
<i>Collecting and Processing Benthic Diatom Samples.....</i>	133
<i>Physical habitat characterization.....</i>	135
<i>Channel Unit Habitat Classes^a</i>	142
<i>Discharge measurement.....</i>	142
<i>Channel gradient</i>	142
<i>Panoramic photos</i>	143
<i>Photodocumentation</i>	143
<i>Site Notes</i>	143
References.....	146
SOP 9: Spherical Panoramic Photography	150
Introduction.....	150
Equipment.....	150
Finding the No Parallax Point and adjusting the panoramic head.....	151
<i>Adjusting for zero parallax step-by-step:</i>	152
<i>Adjusting the panoramic head to the appropriate pan angle for the lens you plan on using.....</i>	156
Workflow in the field.....	157
Post processing upon return.....	158
References.....	160
SOP 10: Discharge Measurement	162
Introduction.....	162
Velocity-Area Procedure	162

<i>Required Gear</i>	163
<i>Velocity-area procedure for determining stream discharge</i>	163
Neutrally-Buoyant Object Procedure	166
Timed Filling Procedure	167
References.....	167
SOP 11: Decontamination.....	170
Introduction.....	170
Existing and Potential Aquatic Invasive Species Threats to Alaska	171
Procedures.....	172
<i>Procedure at non-remote locations when tap water is available</i>	172
<i>Procedure at remote locations when tap water is not available</i>	172
<i>Procedures to follow regardless of remoteness</i>	173
References.....	173
SOP 12: Water Chemistry Laboratory Procedures	176
Selecting Analytes	176
Shipping Samples	176
Laboratory SOPs and Quality Assurance Plan	178
References.....	178
SOP 13: Diatom Laboratory Procedures.....	179
Shipping Samples	179
Summary of Methods - EcoAnalysts, Inc. Phytoplankton/Periphyton.....	180
<i>Sample Receiving and Chain of Custody Tracking</i>	180
<i>Sample Preparation</i>	180
<i>Community Determination</i>	180
<i>Data Compilation and Delivery</i>	181

<i>Sample Components Retention and Return</i>	181
<i>Personnel Safety and Hazardous Materials Handling and Shipping</i>	182
Quality Assurance (QA) of Taxonomic Identifications.....	182
<i>QA Methods</i>	182
<i>Vouchering</i>	183
<i>Data Management and Reporting</i>	183
References.....	183
SOP 14: Macroinvertebrate Laboratory Procedures	186
Shipping samples	186
Macroinvertebrate Sample Processing Procedures.....	187
<i>Sample Inventory and Log In</i>	187
<i>Project Specifications Sheets</i>	189
<i>Sample Preparation for Sorting</i>	189
<i>Sample Sorting Procedures</i>	190
<i>Sample Sorting Rules</i>	192
<i>Sample Processing Products</i>	194
<i>Sorted Sample Log Entry</i>	195
Macroinvertebrate Sample Sorting Quality Assurance/Quality Control Procedures.....	197
<i>Sorting Efficacy</i>	197
<i>Target Count Checks</i>	197
Miscellaneous Notes and Guidelines	199
Macroinvertebrate Identification Procedures	200
<i>Sample Preparation and Microscope Use</i>	200
<i>Use of Bench Sheets</i>	200
<i>Taxonomic Effort: Level of Taxonomic Resolution</i>	200

<i>Taxonomic Resources</i>	<i>10</i>
<i>Special Circumstances: Difficult Taxa</i>	<i>10</i>
<i>Voucher Collection Assembly</i>	<i>10</i>
<i>Use of Existing CE Master Reference Collection</i>	<i>11</i>
Quality Assurance/Quality Control Procedures for Taxonomic and Enumeration Data.....	11
References.....	14
SOP 15: Data Management.....	16
Stream Monitoring Database	16
<i>SQL Server Database Structure.....</i>	<i>17</i>
<i>Preparing Tablet PC for use in the Field</i>	<i>17</i>
<i>Field Data Backups.....</i>	<i>17</i>
<i>Backing up data upon return from Field</i>	<i>18</i>
Lab Sample Tracking.....	18
Spatial Data.....	19
Trimble Data Management	19
Data Entry and Validation of Field Data	19
<i>Data Sources</i>	<i>19</i>
Import and Validation of Laboratory Data	20
Database Concatenation.....	21
Communication with Project Leader	21
Data Administration.....	21
STORET Database.....	22
References.....	22
SOP 16: Field Season Demobilization.....	25
Procedures.....	25

<i>Equipment and Reference Materials</i>	25
<i>Data</i>	25
<i>Samples</i>	26
<i>Protocols</i>	26
References.....	26
SOP 17: Data Analysis and Reporting.....	29
Analysis and reporting.....	29
<i>Overview</i>	29
<i>Reporting exceedances of State of Alaska water quality standards</i>	29
<i>Routine data summaries</i>	30
<i>Biological assessment</i>	32
<i>Trend detection</i>	35
References.....	40
SOP 18: Revising the Protocol	46
Introduction.....	46
Procedures.....	46
References.....	47

Tables

	Page
Table 1. Required field gear for CAKN stream sampling program.	30
Table 2. List of annually-sampled sentinel sites.	35
Table 3. List of sites sampled 2006-2016 with site selection type, rotation type and years sampled.....	40
Table 4. Coordinates of sites sampled from 2006-2016.....	44
Table 5. GRTS site list for Denali NP&P.	49
Table 6. GRTS site list for Wrangell-St. Elias NP&P.	55
Table 7. GRTS site list for Yukon-Charley Rivers NP.....	64
Table 8. Settings for the Nodal Ninja 5 panoramic head for currently-used CAKN camera-lens combinations.....	152
Table 9. Aquatic invasive species considered high priority threats to freshwaters and riparian areas of Alaska.	171
Table 10. List of analytes for CAKN water chemistry samples.....	177
Table 11. Standardized notes used to justify benthic macroinvertebrate identifications where the prescribed taxonomic level is not achieved.....	201
Table 12. Notes of taxonomic interest that convey additional information about benthic macroinvertebrate identifications.....	202
Table 13. Standardized conditional or provisional taxonomic designations applied to benthic macroinvertebrate identifications.....	203
Table 14. State of Alaska surface water quality standards for selected attributes under Designated Use Class C.	30
Table 15. Examples of basin-level descriptive statistics derived for use in the development of RIVPACS models.	33
Table 16. 10 most influential environmental predictive variables used in the CAKN RIVPACS random forest discriminant model.	34
Table 17. Years of data required to achieve a given statistical power to detect a 3% annual change in the value of a parameter as a function of interannual variation.....	37

Table 18. Median years required to detect a 3% annual change for representative water chemistry parameters, based on results from 12 CAKN streams with at least 5 years of data	38
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Figures

Figure 1. Overview of channel measurements.....	137
Figure 2. Marking and using a convex spherical densitometer.....	140
Figure 3. Types of multiple channel patterns.....	144
Figure 4. Nikon D40x with Nikkor 16mm 2.8D fisheye lens mounted on a Nodal Ninja panoramic head	151
Figure 5. The correct positions for a Nikon D40x and 16 mm lens on the Nodal Ninja 3 Mk II	152
Figure 6. The detent rings on the Nodal Ninja 5 (NN5).	156
Figure 7. Office Slough as a .tif still image.	159
Figure 9. Layout of channel cross-section for obtaining discharge data by the velocity-area procedure.....	163
Figure 10. Top-setting wading rod.....	165

Abstract

This protocol describes field, laboratory, data management, and analytical procedures for the Central Alaska Network (CAKN) Stream Monitoring Program. The protocol is published as two separate documents, a Protocol Narrative, and a set of 18 Standard Operating Procedures (SOPs) detailing every aspect of the CAKN Stream Monitoring Program. The Protocol Narrative provides an overview of the Central Alaska Network, as well as descriptions of the fluvial ecosystems of each of the three park units that constitute the network (Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve). It discusses the importance of fluvial systems and processes to network ecosystems and threats to the integrity of these systems due to the effects of climate change and other anthropogenic stressors. It provides an in depth rationale for the selection of Vital Signs for the CAKN Stream Monitoring Program, which include hydrologic regime, composition and distribution of aquatic communities, and water quality. It then provides an overview of all aspects of the Stream Monitoring Program, including survey design, training and field season preparation, field methods, laboratory methods, operational requirements, data management and data analysis. The Protocol Narrative is Natural Resource Report NPS/CAKN/NRR—2017/1470. It is available at: <https://irma.nps.gov/DataStore/Reference/Profile/2215908>.

These 18 Standard Operating Procedures provide detailed instructions for implementing the Central Alaska Network stream monitoring protocol. The SOPS are:

SOP 1: Field Season Preparation

SOP 2: Sampling Design and Site Selection

SOP 3: Continuous Monitoring of Temperature

SOP 4: Training

SOP 5: Field Trip Mobilization

SOP 6: Using the GPS

SOP 7: Multiparameter Sonde Calibration and Maintenance

SOP 8: Field Methods for Water Chemistry and Biological Sampling and Habitat Characterization

SOP 9: Spherical Panoramic Photography

SOP 10: Discharge Measurement

SOP 11: Decontamination

SOP 12: Water Chemistry Laboratory Procedures

SOP 13: Diatom Laboratory Procedures

SOP 14: Macroinvertebrate Laboratory Procedures

SOP 15: Data Management

SOP 16: Field Season Demobilization

SOP 17: Data Analysis and Reporting

SOP 18: Revising the Protocol

Many of the SOPs in this document are adapted directly from The CAKN Shallow Lakes Monitoring Protocol (Larsen *et al.* 2011), including SOPs 1, 2, 4, 5, 6, 7, 15 and 16. Methods for continuous temperature monitoring (SOP 3) are designed to meet the standards for monitoring stream temperature in Alaska detailed in Mauger *et al.* (2014). The field methods (SOP 8 and SOP 10) are adapted directly from field protocols for the Environmental Protection Agency's National Rivers and Streams Assessment (USEPA 2013a). Laboratory SOPs (SOP 12, SOP 13, SOP 14) are consistent with the standards developed for the National Rivers and Streams Assessment, as are the Quality Assurance Plans included in each (USEPA 2013a, 2013b).

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List of Acronyms

ACWA	Alaska Clean Water Actions
ADEC	Alaska Department of Environmental Conservation
ATV	All-terrain vehicle
CAKN	Central Alaska Network
DEM	Digital Elevation Model
DENA	Denali National Park and Preserve
DIC	Deviance Information Criterion
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPS	Global Positioning System
GRTS	Generalized Random Tessellation Stratified
I&M	Inventory and Monitoring
IBI	Index of Biological Integrity
IBO	Information Bearing Object
IRMA	Integration of Resource Management Applications
IT	Information Technology
LTEM	Long Term Ecological Monitoring program
MSDS	Material Safety Data Sheet
NARS	National Aquatic Resource Surveys
NMDS	Non-Metric Multidimensional Scaling
NPS	National Park Service
NRSA	National Rivers and Streams Assessment

NRTR	Natural Resource Technical Report
NWR	National Wildlife Refuge
OTU	Operational Taxonomic Unit
PRISM	Parameter-elevation Regressions on Independent Slopes Model
QA/QC	Quality Assurance/Quality Control
RIVPACS	River Invertebrate Prediction and Classification System
SOP	Standard Operating Procedure
SQL	Structured Query Language
UNESCO	United Nations Educational, Scientific and Cultural Organization
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WRST	Wrangell-St. Elias National Park and Preserve
WSA	Wadeable Streams Assessment
YUCH	Yukon-Charley Rivers National Preserve

SOP 1: Field Season Preparation

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

This SOP provides step-by-step instructions for preparing for the field season. These exercises should be completed before each field season. The procedures outlined here are essential for successful implementation and maintenance of the monitoring program. Outlined in this SOP are training requirements, scheduling requirements, and logistical organization, as well as general organization and preparedness. Each observer needs to carefully review this entire protocol including all the related SOPs, data sheets, and the instructions for use of the YSI sondes, Tablet PC, and Trimble GPS. This SOP was adapted directly from SOP 1: Field Season Preparation in Larsen *et al.* (2011)

General Preparation and Review

1. Each observer should meet with the project leader to discuss the overall objectives of the programgeneral project implementation plan.
2. It is imperative that each observer carefully review all background information including the protocol narrative and all related SOPs and supplementary materials.
3. Each crewmember should review field notes from previous field seasons (if available) to identify any unique events that may be encountered and to familiarize new crewmembers with the procedures. Network aquatics staff should be available to facilitate this process.
4. YSI Sonde(s) should be removed from winter storage, and sensors should be reinstalled and calibrated. Sondes should be tested to determine if they are ready for the field season, or if they will require maintenance or repairs before being used.
5. All temperature and water level loggers to be deployed for the season should be tested. See SOP 3: Continuous Monitoring of Temperature for detailed instructions

6. Prepare the Tablet PC for field use. Ensure that the most recent Access front end and SQL backend have been loaded, and the connection between the two components is working properly. See SOP 16: Data Management for detailed instructions.
7. Prepare the Trimble GPS for field use. Make sure any updates to the TerraSync software, Windows Mobile Operating System, and/or Trimble firmware have been properly applied. Ensure that the most current data dictionary is loaded and functioning properly. Perform a field test where data are collected using the data dictionary to verify that the unit is functioning properly and that no changes need to be made to the data dictionary. Load background files if desired. See SOP 6: Using GPS for detailed instructions.

Scheduling Field Work

Sampling streams in remote parts of Alaska requires a great deal of planning and preparation. Carefully planning and organizing field excursions can help expedite sampling, ensure the collection of high quality data, maintain the integrity of the long term data set, and minimize health and safety concerns for all involved.

1. If dataloggers for temperature or depth are to be deployed for the summer season only, deployment should occur as close to break-up as possible, generally in late April or early May. Dataloggers that will be left in place for multiple years may be deployed at any time that is convenient.
2. Stream sampling should be conducted between approximately late June and late August, which generally corresponds to baseflow conditions in non-glacial systems. Depending on local conditions, earlier sampling may be appropriate, as long as it occurs after spring runoff is complete. Late September sampling should generally be confined to “fall” sampling sentinel sites where multiple samples per year are collected.
3. Stream sampling will require a two to three person crew for a total of approximately 20-25 sampling days. Sampling efforts will vary from year to year depending on budgetary and logistical concerns, and on how many remote sites will be sampled in each park, as access is highly variable from park to park. Depending upon accessibility, one to three streams should be scheduled for completion each field day per 2-person crew.
4. Prior to starting fieldwork, the identities of the streams to be sampled should be determined by referencing SOP 2: Sampling Frame and Site Selection. This SOP contains a detailed table showing which synoptic sites should be sampled each year, as well as listing the sentinel sites that are sampled every year. Using the information obtained from SOP 2: Sampling Frame and Site Selection, outline a coarse schedule for sampling, including providing for alternate synoptic sites in the vicinity of each synoptic site that is being visited for the first time. This schedule should include basic information regarding general locality, mode of access, dates for sampling, observers to be involved. This should be completed by late January.
5. Submit applications for Research Permits to each park by Feb. 1 if necessary. In general, research permits will be granted for multiple years, and the only documentation required in non-application years will be a list of proposed sampling sites and access methods.

6. Submit compliance documents including tentative sampling locations and schedule to appropriate park personnel by February 1.
7. Submit an application to the Alaska Department of Fish and Game for a fish collection permit by Feb 1.
8. Ensure field crewmembers have received all appropriate training in field data collection procedures, deployment of dataloggers, use of Trimble GPS units and Tablet PCs, and maintenance and calibration of all equipment prior to beginning fieldwork (See SOP 4: Training Personnel).
9. Each member of the field crew will be certified in bear safety (according to federal agency standards) and be familiar with the use of bear spray canisters.
10. Ideally, all crewmembers will be certified in Wilderness First Aid and CPR. At least one crewmember must be so certified.
11. Ensure all crewmembers are certified in aviation safety, and if required, ATV operation and/or motorboat operation.
12. Compile a list of coordinates for all of the synoptic sampling sites to be sampled, and forward the information to pilots, the Denali Comm Center and appropriate support staff.
13. Enter site coordinates for all potential sampling sites as waypoints into the GPS unit to be used for navigation to the site (either an eTrex for walk-in locations, or the GPS unit in the aircraft being used for transportation to the site). These location data allow sites to be easily located.

Logistics

1. Arrange primary means of transportation to the field well in advance of the field season (by March) to ensure adequate transportation is available. This includes reserving field vehicles, and arranging fixed-wing or helicopter transport as appropriate. Whenever possible, flights should be coordinated with other researchers to minimize costs.
2. Review the required equipment list (Table 1), and organize and prepare equipment for the field season several weeks before the season begins. This will allow ample opportunity for repairs to be made or any necessary equipment to be ordered. 95% ethanol can be obtained from VWR, Inc. To order 95% ethanol, you must sign in with a government account. Currently, the part number and description for 5 gallons of 95% ethanol is 71002-510 ETHANOL PURE 190 PROOF 5G. During a typical field season, 20-25 liters of 95% ethanol will be required. If desired, dry ice can usually be obtained from Safeway or Fred Meyer. In an emergency, dry ice can be ordered from Arctic Fire and Safety, but is substantially more expensive.
3. Pack equipment and make necessary logistical arrangements.
4. Finalize schedule and confirm logistics (vehicles, lodging, flights).

5. At least six weeks prior to the field season, order all chemical standards (Table 1) and required reagents from HACH and Cole-Parmer (Oakton solutions) to ensure they are received for in plenty of time for pre-season training and instrument calibration.

Table 1. Required field gear for CAKN stream sampling program. Amounts and numbers of consumables are given on a per site basis. The total number/amount of consumables needed will depend on the number of sites to be sampled.

First Aid kit
Bug spray
Bug shirts for each crewmember (optional)
ATG radio preset to correct local frequency (WRST 122.9 except Northway 123.6, Tok 122.8, DENA 122.9, YUCH 122.8)
Satellite phone + spare battery (King radio preprogrammed to appropriate park frequencies + spare battery case) Normally this will be obtained from the park
Bear spray + holster for each crewmember
Remington 870 shotgun + at least 6 shells (optional)
If working in backcountry - emergency survival kit + tent
Spare batteries (4 'C', 4 'AA', 4 'D')
Trimble GeoXH with clickit cradle, cable and external battery. Sampling locations should be entered into the Trimble as waypoints (identified by site code). Current data dictionary should also be loaded. See SOP 6: Using GPS.
Backup GPS (Garmin eTrex or equivalent)
RITR field notebook
RITR Supplemental Data sheets
Communications information sheet
Research permit for appropriate park unit
Mechanical pencils (multiple)
Sharpies (multiple)
Metal storage clipboard or equivalent
Nikon D-40X or equivalent with at least a 1 gigabyte SD card, 18-70mm lens and 16mm fisheye lens, plus spare camera battery and spare SD card
Mannfroto carbon fiber tripod
Nodal Ninja 5 camera mount for panoramic photography, preset for the camera-lens combination you have
Multiparameter sonde (YSI 600QS or equivalent)
Conductivity calibration solution, at least 1500 μ S/cm. 15 mS/cm is preferred. Calibration of the YSI QS650 sonde requires ~250 mL/calibration, and the unit should be calibrated ~every 3 days in the field. <u>Always order more than you think you will need for the season!</u> Oakton conductivity standards can be ordered from Cole-Parmer, VWR and many other scientific suppliers.
pH calibration solutions – 4.0, 7.0 and 10.0. In general only pH 7 and 10 standards will be used, since most streams have pH above 7. Therefore, you will generally not need to order more than 500 mL of pH 4.0 standard unless you anticipate sampling a large number of acidic streams. pH calibrations of the YSI QS650 sonde require ~250 mL/ calibration and the unit should be calibrated ~every 3 days in the field. <u>Always order more than you think you will need for the season!</u> Oakton pH standards can be ordered from Cole-Parmer, VWR and many other scientific suppliers.
1 liter clean Nalgene for collecting water chemistry sample
Acid washed sample bottles (sent each year from CCAL):
1 500 mL per site
1 250 mL per site
1 125 mL per site
Water chemistry kit:
1 liter plastic Erlenmeyer vacuum flask
Magnetic filter apparatus (HACH, Inc)
Manual vacuum pump with pressure gauge (HACH, Inc)
47 mm diameter GF-F filters (at least 3 per site)
47 mm diameter, 0.4 micron pore size Whatman polycarbonate filters (at least 5 per site)
Clean filter forceps (stored in a 15 mL Falcon tube)
Small cooler for field transport of water samples (with dry ice if available)
Large cooler for storage and transport of water samples (with dry ice if available)

Table 1, continued

Periphyton kit:

- 1 liter graduated Nalgene for periphyton
- At least 2 medium stiffness toothbrushes and/or fingernail brushes
- Scraping tool (chisel)
- At least 2 12 cm² rubber templates (2 5/8" x 1 11/16" x 3/32" bathtub drain gaskets)
- Lugol's solution (Carolina Biological Supply), 2 mL per site
- 60 mL syringe with short piece of flexible tubing attached

Modified D-net (500 µm nylon mesh) with detachable extendable handle

At least one spare net and handle

Soil sieve (500 µm mesh - #35) with bottom pan and lid

In sieve:

- At least 2 pairs of forceps
- At least 2 small plastic spoons
- Sharpie(s)
- Pencil(s)
- Pre-printed RITR internal labels (at least 6/site)

Pump-type insecticide sprayer

2 14-liter buckets with pour spouts

2 white plastic dish tubs

At least 6 500 mL HDPE Nalgene sample bottles per site, with tops, 4 filled with 95% ethanol.

At least 2 50 mL Falcon tubes with lid per site

Preprinted RITR internal labels, 10 per site

Gravelometer (USGS standard)

30 meter tape

100 meter tape

Spherical densiometer (convex)

Stadia rod or 3 meter (3 piece) marked 1" PVC or 2 x 2 meter marked 1" PVC (2 piece)

[transit level or equiv. + tripod]

AND/OR

[hydrostatic level setup – marked tubing, 4 hose clamps]

AND/OR

[clinometer]

Topsetting wading rod, metric

Flowmeter (Flo-Mate or equivalent)

Active layer probe tool, marked to 5 cm intervals

Multi-pocketed field vest

Heavy-duty Gore-Tex waders for each crewmember. Guide-quality waders are recommended.

Non-felt-soled wading boots for each crewmember. Guide-quality wading boots are recommended. Korker wading boots, supplied with interchangeable soles, are recommended in case safety considerations necessitate a felt-soled boot. Low-rise Xtra-Tuf rubber boots ("Alaska sneakers") make excellent non-felt-soled wading boots for many streams.

Shoulder-length rubber gloves, connected with cloth "bungee"

Neoprene fishing gloves ("Glacier Gloves") – at least 1 pair per crewmember

References

- Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, R. McGinnis, H. Kristenson. 2011. Shallow lake limnology monitoring protocol: Central Alaska Network (CAKN) and Arctic Network (ARCN), Version 2.0. Natural Resource Report NPS/AKRO/NRR—2011/347. National Park Service, Fort Collins, Colorado.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 2: Sampling Design and Site Selection

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Survey Design

Rationale for survey design selection

We have selected a multi-panel survey design focused on wadeable streams that incorporates a large set of probabilistically-selected synoptic sites that will be sampled on a long rotation schedule, along with a small number of sentinel sites that will be sampled annually. The rationale for this design is as follows. In principle there are a number of survey designs that could be implemented in a stream monitoring program. One goal of the CAKN program is to be able to make statements about status and trends at the network scale.

Generally a probabilistic survey design is considered to be preferable for surveys of this type, where maximal inference to unsampled sites is a goal. Probabilistic surveys rely on each site in the population having a positive, though not necessarily equal, chance of being selected as part of the sample, and generally allow the use of standard statistical methods to estimate bias and variances. Inference in study designs of this type is design-based. The Environmental Protection Agency (EPA) has developed a probabilistic survey design intended specifically for large-scale environmental monitoring programs (Herlihy *et al.* 2000, Stevens and Olsen 2004). It is particularly well suited to monitoring stream and river resources, as it allows the selection of discrete sampling locations from complex linear networks. This design, known as the Generalized Random Tessellation Stratified (GRTS) design, generates a spatially-balanced, probabilistic sample that can be stratified and unequally weighted, which will allow us to account for differences in the cost of access and in stream size across the network (Overton and Stehman 1993, Stevens and Olsen 2004). The GRTS design is used by the EPA in state, regional and national surveys of water quality and aquatic ecosystems (Herlihy *et al.* 2000, USEPA 2006), and by other state and federal agencies as well. A number of NPS Inventory and Monitoring Networks also employ GRTS designs for their monitoring programs (*e.g.*, Magdalene *et al.* 2008, Dinger *et al.* 2011, Schweiger *et al.* 2015). For these reasons, we determined that a GRTS design is the most appropriate survey design for monitoring status and trends in fluvial ecosystems in the CAKN with maximal spatial inference. We refer to the probabilistically selected sites as “synoptic” sites.

There are 4 components of variance that are important for evaluating the power of these designs to detect regional trends: site-site, year, site-year interaction, and residual (Urquhart *et al.* 1998, Larsen *et al.* 2001, Larsen *et al.* 2004). Site-to-site variation in metric value(s) represents persistent differences among stream reaches in a region (*e.g.*, gradient, elevation, catchment area). There is also coherent yearly variation in metric values across all reaches in a region in response to regional-scale forcings such as climate. Site-year interaction indicates independent, desynchronized yearly variation among all reaches in a region resulting from local-scale influences. Finally, residual variation represents the remaining variation, and consists primarily of short-term variation during the temporal window when measurements are made, measurement error, crew-to-crew variation in protocol application, *etc.* Site-to-site variability tends to swamp others sources of variance and can substantially reduce sensitivity to trends (Urquhart *et al.* 1998). However, explicitly incorporating revisits can effectively eliminate this effect and greatly increase sensitivity to trends (Urquhart *et al.* 1998, Urquhart and Kincaid 1999), assuming reasonable coherence in regional response (*i.e.*, that site-year variability is not large). For this reason, we are using a panel rotation approach, in which sites are revisited periodically according to a master schedule.

Maintaining a strict revisit schedule for the synoptic sites in a large remote landscape like the CAKN will be challenging, given the cost of accessing sites and logistical constraints imposed by weather and other considerations. Deviations from the revisit schedule will complicate trend detection and accurate variance estimation. In addition, given the large number of sites that must be sampled to adequately represent the variety of stream ecosystems in this large and complex landscape, the revisit interval is of necessity fairly long. This will also affect our ability to detect trends; however, we are incorporating a second survey approach to ameliorate this issue. We consider the benefits of a large-scale landscape approach to sampling to outweigh these potential drawbacks.

The use of a small number of accessible “sentinel” sites that are sampled repeatedly will aid in reducing the effects of site-to-site variability on trend detection. Annual visitation will maximize our ability to detect trends at these sites, although inference to unsampled sites will be limited. Therefore, in addition to the synoptic site panels, we have established a set of “sentinel sites” that are sampled annually. Sentinel sites have been selected primarily according to ease of access, but are distributed as much as possible among representative stream types. The typology is based on expert opinion, and relies on broad physical attributes (size, geology, glacial influence, geomorphology, elevation, *etc.*). To the extent possible, these sites will be visited more than once per year, allowing the seasonal component of variance in the values of ecological metrics to be estimated and accounted for (*e.g.*, Larsen *et al.* 2004). The sentinel sites for DENA and WRST are listed in Table 2. At present we have not yet identified any logistically feasible sentinel sites in YUCH (*i.e.* sites we can reliably access every year).

Finally, one potential drawback of GRTS and other probabilistic survey designs is that they do not always capture the full range of ecological gradients present in a population. This is particularly so in a landscape as large and ecologically complex as the CAKN. Failure to adequately represent these ecological gradients in a sample can complicate the development of robust models. For this reason, we will also select “judgment” sites as necessary to increase representation of ecological gradients in the data set. Inference to unsampled sites from data collected at these sites will also be limited. However, Bayesian hierarchical models can be used

to combine data from probabilistic and non-probabilistic surveys. We will therefore use Bayesian methods to facilitate the synthesis of data collected from synoptic, sentinel and judgment sites. This should allow us to combine sensitivity for trends with spatial inference and provide a powerful methodology for detecting trends at a landscape scale while providing the range of data necessary to construct robust predictive and explanatory models.

Additional sites may be sampled for a variety of reasons. For example, park managers may request that particular streams be sampled. This was the case in 2012, when DENA managers requested that a number of historically mined streams, some partially restored, be resampled. In other cases, streams may be sampled as part of cooperative research projects with other agencies or individuals.

Stream population to be sampled

Due to limited resources and safety concerns, it is unlikely that we will be able to sample large rivers that cannot be waded safely. Hence, the target population for the program is all wadeable streams in the three park units and inference will be limited to those systems. We will continue to evaluate potential approaches to monitoring large river ecosystems, which are numerous and important in the network. Although a number of large river sampling protocols have been developed (*e.g.*, Angradi 2006, Magdalene *et al.* 2008), none are currently feasible to implement at the network scale given the resources of the program. The exception to this rule is the hydrology monitoring station on the Nabesna River, where we will use a jetboat to conduct discharge measurements and water quality data collection. In general, 1st-3rd order streams are nearly always wadeable, although glacially influenced streams and low-gradient streams in permafrost-dominated basins may not be safe to sample even when they are 1st order. A substantial subset of data can be collected from many non-wadeable streams by modifying certain aspects of the field methods (SOP 8: Field Methods). The main modification is to designate the area to be sampled as that portion of the stream extended out from the bank to the

Table 2. List of annually-sampled sentinel sites. Latitude and longitude correspond to the coordinates of the bottom of the sampling reach, with the exception of Igloo Creek, where the coordinates correspond to the location of sampling transect 4, and Moose Creek, where the coordinates correspond to the top of the sampling reach (sampling transect 11).

Sitecode	Stream name	Park unit	Latitude (WGS84)	Longitude (WGS84)
DENA-029	Lake Creek	DENA	63.49585754	-150.88984518
DENA-GRTS-084	Igloo Creek	DENA	63.60833298	-149.58635755
DENA-GRTS-104	Sanctuary River	DENA	63.72090517	-149.4767707
DENA-017	Tattler Creek	DENA	63.56780434	-149.64026188
DENA-GRTS-027	E. F. Toklat River	DENA	63.55647600	-149.78280800
DENA-GRTS-014	E.F. Toklat tributary	DENA	63.55712500	-149.78065605
DENA-008	Little Stony Creek	DENA	63.45073516	-150.24667277
DENA-GRTS-010	Moose Creek	DENA	63.51587903	-150.91026482
WRST-GRTS-130	Jack Creek	WRST	62.46398770	-143.10518440
WRST-006	Rock Creek	WRST	62.56496220	-143.43228640
WRST-004	Chalk Creek	WRST	62.50457000	-143.15960000
WRST-060	Paco Creek	WRST	62.53289400	-143.28423800
WRST-036	Rufus Creek	WRST	62.65967400	-143.84312100
WRST-013	Gilahina River	WRST	61.43921243	-143.71648080

limit of wadeability. Transects for collection of macroinvertebrates and diatoms can then be established as detailed in SOP 8: Field Methods. Intermittent streams are not typically part of the target population for stream monitoring programs (*e.g.*, USEPA 2013a). However, the CAKN monitoring program will retain intermittent streams in the target population. The rationale for this is that we expect climate change to alter hydrologic regimes in many CAKN streams, resulting in the “conversion” of intermittent flow to perennial flow, particularly in areas dominated by permafrost. In order to capture this important hydrologic change on the landscape, streams that are dry when visited will be documented and retained in the sampling schedule for future revisits.

Construction of sampling frame for synoptic sites

The National Hydrography Dataset (NHD, see Simley and Carswell Jr. 2009) constitutes the base data for selection of the synoptic sites using the GRTS design algorithm (Stevens and Olsen 2004). The NHD for Alaska has not been edited extensively for either topological consistency or accuracy to reality; as such it is not currently appropriate to use as a basis for site selection. Accordingly, the first step was to edit the NHD for all 3 CAKN parks to ensure topological consistency; editing for accuracy was not possible at the park scale. A Geographic Information System (GIS) was used to edit the NHD as follows. GIS datalayers for the 4-digit hydrographic units that encompass each park unit were first merged, and then clipped to the appropriate park boundary using ArcGIS Desktop 9.3 (ESRI, Redlands, CA). The RivEX network analysis tool (Hornby 2009) was used to evaluate the resulting clipped NHD for topological errors (*e.g.*, disconnected polylines). Corrections to the network were effected using tools available in ArcGIS. The RivEX tool was then used with the edited and corrected NHD layer to attribute each stream segment with Strahler stream order (Strahler 1952). Stream order can be used as a surrogate for stream size; because the program is largely limited to sampling wadeable streams, it is important to over-represent stream segments likely to be wadeable in the final site list. Although catchment area (upstream contributing area) is generally a better surrogate, it is not feasible to calculate the catchment area for every potential sampling site in even a small portion of a stream network. To allow for stratification by accessibility, we established a 1 mile buffer around points of access. These included roads, ATV trails, large rivers, airstrips, and floatplane-accessible lakes. The edited, attributed and buffered shapefile was then ready to be used as the sampling frame for the appropriate park.

Stream selection

The synoptic sites for each park were selected using the *spsurvey* package (Kincaid 2008) in the R statistical software environment, which uses the GRTS algorithm to define a spatially-balanced, probabilistic sample. For each park, the sample was both stratified by accessibility and unequally weighted by stream order. The idea behind stratification is that, at least in principle, accessible sites will tend to be less expensive to sample; thus, monitoring at these sites will be more sustainable over the long term. By comparing data from accessible and inaccessible sites, it should be possible to determine how comparable the two strata are, which will allow us to estimate whether trends identified at accessible sites are representative of the larger sample should it become necessary to reduce our sampling effort at synoptic sites, restricting it to only the accessible stratum. Accessible sites were defined as those sites located on a stream segment that intersected the 1-mile buffer created around points of access in the sampling frame. Inaccessible sites were defined as sites located on stream segments that did not intersect the

buffer. The sample was unequally weighted to preferentially select sites located on 2nd and 3rd order stream segments over higher-order streams in order to maximize the probability that selected sites would be wadeable. 1st and 4th and greater order streams were underweighted for different reasons. The majority of 1st order streams in the NHD in Alaska have intermittent flow, although they are attributed as perennial. Another shortcoming of the Alaska NHD is that all stream segments are attributed as perennial, making it difficult to target perennial streams. As discussed above, we will retain intermittent streams in the overall sample even if they are dry when sampled, as many of these streams can be expected to become perennial in the future due to changes in groundwater connectivity as a result of climate change (conversely, many perennial stream sections may become intermittent as a result of climate change). Fourth and greater order streams were underweighted because they are expected to be less likely to be safe to sample.

In every park, we adjusted the GRTS algorithm to include an oversample equal to three times the target sample size. The large oversample was chosen because it was deemed likely that the majority of sites would not be sampleable (either due to accessibility or to safety concerns), making it difficult to identify a complete set of sampleable sites without a substantially longer starting list of possibilities. For WRST, the target sample is 60 sites. The initial target sample was 100 sites; this target was scaled back after pilot work indicated it was unrealistic. Based on the original target sample, we selected a 50-site accessible stratum with a 150-site oversample, and a 50-site inaccessible stratum with a 150-site oversample. For DENA, the target sample is 30 sites. Again, the original target sample of 60 sites was deemed to be too high; however, based on that target we selected a 30-site accessible stratum with a 90-site oversample and a 30-site inaccessible stratum, also with a 90-site oversample. For YUCH the target sample is 20 sites. For technical reasons, the YUCH accessible stratum list is 22 sites with a 66-site oversample, and the inaccessible stratum is 40 sites with a 120-site oversample. All potential sampling sites were then examined using a variety of remotely sensed data (primarily IKONOS satellite imagery or aerial photographs) to determine whether they were likely part of the target population. Approximately 25% of the sites were eliminated through this process. Sites were eliminated for a variety of reasons, most related to inaccuracies in the NHD (site was actually a lake, no visible stream channel), or because it was clear the site would be inaccessible or would be unsafe to sample. The edited GRTS site lists are provided in Tables 5-7.

GRTS samples are designed to be sampled in strict order moving down a list. If a particular site cannot be sampled, it is simply eliminated from the target population, and the next site on the list is sampled. In the National Rivers and Streams Assessment, this “next” site is restricted to fall within a range of Strahler stream orders determined by the stream order of the skipped site (USEPA 2007). However, this approach is unrealistic for the Central Alaska Network, where consecutive sites may be hundreds of miles apart, and require helicopter access as well. Accordingly, the CAKN has adopted a modified approach that maximizes the cost-effectiveness of data collection by de-emphasizing the ordering of the sites and instead emphasizing logistics. In practice, this means that in any given year the sites visited will be in geographic proximity to one another, and that certain areas of the network (*e.g.* coastal WRST, far western DENA) are probably going to be underrepresented in the final site list, as it is more difficult to arrange shared helicopter time in those areas. Although this modified sampling scheme will complicate analyses of the data, such challenges are an inevitable consequence of attempting to monitor a large, remote landscape with finite resources.

Reach selection

Sampling reaches will be defined using guidelines from the EPA's Wadeable Streams Assessment field methods (USEPA 2004), and modified as necessary. According to these guidelines, a reach is defined as 40 times the mean wetted width of the stream, based on five equally spaced measurements near the bottom of the proposed reach. Although this length was initially chosen as the minimum sufficient to adequately assess fish community composition in streams and rivers (Reynolds *et al.* 2003), it is also generally long enough to include a complete meander bend, which is a fundamental unit of stream geomorphology. Hence, a reach sufficiently long to encompass a meander bend should adequately capture the habitat complexity of the stream section in which it is embedded (Kaufmann *et al.* 1999). The minimum sampling reach length has been set at 150 meters, and the maximum at 500 meters (the latter for feasibility and safety reasons). For sentinel sites, reaches will be selected to be as representative as possible of the stream section in which they are embedded; in addition, major tributary junctions will be avoided and reaches near road crossings will be located so as to begin at least 50 meters upstream of the road. For GRTS sites, the spatial coordinates generated by the GRTS algorithm will be used to define the location of the bottom of the sampling reach. If necessary, it will be acceptable to adjust the sampling reach downstream according to the rules above, as long as the adjusted reach still contains the GRTS coordinates. Once defined, the reach will be subdivided into ten equally spaced sections by the placement of 11 cross-sectional transects (A – K). These transects form the framework around which the bulk of biological and physical sampling occur. During pilot studies, transects were laid out with a measuring tape and flagged. This procedure can take upwards of 30 minutes, which is a substantial portion of the time spent at each site. Subsequently, the program has elected instead to estimate the inter-transect distance by stepping it off in approximately 1-meter intervals. Although this results in some variability in transect location between different sampling efforts (*e.g.*, macroinvertebrates vs. channel geometry), the loss of overall accuracy is minimal because the goal of the program is to characterize the reach, rather than to establish monumented cross sections; therefore, the exact locations at which data are collected should not affect their validity.

Sampling frequency and rotation schedule

Sentinel sites will be sampled annually during an index period from late June through late August. Additional sampling will be conducted at sentinel sites in the spring (early May through early June) and the fall (September) each year, as resources allow. This constitutes the core program, which we expect to be sustainable even with diminishing budgets. Although these sites do not fully capture the ecological gradients in the network, they provide a reasonable cross-section of stream types and cover a large geographical area. The number of potentially accessible sites currently exceeds the number of sentinel sites, which would allow us to increase the number of sentinel sites in the core program if budgetary considerations force us to restrict the number of remote synoptic sites that are sampled.

Synoptic sites will be sampled with an approximately 10-year return interval, also during the index period of late June through late August, with the number of sites sampled per year varying from park to park, depending on the total number of synoptic sites in that park. Each year, therefore, the goal will be to sample 10% of the total number of synoptic sites in the network. For each park, 10 panels have been established, with a 10-year return interval for each panel. For WRST, there are a total of 60 synoptic sites, constituting 10 panels of 6 sites each. For DENA, there are a total of 30 synoptic sites, constituting 10 panels of 3 sites each, and for YUCH there

are a total of 20 synoptic sites, constituting 10 panels of 2 sites each. During the development of the program, these panels were rolled out on a staggered schedule. Synoptic sampling for WRST began in 2008, for DENA in 2010, and for YUCH in 2011. Therefore, the complete set of synoptic sites will have been sampled once in 2017 for WRST, in 2019 for DENA, and in 2020 for YUCH. Network wide, then, there will be a total of 110 synoptic sites, 11 of which will be sampled each year, and 14 sentinel sites, each of which will be sampled every year, for a total of approximately 25 sites sampled each year.

In addition to these, a varying number of judgment sites will be sampled each year, and a varying subset of the sentinel sites will be sampled more than once per year, bringing the total number of sampling visits each year to approximately 30. Additional visits to sentinel sites for temperature sensor replacement and sonde measurements are not counted in this total. Through 2016, we have been able to roughly meet this schedule. In WRST, 47 synoptic sites have been sampled over 8 years, for an average of just under 6/year. For DENA, 22 synoptic sites have been sampled over 6 years, for a total of just under 4/year (however, 7 of these are coincidentally sentinel sites that have been sampled since 2007; when these are eliminated, we have sampled 15 GRTS sites in 6 years, or just under 3/year). In YUCH we have sampled 8 synoptic sites in 5 years, or between 1 and 2 sites/year.

This schedule will be continuously evaluated, and adjusted as necessary according to the resources available. Because the vast majority of synoptic sites are only accessible by helicopter, it will not always be possible to meet the goal of maintaining a strict rotation schedule for each park. Inevitable deviations from the set rotation schedule will reduce our ability to detect regional trends moderately, but reflect the realities of implementing a large-scale, long-term monitoring program in a remote landscape on a limited budget.

Planning Annual Sampling

Each year the goal should be to sample as many sites as time and budgetary considerations allow. If possible, the 14 sentinel sites listed in Table 2 should be sampled every year. For synoptic GRTS sites, the goal is to sample 6 sites from WRST, 3 sites from DENA and 2 sites from YUCH. If these goals are met, a total of 40 sites will be sampled during each field season. For each park, half of the sites should be selected from the “Accessible” stratum, and half from the “Inaccessible” stratum of the GRTS draw. If possible, GRTS sites should be sampled in the order given in the GRTS list; however, as explained above, logistical constraints will often make this impossible. Nevertheless, every effort should be made to conform to the list order. Although in general synoptic sites should be sampled according to the panel rotation schedule (once every 10 years), they may be sampled more often if the opportunity arises. Table 3 lists all sites sampled since 2006, including synoptic sites, several of which have been sampled on more than one occasion. Table 4 gives the coordinates of all sites sampled from 2006-2016.

In Table 3, the “Selection Type” should be interpreted as follows. “GRTS” indicates that the site was selected using the GRTS algorithm discussed above. “Sentinel” indicates that the site was selected for ease of access to facilitate annual sampling. Note that some of the Sentinel sites were originally selected using GRTS; these sites are listed with a Selection Type of GRTS, although they are classified as Sentinel sites. “Judgment” indicates sites that were selected either to better capture ecological gradients on the landscape, or sites that were chosen for logistical reasons

Table 3. List of sites sampled 2006-2016 with site selection type, rotation type and years sampled. The exact data collected varies between sites and sampling visits.

Sitecode	Site name	Selection type	Rotation type	Park	Years sampled
DENA-001	Rock Creek DENA	Judgment	Other	DENA	2007,09-16
DENA-002	E. Savage River spring	Judgment	None	DENA	2007
DENA-003	E. Branch Toklat spring	Other	None	DENA	2007
DENA-004	Travertine Stream	Judgment	Other	DENA	2007-9,11-13,15-16
DENA-008	Little Stony Creek	Sentinel	Annual	DENA	2007-9,11-16
DENA-009	Little Stony trib center	Judgment	Other	DENA	2007,15,16
DENA-010	Little Stony trib east	Judgment	Other	DENA	2007
DENA-011	Gorge Creek Spring	Judgment	Other	DENA	2007-9,11,13,15
DENA-012	McKinley Bar spring	Judgment	Other	DENA	2007-8
DENA-013	McKinley Bar Creek South	Judgment	None	DENA	2007
DENA-014	McKinley Bar Creek Center	Judgment	None	DENA	2007
DENA-015	McKinley Bar Trail Creek	Judgment	Other	DENA	2007,8,10
DENA-017	Tattler Creek	Sentinel	Annual	DENA	2007-16
DENA-018	Igloo Creek above Tattler	Judgment	Other	DENA	2007-8
DENA-021	Hogan Creek	Judgment	Other	DENA	2007-16
DENA-022	Savage River	Judgment	Other	DENA	2007-9
DENA-024	Gorge Creek	Judgment	None	DENA	2008
DENA-026	Moose Creek at crossing	Other	None	DENA	2008
DENA-028	Moose Creek at airstrip	Other	None	DENA	2008
DENA-029	Lake Creek DENA	Sentinel	Annual	DENA	2008-9,11-16
DENA-031	Cantwell Creek	Judgment	None	DENA	2008
DENA-033	Hines Creek trib	Judgment	None	DENA	2011,13
DENA-034	Wonder Lake inflow	Judgment	Other	DENA	2011,12,14-16
DENA-035	Eureka Creek	Other	Other	DENA	2012-15
DENA-036	Friday Creek	Other	Other	DENA	2008,12
DENA-045	Tokositna trib	Judgment	Other	DENA	2014-15
DENA-046	Eldorado Creek below Slate	Other	None	DENA	2014
DENA-047	Eldorado Creek above Slate	Other	None	DENA	2014
DENA-048	lower Slate Creek	Other	None	DENA	2014
DENA-051	Ruth Glacier trib	Judgment	None	DENA	2016
DENA-GRTS-003	Stony Creek trib	GRTS	Long Term	DENA	2010-13
DENA-GRTS-007	Glen Creek	GRTS	Long Term	DENA	2012
DENA-GRTS-010	Moose Creek at bridge	GRTS	Annual	DENA	2007-16
DENA-GRTS-014	E.F. Toklat trib	GRTS	Annual	DENA	2007-16
DENA-GRTS-023	Last Chance Creek	GRTS	Long Term	DENA	2012
DENA-GRTS-027	E.F. Toklat River	GRTS	Annual	DENA	2007-16
DENA-GRTS-039	Upper Moose Creek	GRTS	Long Term	DENA	2008,10
DENA-GRTS-049	White Creek	GRTS	Long Term	DENA	2012
DENA-GRTS-051	Clearwater Fork	GRTS	Long Term	DENA	2012
DENA-GRTS-060	Savage River GRTS	GRTS	Long Term	DENA	2010-16
DENA-GRTS-071	Stony Creek	GRTS	Long Term	DENA	2009-13,15
DENA-GRTS-084	Igloo Creek	GRTS	Annual	DENA	2007-16
DENA-GRTS-104	Sanctuary River	GRTS	Annual	DENA	2007-16
DENA-GRTS-122	Highway Pass Creek	GRTS	Long Term	DENA	2007,10-13
DENA-GRTS-127	Birch Creek	GRTS	Long Term	DENA	2010
DENA-GRTS-128	Coffee River	GRTS	Long Term	DENA	2013
DENA-GRTS-134	Marten Creek	GRTS	Long Term	DENA	2010
DENA-GRTS-137	Bear Creek DENA	GRTS	Long Term	DENA	2012

Table 3, cont.

Sitecode	Site name	Selection type	Rotation type	Park	Years sampled
DENA-GRTS-143	Birch Creek trib	GRTS	Long Term	DENA	2012
DENA-GRTS-173	Sanctuary River trib	GRTS	Long Term	DENA	2010
DENA-GRTS-183	McLeod Creek	GRTS	Long Term	DENA	2010
DENA-GRTS-196	Alder Creek	GRTS	Long Term	DENA	2012-13,15
DENA-MINE-001	Stampede Creek	Other	None	DENA	2012
DENA-MINE-002	Rock Creek	Other	None	DENA	2012
DENA-MINE-003	Caribou Creek	Other	None	DENA	2012
DENA-MINE-004	Slate Creek	Other	None	DENA	2012
DENA-WQ-017	Cloud Creek	Other	Other	DENA	2013
DENA-WQ-056	Slide Creek	Other	Other	DENA	2013
DENA-WQ-067	Wildhorse Creek	Other	Other	DENA	2012
DENA-WQ-100	upper Alder Creek	Other	Other	DENA	2014
DENA-WQ-101	Bear Creek	Other	Other	DENA	2014
NABA2	Nabesna River	Other	Annual	TETLIN	2013-16
TETLIN-001	Scottie Creek	Other	Annual	TETLIN	2014-15
Tomco-001	Toby Creek	Other	None	WRST	2012
Tomco-002	E.F. Kiagna River	Other	None	WRST	2012
Tomco-003	Kiagna River	Other	None	WRST	2012
WRST-001	Trib W of Tana River	Judgment	None	WRST	2006
WRST-002	Chakina River braid	Judgment	None	WRST	2006
WRST-003	Trib E of Tebay River	Judgment	None	WRST	2006
WRST-004	Chalk Creek	Sentinel	Annual	WRST	2006-16
WRST-005	Swift Creek	Judgment	None	WRST	2006
WRST-006	Rock Creek WRST	Sentinel	Annual	WRST	2006-16
WRST-007	Gravel Creek	Judgment	None	WRST	2006
WRST-008	Beaver Creek	Judgment	Other	WRST	2006,08
WRST-009	Rock Lake Outflow	Judgment	None	WRST	2006
WRST-010	Ptarmigan Creek	Judgment	None	WRST	2006
WRST-011	Rock Creek trib	Judgment	None	WRST	2007, 2009-16
WRST-013	Gilahina River	Sentinel	Annual	WRST	2007,09-13,15-16
WRST-014	Skookum Creek	Judgment	None	WRST	2006
WRST-015	Little Jack Creek	Judgment	Other	WRST	2006,08-16
WRST-016	Nizina trib	Judgment	None	WRST	2007
WRST-017	Lake Creek WRST	Judgment	None	WRST	2007-8
WRST-019	Willow Creek	Judgment	None	WRST	2007-8
WRST-020	Skolai Pass stream	Judgment	None	WRST	2007
WRST-021	Moonshine Creek	Judgment	None	WRST	2007
WRST-022	4th of July Creek	Judgment	None	WRST	2007
WRST-023	Bear Creek	Judgment	None	WRST	2007
WRST-024	Amy Creek	Judgment	None	WRST	2007
WRST-025	May Creek	Judgment	None	WRST	2007
WRST-026	Galiano West creek	Judgment	None	WRST	2007
WRST-027	Icy Bay stream	Judgment	None	WRST	2007
WRST-028	Independence Creek	Judgment	None	WRST	2007
WRST-029	Little Esker Creek	Judgment	None	WRST	2007
WRST-030	Little Esker glacial trib	Judgment	None	WRST	2007
WRST-036	Rufus Creek	Sentinel	Annual	WRST	2008-16
WRST-038	Horsfeld Creek	Other	None	WRST	2008
WRST-039	Caribou Creek @ culvert	Judgment	None	WRST	2008-13,15-16
WRST-040	Chokosna River	Judgment	Other	WRST	2008,11-13

Table 3, cont.

Sitecode	Site name	Selection type	Rotation type	Park	Years sampled
WRST-041	Strelna Creek @ culvert	Judgment	None	WRST	2008,11
WRST-043	Lakina River abv bridge	Judgment	Other	WRST	2008,13,15
WRST-045	Kennicott River	Judgment	Other	WRST	2008
WRST-046	Solo Creek	Other	Other	WRST	2008
WRST-047	Creek near Tana strip	Other	Other	WRST	2008
WRST-048	Creek SW of Tana strip	Other	Other	WRST	2008
WRST-050	Nadina River	Judgment	None	WRST	2009
WRST-051	Long Lake Creek	Judgment	Other	WRST	2008,10-13,15,16
WRST-060	Paco Creek	Sentinel	Annual	WRST	2010-16
WRST-061	Tanada Creek @weir	Judgment	Other	WRST	2011
WRST-064	Chicken Creek	Judgment	Other	WRST	2011
WRST-065	Toby Creek trib	Judgment	None	WRST	2012
WRST-067	Hidden Creek	Judgment	None	WRST	2012
WRST-068	Perched Culvert	Other	None	WRST	2012
WRST-069	Trail Creek	Judgment	Annual	WRST	2012-16
WRST-070	Lost Creek	Judgment	Annual	WRST	2008,12-16
WRST-071	Boyden Creek	Judgment	Annual	WRST	2012-16
WRST-072	Crystal Creek @ road	Judgment	Other	WRST	2010-12,15
WRST-073	Long Lake inflow abv culvert	Judgment	Other	WRST	2013
WRST-074	White Creek	Judgment	None	WRST	2014
WRST-077	Sangaina River	Judgment	None	WRST	2014
WRST-078	EF Bremner trib	Judgment	None	WRST	2015
WRST-079	lower Chicken Creek	Judgment	Other	WRST	2015
WRST-080	Tana Knob Creek	Judgment	Other	WRST	2015
WRST-081	Falls Creek trib	Judgment	None	WRST	2016
WRST-087	Upper Young Creek	Judgment	None	WRST	2016
WRST-091	Lakina trib 2	Judgment	None	WRST	2016
WRST-095	Tana Knob creek 2	Judgment	None	WRST	2016
WRST-GRTS-004	Notch Creek trib	GRTS	Long Term	WRST	2008
WRST-GRTS-006	Sanford River FP stream	GRTS	Long Term	WRST	2010
WRST-GRTS-008	McCarthy Creek	GRTS	Long Term	WRST	2009
WRST-GRTS-012	Bryan Creek	GRTS	Long Term	WRST	2008
WRST-GRTS-018	Jack Creek trib	GRTS	Long Term	WRST	2009
WRST-GRTS-021	Caribou Creek	GRTS	Long Term	WRST	2009-16
WRST-GRTS-030	Strelna Creek @crossing	GRTS	Long Term	WRST	2011-13,15-16
WRST-GRTS-036	Solo Creek trib	GRTS	Long Term	WRST	2008
WRST-GRTS-037	Tanada Creek	GRTS	Long Term	WRST	2009
WRST-GRTS-054	Black Mtn East stream	GRTS	Long Term	WRST	2010
WRST-GRTS-106	Trail Creek	GRTS	Long Term	WRST	2010
WRST-GRTS-126	upper Strelna Creek	GRTS	Long Term	WRST	2012
WRST-GRTS-130	Jack Creek at bridge	GRTS	Annual	WRST	2006-16
WRST-GRTS-131	Iceberg Bench creek	GRTS	Long Term	WRST	2010
WRST-GRTS-135	Chititu Creek	GRTS	Long Term	WRST	2015
WRST-GRTS-136	Glacier Creek	GRTS	Long Term	WRST	2014-15
WRST-GRTS-160	Beaver Dam Creek	GRTS	Long Term	WRST	2014
WRST-GRTS-174	Lakina River trib	GRTS	Long Term	WRST	2012
WRST-GRTS-178	Sanford River trib	GRTS	Long Term	WRST	2010
WRST-GRTS-190	Black Mtn West stream	GRTS	Long Term	WRST	2010
WRST-GRTS-204	Tana River trib	GRTS	Long Term	WRST	2009
WRST-GRTS-215	Nadina River trib	GRTS	Long Term	WRST	2009

Table 3, cont.

Sitecode	Site name	Selection type	Rotation type	Park	Years sampled
WRST-GRTS-219	Chakina River trib	GRTS	Long Term	WRST	2009
WRST-GRTS-220	high elevation Tana trib	GRTS	Long Term	WRST	2010
WRST-GRTS-223	Sheep Gulch	GRTS	Long Term	WRST	2009
WRST-GRTS-224	Clear Stream trib	GRTS	Long Term	WRST	2009
WRST-GRTS-225	Dadina River trib	GRTS	Long Term	WRST	2009
WRST-GRTS-228	Hunter Creek	GRTS	Long Term	WRST	2009
WRST-GRTS-234	Stuver Creek trib	GRTS	Long Term	WRST	2011
WRST-GRTS-241	Mt. Sanford stream	GRTS	Long Term	WRST	2010
WRST-GRTS-244	Ultima Thule Creek	GRTS	Long Term	WRST	2012
WRST-GRTS-246	Monahan Creek	GRTS	Long Term	WRST	2012
WRST-GRTS-247	Paco's River	GRTS	Long Term	WRST	2011
WRST-GRTS-251	Hanagita River	GRTS	Long Term	WRST	2011
WRST-GRTS-262	Klu River	GRTS	Long Term	WRST	2012
WRST-GRTS-270	Chavolda Creek	GRTS	Long Term	WRST	2008
WRST-GRTS-271	Nadina River trib 2	GRTS	Long Term	WRST	2009
WRST-GRTS-289	Sheep Glacier stream trib	GRTS	Long Term	WRST	2010
WRST-GRTS-296	W.F. Glacier trib	GRTS	Long Term	WRST	2012
WRST-GRTS-302	North Fork White River	GRTS	Long Term	WRST	2008
WRST-GRTS-324	Young Creek	GRTS	Long Term	WRST	2007,10
WRST-GRTS-345	Capital Mountain stream	GRTS	Long Term	WRST	2010
WRST-GRTS-355	Chokosna River trib	GRTS	Long Term	WRST	2010
WRST-GRTS-356	Copper Creek	GRTS	Long Term	WRST	2012
WRST-GRTS-372	Tana Glacier trib	GRTS	Long Term	WRST	2014
WRST-GRTS-375	Bridge Creek	GRTS	Long Term	WRST	2011
WRST-GRTS-386	Chisana trib	GRTS	Long Term	WRST	2015
YUCH-001	Copper Creek	Judgment	None	YUCH	2014
YUCH-002	Beaton Pup	Judgment	None	YUCH	2014
YUCH-003	Cathedral Creek	Judgment	Other	YUCH	2015
YUCH-004	Crescent Creek	Judgment	Other	YUCH	2015
YUCH-005	Coal Creek hobo	Judgment	Other	YUCH	2015
YUCH-010	Copper Creek	Judgment	None	YUCH	2016
YUCH-GRTS-001	Upper Charley River	GRTS	Long Term	YUCH	2011
YUCH-GRTS-003	Coal Creek	GRTS	Other	YUCH	2011
YUCH-GRTS-007	Andrew Creek	GRTS	Long Term	YUCH	2011
YUCH-GRTS-017	Three Fingers stream	GRTS	Long term	YUCH	2016
YUCH-GRTS-035	Coal Creek at strip	GRTS	Long Term	YUCH	2011
YUCH-GRTS-099	Seventymile River trib	GRTS	Long Term	YUCH	2011
YUCH-GRTS-115	Cedar Creek	GRTS	Long Term	YUCH	2015
YUCH-GRTS-123	Maggie Creek	GRTS	Long Term	YUCH	2015

(e.g., no alternate GRTS site was available within a reasonable distance of a primary GRTS site, or we had an unexpected opportunity to sample a site for other reasons). “Other” indicates sites that were chosen for other reasons (e.g., a park manager requested that the site be sampled).

The “Rotation Type” should be interpreted as follows. “Annual” indicates sites that should be sampled every year. This includes all of the Sentinel sites, whether they were originally selected for ease of access, or using GRTS. “Long Term” indicates synoptic sites that will be sampled approximately once every 10 years. Note that the precise panel rotation will be determined once

the complete set of synoptic sites has been sampled for each park. This is necessary due to the interannual variability in the number of synoptic sites actually sampled to date. “Other” indicates sites that are resampled periodically, but that are not strictly considered “Annual” or “Long Term”. Many of these sites are located along the road system, and are sampled relatively frequently, as resources allow. “None” indicates sites that have been sampled once, and for which there is currently no formal plan to resample. Most of these sites are remote “Judgment” sites that were sampled either to extend or densify ecological gradients, or were sampled opportunistically.

For the GRTS sites listed in Table 3, the coordinates given in Table 4, rather than those given in Tables 5-7, should be used to relocate the sampling reach, as the coordinates of the reach that was actually sampled rarely corresponds exactly to the original coordinates in the GRTS site list. This is usually due to safety considerations when selecting helicopter landing zones. Although every effort should be made to sample at the listed coordinates, if safety considerations require landing upstream or downstream from those coordinates, the site actually sampled may be considered to be the same as the target site on the list, as long as the two sites are geomorphologically similar, based on best professional judgment.

Prior to the field season, you should assemble lists of potential GRTS sampling sites for each park, taken from the lists provided in Tables 5-7. Be sure to include 2-3 times as many sites as you actually plan to sample, to account for sites that turn out to be non-target sites (e.g., unsampleable, too large to sample safely or cannot be accessed safely). Update the site list each year to reflect the results of field reconnaissance (*i.e.*, mark non-target sites as non-target and include an explanation). Streams that are dry when visited should be marked as target so they remain in the panel for future sampling visits.

Table 4. Coordinates of sites sampled from 2006-2016. Latitude and longitude are WGS84. In most cases, the listed coordinates correspond to the bottom of the sampling reach. Exceptions are DENA-GRTS-010 (coordinates are top of reach), DENA-GRTS-027 (sampling reach is transverse across all braided channels, starting at coordinates), DENA-GRTS-084 (coordinates are at transect 5), WRST-008 (coordinates are top of reach), WRST-051 (coordinates are top of reach), WRST-GRTS-160 (coordinates are top of reach), WRST-GRTS-228 (coordinates are at transect 5).

Sitecode	Site Name	Park	Latitude	Longitude
DENA-001	Rock Creek DENA	DENA	63.72348790	-148.96405810
DENA-002	E. Savage River spring	DENA	63.72834013	-149.28556952
DENA-003	E. Branch Toklat spring	DENA	63.4978639	-149.967815
DENA-004	Travertine Stream	DENA	63.46632779	-150.18010612
DENA-008	Little Stony Creek	DENA	63.45073516	-150.24667277
DENA-009	Little Stony trib center	DENA	63.453110	-150.237290
DENA-010	Little Stony trib east	DENA	63.454638	-150.234569
DENA-011	Gorge Creek Spring	DENA	63.43208617	-150.29739601
DENA-012	McKinley Bar Spring	DENA	63.42942843	-150.81377369
DENA-013	McKinley Bar Creek South	DENA	63.438010	-150.830645
DENA-014	McKinley Bar Creek Center	DENA	63.443594	-150.836927

Table 4, continued.

Sitecode	Site Name	Park	Latitude	Longitude
DENA-015	McKinley Bar Trail Creek	DENA	63.44635322	-150.83901045
DENA-017	Tattler Creek	DENA	63.56780434	-149.64026188
DENA-018	Igloo Creek above Tattler	DENA	63.56753661	-149.63805077
DENA-021	Hogan Creek	DENA	63.72204176	-149.43218822
DENA-022	Savage River	DENA	63.74225946	-149.29061775
DENA-024	Gorge Creek	DENA	63.42204286	-150.32118263
DENA-026	Moose Creek at crossing	DENA	63.51434397	-150.81429909
DENA-028	Moose Creek at airstrip	DENA	63.54276784	-150.99997363
DENA-029	Lake Creek DENA	DENA	63.49585754	-150.88984518
DENA-031	Cantwell Creek	DENA	63.33632370	-149.17169594
DENA-033	Hines Creek trib	DENA	63.718305	-149.014038
DENA-034	Wonder Lake inflow	DENA	63.496773	-150.881392
DENA-035	Eureka Creek	DENA	63.527576	-150.961538
DENA-036	Friday Creek	DENA	63.539109	-150.985833
DENA-045	Tokositna trib	DENA	62.659918	-150.800620
DENA-046	Eldorado Creek below Slate	DENA	63.493320	-151.021006
DENA-047	Eldorado Creek above Slate	DENA	63.493249	-151.020051
DENA-048	lower Slate Creek	DENA	63.493001	-151.020409
DENA-051	Ruth Glacier trib	DENA	62.85852138	-150.5654362
DENA-GRTS-003	Stony Creek trib	DENA	63.47052200	-150.17424600
DENA-GRTS-007	Glen Creek	DENA	63.521117	150.707233
DENA-GRTS-010	Moose Creek at Bridge	DENA	63.51587903	-150.91026482
DENA-GRTS-014	EF Toklat trib	DENA	63.55712500	-149.78065605
DENA-GRTS-023	Last Chance Creek	DENA	63.588413	-150.782753
DENA-GRTS-027	E.F. Toklat River	DENA	63.55647600	-149.78280800
DENA-GRTS-039	Upper Moose Creek	DENA	63.46351028	-150.57879777
DENA-GRTS-049	White Creek	DENA	63.154250	-151.698210
DENA-GRTS-051	Clearwater Fork	DENA	63.723706	-150.331961
DENA-GRTS-060	Savage River GRTS	DENA	63.766193	-149.294581
DENA-GRTS-071	Stony Creek	DENA	63.45978050	-150.19320120
DENA-GRTS-084	Igloo Creek	DENA	63.60833298	-149.58635755
DENA-GRTS-104	Sanctuary River	DENA	63.72090517	-149.47677071
DENA-GRTS-122	Highway Pass Creek	DENA	63.49762015	-150.07249464
DENA-GRTS-127	Birch Creek	DENA	63.19557400	-151.31917600
DENA-GRTS-128	Coffee River	DENA	62.835810	-150.312460
DENA-GRTS-134	Marten Creek	DENA	63.81658700	-150.42566500
DENA-GRTS-137	Bear Creek DENA	DENA	63.686225	-151.223405
DENA-GRTS-143	Birch Creek trib	DENA	63.197200	-151.252560
DENA-GRTS-173	Sanctuary River trib	DENA	63.56497200	-149.26114700
DENA-GRTS-183	McLeod Creek	DENA	63.42593300	-151.22403900
DENA-GRTS-196	Alder Creek	DENA	62.760687	-150.434247
DENA-MINE-001	Stampede Creek	DENA	63.741200	-150.375867
DENA-MINE-002	Rock Creek	DENA	63.655160	-150.870833
DENA-MINE-003	Caribou Creek	DENA	63.682217	-150.945000
DENA-MINE-004	Slate Creek	DENA	63.481117	-151.073617
DENA-WQ-017	Cloud Creek	DENA	62.835610	-150.309980
DENA-WQ-056	Slide Creek	DENA	62.812700	-150.430420

Table 4, continued.

Sitecode	Site Name	Park	Latitude	Longitude
DENA-WQ-067	Wildhorse Creek	DENA	62.655569	-150.900819
DENA-WQ-100	upper Alder Creek	DENA	62.799870	-150.523130
DENA-WQ-101	Bear Creek	DENA	62.642670	-150.911180
NABA2	Nabesna River	TETLIN	62.791027	-142.169228
TETLIN-001	Scottie Creek	TETLIN	62.639263	-141.027514
Tomco-001	Toby Creek	WRST	61.465115	-142.262863
Tomco-002	E.F. Kiagna River	WRST	61.018888	-142.379340
Tomco-003	Kiagna River	WRST	61.018780	-142.380257
WRST-001	Trib W of Tana River	WRST	61.21659000	-142.84250000
WRST-002	Chakina River braid	WRST	61.32841040	-143.14215510
WRST-003	Trib E of Tebay River	WRST	61.36657000	-143.96683000
WRST-004	Chalk Creek	WRST	62.50457000	-143.15960000
WRST-005	Swift Creek	WRST	61.41624000	-143.01735000
WRST-006	Rock Creek WRST	WRST	62.56496220	-143.43228640
WRST-007	Gravel Creek	WRST	62.05445000	-141.08015000
WRST-008	Beaver Creek	WRST	62.03695570	-141.78772890
WRST-009	Rock Lake Outflow	WRST	61.81623250	-141.18671670
WRST-010	Ptarmigan Creek	WRST	61.86868000	-141.15100000
WRST-011	Rock Creek trib	WRST	62.56496220	-143.43228640
WRST-013	Gilahina River	WRST	61.43921243	-143.71648080
WRST-014	Skookum Creek	WRST	62.40470000	-142.99970000
WRST-015	Little Jack Creek	WRST	62.54677842	-143.33117824
WRST-016	Nizina trib	WRST	61.46427613	-142.60747500
WRST-017	Lake Creek WRST	WRST	61.37648701	-142.64329943
WRST-019	Willow Creek	WRST	61.05288013	-142.74566480
WRST-020	Skolai Pass stream	WRST	61.64847740	-142.11684320
WRST-021	Moonshine Creek	WRST	61.60721608	-142.43949233
WRST-022	4th of July Creek	WRST	61.49453305	-143.01194330
WRST-023	Bear Creek	WRST	61.48551927	-143.23729000
WRST-024	Amy Creek	WRST	61.03685613	-143.61042343
WRST-025	May Creek	WRST	61.34812160	-142.69884520
WRST-026	Galiano West creek	WRST	59.91679352	-139.72940629
WRST-027	Icy Bay stream	WRST	60.04189145	-141.38546061
WRST-028	Independence Creek	WRST	60.00796900	-141.41788491
WRST-029	Little Esker Creek	WRST	59.87888869	-139.77477480
WRST-030	Little Esker glacial trib	WRST	59.87932950	-139.77532130
WRST-036	Rufus Creek	WRST	62.65967400	-143.84312100
WRST-038	Horsfeld Creek above crossing	WRST	62.00144240	-141.16552530
WRST-039	Caribou Creek	WRST	62.57322628	-143.51831183
WRST-040	Chokosna River	WRST	61.45522878	-143.76353023
WRST-041	Strelina Creek	WRST	61.51076342	-144.06818111
WRST-043	Lakina River	WRST	61.37528000	-143.34658000
WRST-045	Kennicott River	WRST	61.434320	-142.940530
WRST-046	Solo Creek	WRST	61.75846667	-141.70355000
WRST-047	Creek near Tana strip	WRST	60.950817	-142.689367
WRST-048	Creek SW of Tana strip	WRST	60.939817	-142.707833
WRST-050	Nadina River	WRST	61.97100700	-144.87518400

Table 4, continued.

Sitecode	Site Name	Park	Latitude	Longitude
WRST-051	Long Lake Creek	WRST	61.37746040	-143.31405410
WRST-060	Mile 27 Stream	WRST	62.53289400	-143.28423800
WRST-061	Tanada Creek @ weir	WRST	62.613834	-143.777758
WRST-064	Chicken Creek	WRST	62.12478503	-141.85029256
WRST-065	Toby Creek trib	WRST	61.465052	-142.263493
WRST-067	Hidden Creek	WRST	61.558236	-143.122063
WRST-068	Perched Culvert	WRST	61.455806	-143.790769
WRST-069	Trail Creek	WRST	62.523380	-143.220810
WRST-070	Lost Creek	WRST	62.513260	-143.173370
WRST-071	Boyden Creek	WRST	62.475920	-143.115680
WRST-072	Crystal Creek @ road	WRST	61.366593	-143.429155
WRST-073	Long Lake inflow abv culvert	WRST	61.386750	-143.241206
WRST-074	White Creek	WRST	61.280104	-142.554860
WRST-077	Sangaina River	WRST	61.137522	-143.956144
WRST-078	EF Bremner trib	WRST	61.062225	-144.038810
WRST-079	lower Chicken Creek	WRST	62.120922	-141.861718
WRST-080	Tana Knob Creek	WRST	60.976210	-143.013708
WRST-081	Falls Creek trib	WRST	61.20969094	-144.4562034
WRST-087	Upper Young Creek	WRST	61.27227616	-142.3605535
WRST-091	Lakina trib 2	WRST	61.5343899	-143.3841046
WRST-095	Tana Knob creek 2	WRST	60.9565606	-142.9559578
WRST-GRTS-004	Notch Creek trib	WRST	62.18542439	-142.27948973
WRST-GRTS-006	Sanford River FP stream	WRST	62.23426800	-144.62319800
WRST-GRTS-008	McCarthy Creek	WRST	61.49376470	-142.78697090
WRST-GRTS-012	Bryan Creek	WRST	62.02336474	-141.92002111
WRST-GRTS-018	Jack Creek trib	WRST	62.45025800	-143.11787733
WRST-GRTS-021	Caribou Creek	WRST	62.60113474	-143.61862764
WRST-GRTS-030	Strelna Creek @crossing	WRST	61.540079	-144.060880
WRST-GRTS-036	Solo Creek trib	WRST	61.78895419	-141.76104681
WRST-GRTS-037	Tanada Creek	WRST	62.60534800	-143.74651383
WRST-GRTS-054	Black Mtn East stream	WRST	62.28908000	-143.71403300
WRST-GRTS-106	Trail Creek	WRST	61.59007200	-143.74106600
WRST-GRTS-126	upper Strelna Creek	WRST	61.612999	-143.923476
WRST-GRTS-130	Jack Creek at bridge	WRST	62.46398770	-143.10518440
WRST-GRTS-131	Iceberg Bench creek	WRST	60.81289700	-142.98816400
WRST-GRTS-135	Chititu Creek	WRST	61.294504	-142.599960
WRST-GRTS-136	Glacier Creek	WRST	62.118710	-141.864727
WRST-GRTS-160	Beaver Dam Creek	WRST	61.166181	-144.404024
WRST-GRTS-174	Lakina River trib	WRST	61.526846	-143.383225
WRST-GRTS-178	Sanford River trib	WRST	62.19140000	-144.52147717
WRST-GRTS-190	Black Mtn West stream	WRST	62.32067700	-143.82827600
WRST-GRTS-204	Tana River trib	WRST	60.93130610	-142.71355740
WRST-GRTS-215	Nadina River trib	WRST	61.97069300	-144.77438100
WRST-GRTS-219	Chakina River trib	WRST	61.226022	-143.101990
WRST-GRTS-220	high elevation Tana trib	WRST	60.90348400	-142.57206900
WRST-GRTS-223	Sheep Gulch	WRST	61.95166200	-144.44920800
WRST-GRTS-224	Clear Stream trib	WRST	61.10829010	-141.98809590

Table 4, continued.

Sitecode	Site Name	Park	Latitude	Longitude
WRST-GRTS-225	Dadina River trib	WRST	62.02701517	-144.49140983
WRST-GRTS-228	Hunter Creek	WRST	61.10801780	-142.62208440
WRST-GRTS-234	Stuver Creek trib	WRST	62.33850779	-142.28798443
WRST-GRTS-241	Mt. Sanford stream	WRST	62.33611400	-144.46251400
WRST-GRTS-244	Ultima Thule Creek	WRST	61.131923	-142.330943
WRST-GRTS-246	Monahan Creek	WRST	61.098285	-143.296539
WRST-GRTS-247	Paco's River	WRST	60.93902563	-143.25012442
WRST-GRTS-251	Hanagita River	WRST	61.20367677	-143.61284026
WRST-GRTS-262	Klu River	WRST	61.140902	-143.439922
WRST-GRTS-270	Chavolda Creek	WRST	62.12734100	-141.96660090
WRST-GRTS-271	Nadina River trib 2	WRST	61.97089500	-144.87500400
WRST-GRTS-289	Sheep Glacier stream trib	WRST	62.32139300	-144.32865300
WRST-GRTS-296	W.F. Glacier trib	WRST	61.611991	-142.683450
WRST-GRTS-302	North Fork White River	WRST	61.85885242	-141.73667191
WRST-GRTS-324	Young Creek	WRST	61.20475900	-142.34287000
WRST-GRTS-345	Capital Mountain stream	WRST	62.47547100	-144.07355900
WRST-GRTS-355	Chokosna River trib	WRST	61.53645302	-143.57465113
WRST-GRTS-356	Copper Creek	WRST	61.329612	-142.396373
WRST-GRTS-372	Tana Glacier trib	WRST	60.806562	-142.740204
WRST-GRTS-375	Bridge Creek	WRST	61.30566877	-144.15300865
WRST-GRTS-386	Chisana trib	WRST	62.256220	-141.946420
YUCH-001	Copper Creek	YUCH	64.863780	-143.387850
YUCH-002	Beaton Pup	YUCH	65.305873	-143.155413
YUCH-003	Cathedral Creek	YUCH	65.173840	-141.147750
YUCH-004	Crescent Creek	YUCH	64.852410	-143.950200
YUCH-005	Coal Creek hobo	YUCH	65.312000	-143.132000
YUCH-010	Copper Creek	YUCH	64.86385326	-143.3992281
YUCH-GRTS-001	Upper Charley River	YUCH	64.563213	-143.214642
YUCH-GRTS-003	Coal Creek	YUCH	65.333217	-143.111583
YUCH-GRTS-007	Andrew Creek	YUCH	65.367412	-143.024620
YUCH-GRTS-017	Three Fingers stream	YUCH	64.57173957	-143.2252897
YUCH-GRTS-035	Coal Creek @ strip	YUCH	65.308467	-143.135433
YUCH-GRTS-099	Seventymile River trib	YUCH	64.929117	-142.911117
YUCH-GRTS-115	Cedar Creek	YUCH	64.866040	-143.207210
YUCH-GRTS-123	Maggie Creek	YUCH	65.415290	-142.168530

Table 5. GRTS site list for Denali NP&P. Under “EvalStatus”, sites are listed as either “Target”, “Nontarget” or “NotEval.” “NotEval” indicates the site has yet to be fully evaluated. “EvalReason” gives the reason a site was designated Nontarget. The reasons listed are Lake, Private (on private land), Too big (unsafe), Doesn’t exist , and No access (can’t land helicopter or otherwise get access to site). “Name” refers to the attributed name from the National Hydrography Dataset (NHD) or a name provided by the CAKN in cases where sites have already been sampled; not all segments have names in the NHD. DENA-GRTS-001 through DENA-GRTS-124 is the Accessible stratum. DENA-GRTS-125 through DENA-GRTS-248 is the Inaccessible stratum. Latitude and longitude are NAD83 and are given in digital degrees.

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
DENA-GRTS-001	Target		Castle Rocks Lake inlet	63.3448720	-152.1379440
DENA-GRTS-002	Nontarget	Lake	Deep Creek	63.6083963	-152.5928313
DENA-GRTS-003	Target		Stony Creek trib	63.4704134	-150.1740121
DENA-GRTS-004	Nontarget	Lake		63.8861308	-151.8497177
DENA-GRTS-005	Target		East Fork Yentna River	62.6209408	-151.9035123
DENA-GRTS-006	Target		Lonestar Creek	63.5956395	-152.7164287
DENA-GRTS-007	Target		Glen Creek near mine	63.5269302	-150.7090145
DENA-GRTS-008	Target		Hines Creek trib	63.7080975	-149.0626506
DENA-GRTS-009	Target		Camp Creek	63.2806403	-149.5059508
DENA-GRTS-010	Target		Moose Creek	63.5163928	-150.9063075
DENA-GRTS-011	Target		Thorofare River	63.4257328	-150.5107442
DENA-GRTS-012	Target		Big Creek	63.6838879	-149.6145260
DENA-GRTS-013	Target		Old Cache Lake outflow	63.6145262	-152.2874315
DENA-GRTS-014	Target		EF Toklat trib	63.5563737	-149.7650178
DENA-GRTS-015	Nontarget	Lake		64.0134209	-151.7723954
DENA-GRTS-016	Target		Jenny Creek trib	63.7027753	-149.1823174
DENA-GRTS-017	Nontarget	Lake		63.3562390	-152.1465001
DENA-GRTS-018	Nontarget	Lake		63.5570622	-152.4951552
DENA-GRTS-019	Target		Stony Creek	63.4844713	-150.2276297
DENA-GRTS-020	Nontarget	Doesn't exist		63.8788106	-151.5171644
DENA-GRTS-021	Target		trib of EF Yentna River	62.5431979	-151.9339700
DENA-GRTS-022	Nontarget		Muddy River trib	63.9559934	-151.8701464
DENA-GRTS-023	Target		Last Chance Creek	63.5927719	-150.7907311
DENA-GRTS-024	Target		EF Toklat trib at Sable Pass	63.5538749	-149.6898165
DENA-GRTS-025	Target		trib of Foraker River	63.7917123	-151.9539361
DENA-GRTS-026	Target		Moose Creek	63.5234052	-150.9611302
DENA-GRTS-027	Target		East Fork Toklat River	63.5708089	-149.8219830
DENA-GRTS-028	Target		Teklanika River	63.7251834	-149.5418397
DENA-GRTS-029	Target		Old Cache Lake inflow	63.5836433	-152.3426762
DENA-GRTS-030	Target		EF Toklat Polychrome trib	63.5358663	-149.8038850
DENA-GRTS-031	Nontarget	No access		63.9867659	-151.6374508
DENA-GRTS-032	NotEval			63.7146669	-149.4250322
DENA-GRTS-033	NotEval			63.3794931	-152.4383905
DENA-GRTS-034	NotEval		Deep Creek	63.3937643	-152.6390383
DENA-GRTS-035	NotEval		Caribou Creek	63.6129127	-150.7119450
DENA-GRTS-036	NotEval			63.9951030	-150.6297842
DENA-GRTS-037	NotEval		Costello Creek	63.2377095	-149.5028138
DENA-GRTS-038	Target		Muddy River	63.9519511	-151.9346074
DENA-GRTS-039	Target		Moose Creek	63.4776658	-150.6084955

Table 5, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
DENA-GRTS-040	NotEval		Teklanika River	63.6785831	-149.5889657
DENA-GRTS-041	NotEval			63.8496565	-151.9049435
DENA-GRTS-042	NotEval		Flat Creek	63.5790246	-150.9675131
DENA-GRTS-043	NotEval			64.0451607	-151.6911522
DENA-GRTS-044	NotEval		Savage River	63.7571704	-149.2892233
DENA-GRTS-045	NotEval			63.5954196	-152.2766666
DENA-GRTS-046	NotEval		Toklat River	63.4832758	-149.9624642
DENA-GRTS-047	NotEval		Muddy River	63.9007265	-151.5891070
DENA-GRTS-048	NotEval		Bain Creek	63.4588572	-148.8424948
DENA-GRTS-049	Target		White Creek	63.1905419	-151.6012482
DENA-GRTS-050	NotEval			63.3967931	-152.5058695
DENA-GRTS-051	Target		Clearwater Fork	63.7208732	-150.3317389
DENA-GRTS-052	NotEval			63.5387372	-148.8136875
DENA-GRTS-053	NotEval		West Fork Chulitna River	63.2390416	-149.5813540
DENA-GRTS-054	NotEval			63.8570222	-151.9421016
DENA-GRTS-055	NotEval		Thorofare River	63.4186108	-150.3414456
DENA-GRTS-056	NotEval			63.6204396	-149.5444755
DENA-GRTS-057	NotEval		Deep Creek	63.6426464	-152.5844645
DENA-GRTS-058	NotEval			63.8300468	-151.8473406
DENA-GRTS-059	NotEval			64.0224951	-151.7917358
DENA-GRTS-060	Target		Savage River	63.7268719	-149.2903446
DENA-GRTS-061	NotEval			63.5306500	-152.6223539
DENA-GRTS-062	NotEval			63.4929837	-150.0364333
DENA-GRTS-063	NotEval			63.9510995	-151.6110465
DENA-GRTS-064	NotEval		Windy Creek	63.4278190	-148.9440740
DENA-GRTS-065	NotEval			62.5964340	-151.9195063
DENA-GRTS-066	NotEval		Lonestar Creek	63.5718083	-152.7561716
DENA-GRTS-067	NotEval		Moose Creek	63.5164898	-150.7608317
DENA-GRTS-068	NotEval		Riley Creek	63.7141574	-148.9289265
DENA-GRTS-069	NotEval			63.3677225	-152.1063767
DENA-GRTS-070	NotEval			63.5534176	-152.4546447
DENA-GRTS-071	Target		Stony Creek	63.4482432	-150.1844619
DENA-GRTS-072	NotEval			63.9960137	-150.6770436
DENA-GRTS-073	NotEval			62.8592688	-150.6857720
DENA-GRTS-074	NotEval			63.9401031	-151.9090818
DENA-GRTS-075	NotEval			63.5292092	-150.6634282
DENA-GRTS-076	NotEval		Cantwell Creek	63.3265307	-149.2824873
DENA-GRTS-077	Nontarget	Lake		63.2110176	-151.6008838
DENA-GRTS-078	NotEval		Deep Creek	63.3890626	-152.6120072
DENA-GRTS-079	NotEval		Clearwater Fork	63.7465615	-150.3224608
DENA-GRTS-080	NotEval			63.9541905	-150.6622168
DENA-GRTS-081	NotEval		Colorado Creek	63.2464183	-149.5584415
DENA-GRTS-082	NotEval			63.8568261	-151.9214253
DENA-GRTS-083	NotEval		North Fork Moose Creek	63.5408643	-150.6340606
DENA-GRTS-084	Target		Igloo Creek	63.6088700	-149.5858253
DENA-GRTS-085	NotEval		Granite Creek	62.4871030	-151.1785467
DENA-GRTS-086	NotEval		Highpower Creek	63.4998989	-152.6559457

Table 5, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
DENA-GRTS-087	NotEval		Moose Creek	63.5099823	-150.7111981
DENA-GRTS-088	NotEval		Hines Creek	63.7182557	-149.0974637
DENA-GRTS-089	NotEval		Costello Creek	63.2774339	-149.5500772
DENA-GRTS-090	NotEval		Spence Creek	63.8831961	-152.0409481
DENA-GRTS-091	NotEval		Thorofare River	63.4103771	-150.3793864
DENA-GRTS-092	NotEval		Teklanika River	63.6562264	-149.5764951
DENA-GRTS-093	NotEval		Costello Creek	63.2888652	-149.5676800
DENA-GRTS-094	NotEval		Moose Creek	63.5112236	-150.8694143
DENA-GRTS-095	NotEval			63.4315667	-150.6767637
DENA-GRTS-096	NotEval			63.7054875	-149.5445906
DENA-GRTS-097	NotEval			63.5771650	-152.3815975
DENA-GRTS-098	NotEval			63.5410929	-149.7939566
DENA-GRTS-099	NotEval		Muddy River	64.0028945	-151.7139389
DENA-GRTS-100	NotEval			63.7066038	-149.3188851
DENA-GRTS-101	NotEval			63.8017003	-151.9605963
DENA-GRTS-102	NotEval		Eureka Creek	63.5377456	-150.9316455
DENA-GRTS-103	NotEval			64.0380403	-151.6951360
DENA-GRTS-104	Target		Sanctuary River	63.7102671	-149.4802653
DENA-GRTS-105	NotEval		Herron River	63.5813742	-152.2572616
DENA-GRTS-106	NotEval			63.5331927	-149.7944862
DENA-GRTS-107	NotEval			63.9947211	-151.6470948
DENA-GRTS-108	NotEval		Savage River	63.7687901	-149.2935362
DENA-GRTS-109	NotEval			63.8433581	-151.8775422
DENA-GRTS-110	NotEval			63.6924138	-151.7631200
DENA-GRTS-111	NotEval		Muddy River	63.9931996	-151.7554406
DENA-GRTS-112	Target			63.7076812	-149.2391337
DENA-GRTS-113	NotEval			63.5785404	-152.4811152
DENA-GRTS-114	NotEval			63.5026265	-150.0301647
DENA-GRTS-115	NotEval			63.9323412	-151.7904657
DENA-GRTS-116	NotEval			63.4364204	-149.0285710
DENA-GRTS-117	NotEval			63.5956708	-152.2946977
DENA-GRTS-118	NotEval		Caribou Creek	63.6063793	-150.8176625
DENA-GRTS-119	NotEval		Muddy River	63.9801595	-151.7857706
DENA-GRTS-120	NotEval		Jenny Creek	63.7013878	-149.2132526
DENA-GRTS-121	NotEval			63.5521657	-152.6621653
DENA-GRTS-122	Target		Highway Pass Creek	63.4935351	-150.0851868
DENA-GRTS-123	NotEval			63.9255383	-151.6536652
DENA-GRTS-124	NotEval			63.4274552	-149.0757216
DENA-GRTS-125	Target		trib of Riley Creek	63.6370675	-148.9962814
DENA-GRTS-126	Target		small stream near McKinley R.	63.7910617	-151.5317054
DENA-GRTS-127	Target		Birch Creek	63.1937489	-151.3170983
DENA-GRTS-128	Target		Coffee River	62.8343674	-150.3135835
DENA-GRTS-129	Target		Toklat River	63.5112638	-149.7140738
DENA-GRTS-130	Target		trib of Muddy River	64.0294339	-151.5815727
DENA-GRTS-131	Target		small stream near Birch Cr.	63.3849365	-151.6703603
DENA-GRTS-132	Target		branch of Swift Fork	63.0410701	-152.3561201
DENA-GRTS-133	Target		trib of Kantishna River	63.9660215	-151.0355154

Table 5, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
DENA-GRTS-134	Target		Marten Creek	63.8277209	-150.4485641
DENA-GRTS-135	Target		Slippery Creek trib	63.5891005	-151.6433630
DENA-GRTS-136	Target		Foraker River trib	63.4928386	-152.0468028
DENA-GRTS-137	Target		Bear Creek	63.7049421	-151.2221914
DENA-GRTS-138	Target		trib of 4th of July Creek	62.3028366	-152.1499209
DENA-GRTS-139	Target		Bear Creek trib	63.5624074	-151.1837996
DENA-GRTS-140	Target		Highpower Creek trib	63.1690194	-152.1254844
DENA-GRTS-141	Target		Teklanika River trib	63.9578783	-149.6279848
DENA-GRTS-142	Target		small stream near McKinley R.	63.7504330	-151.5160789
DENA-GRTS-143	Target		Birch Creek trib	63.1927608	-151.2531549
DENA-GRTS-144	Target		West Branch Tokositna River	62.6703574	-150.8284082
DENA-GRTS-145	Nontarget	Too big	Muddy River	63.9273034	-152.0006393
DENA-GRTS-146	Nontarget	Too big	Kantishna River	63.9109440	-151.4285797
DENA-GRTS-147	Target		small stream near Foraker R.	63.3147394	-151.7526192
DENA-GRTS-148	Target		trib of upper Swift Fork	62.9754868	-152.1138597
DENA-GRTS-149	Target		small stream near Bearpaw R	63.9000021	-150.9767496
DENA-GRTS-150	Nontarget	Too big	East Fork Toklat River	63.8892208	-150.1087744
DENA-GRTS-151	Target		Birch Creek	63.4879099	-151.8713088
DENA-GRTS-152	NotEval		stream near Herron River	63.5706100	-152.2345785
DENA-GRTS-153	NotEval		trib of lower Moose Creek	63.8576378	-150.9410064
DENA-GRTS-154	NotEval		trib of Kichatna River	62.3350887	-152.6031423
DENA-GRTS-155	NotEval		Boundary Creek	63.5567312	-150.3335631
DENA-GRTS-156	NotEval			63.2990083	-152.1939899
DENA-GRTS-157	NotEval			63.2051728	-149.6968924
DENA-GRTS-158	NotEval			63.6882133	-151.8983851
DENA-GRTS-159	NotEval		McLeod Creek	63.3695404	-151.1825488
DENA-GRTS-160	NotEval			63.1254001	-151.6259741
DENA-GRTS-161	NotEval		Foraker River	63.8145794	-152.1095952
DENA-GRTS-162	NotEval		Wigand Creek	63.8146880	-150.0909076
DENA-GRTS-163	NotEval			63.5001232	-151.6319294
DENA-GRTS-164	NotEval			63.1446885	-152.0677332
DENA-GRTS-165	NotEval		Kantishna River	63.9844229	-151.1958409
DENA-GRTS-166	NotEval		Toklat River	63.9866781	-150.0555886
DENA-GRTS-167	NotEval			63.6033317	-151.5680442
DENA-GRTS-168	NotEval			63.5589759	-151.9545865
DENA-GRTS-169	NotEval		Flat Creek	63.6591827	-151.0071184
DENA-GRTS-170	NotEval		Granite Creek	62.5605849	-151.1690976
DENA-GRTS-171	NotEval		Sunrise Creek	63.3865174	-150.2167507
DENA-GRTS-172	NotEval			63.3464971	-152.2267869
DENA-GRTS-173	Target		Sanctuary River trib	63.5678862	-149.3030940
DENA-GRTS-174	NotEval			63.7649311	-151.8365202
DENA-GRTS-175	NotEval			63.1438201	-151.4637947
DENA-GRTS-176	NotEval			63.0971118	-151.9402448
DENA-GRTS-177	NotEval			63.6832548	-151.9642793
DENA-GRTS-178	NotEval		East Fork Toklat River	63.6000990	-149.8919574
DENA-GRTS-179	NotEval			63.5541882	-151.7156566
DENA-GRTS-180	NotEval		Jack Frost Creek	63.3590063	-152.5949864

Table 5, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
DENA-GRTS-181	NotEval			63.7899875	-151.3255123
DENA-GRTS-182	NotEval			63.9321633	-150.6025199
DENA-GRTS-183	Target		McLeod Creek	63.4203997	-151.2192023
DENA-GRTS-184	NotEval		Lonestar Creek	63.5486194	-152.8183312
DENA-GRTS-185	NotEval			63.8315353	-151.6229543
DENA-GRTS-186	NotEval			62.4347024	-151.7825577
DENA-GRTS-187	NotEval		Clearwater Creek	63.3545309	-150.7209208
DENA-GRTS-188	NotEval			63.1611444	-152.2263575
DENA-GRTS-189	NotEval			63.5678406	-149.1625056
DENA-GRTS-190	NotEval			63.8841503	-151.6011109
DENA-GRTS-191	NotEval			63.3179011	-151.8192435
DENA-GRTS-192	NotEval			63.1102195	-152.2224263
DENA-GRTS-193	NotEval			63.7790874	-149.5402970
DENA-GRTS-194	NotEval		Birch Creek	63.7468364	-151.8626196
DENA-GRTS-195	NotEval			63.2571266	-150.9820785
DENA-GRTS-196	Target		Alder Creek	62.7440634	-150.4240019
DENA-GRTS-197	NotEval		Spence Creek	63.8578843	-151.9873166
DENA-GRTS-198	NotEval			63.6469866	-150.2537087
DENA-GRTS-199	NotEval		White Creek	63.2569307	-151.8763104
DENA-GRTS-200	NotEval			63.0788436	-152.1508931
DENA-GRTS-201	NotEval			63.2629654	-149.4478079
DENA-GRTS-202	NotEval			63.6936853	-151.6852114
DENA-GRTS-203	NotEval		Iron Creek	63.3705896	-151.3368233
DENA-GRTS-204	NotEval			62.9145362	-151.9547406
DENA-GRTS-205	NotEval			63.7378613	-151.9636906
DENA-GRTS-206	NotEval		Sushana River	63.7177300	-149.7175801
DENA-GRTS-207	NotEval			63.3908218	-151.5365345
DENA-GRTS-208	NotEval			63.0211930	-152.3045981
DENA-GRTS-209	NotEval		Cantwell Creek	63.3504263	-149.3066241
DENA-GRTS-210	NotEval			63.8130144	-151.6992505
DENA-GRTS-211	NotEval			63.2944709	-151.5872611
DENA-GRTS-212	NotEval			62.6602329	-151.7214802
DENA-GRTS-213	NotEval			63.6579319	-152.0902978
DENA-GRTS-214	NotEval			63.7669585	-150.7076169
DENA-GRTS-215	NotEval			63.5911221	-151.8391331
DENA-GRTS-216	NotEval			63.4791688	-152.1862724
DENA-GRTS-217	NotEval		Bearpaw River	63.9171515	-150.8638253
DENA-GRTS-218	NotEval		Stony Creek	63.6195966	-150.2918165
DENA-GRTS-219	NotEval		White Creek	63.4398621	-151.8955169
DENA-GRTS-220	NotEval		Herron River	63.4456013	-152.3339732
DENA-GRTS-221	NotEval			63.6688540	-151.1097391
DENA-GRTS-222	NotEval			62.4275645	-152.1139935
DENA-GRTS-223	NotEval		Moose Creek	63.4585371	-150.5077382
DENA-GRTS-224	NotEval		Herron River	63.1552623	-151.9489016
DENA-GRTS-225	NotEval			63.9573067	-151.0668442
DENA-GRTS-226	NotEval			63.9422845	-149.9053813
DENA-GRTS-227	NotEval			63.5670184	-151.5311444

Table 5, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
DENA-GRTS-228	NotEval			63.5818879	-152.1096595
DENA-GRTS-229	NotEval			63.7617158	-151.0081769
DENA-GRTS-230	NotEval		West Fork Yentna River	62.6030011	-152.6013992
DENA-GRTS-231	NotEval			63.5142579	-150.5830470
DENA-GRTS-232	NotEval			63.3542650	-151.9632591
DENA-GRTS-233	NotEval			63.8817657	-151.1780423
DENA-GRTS-234	NotEval		Flume Creek	63.8946285	-150.4193677
DENA-GRTS-235	NotEval			63.5460698	-151.4993001
DENA-GRTS-236	NotEval			63.4669058	-152.6588434
DENA-GRTS-237	NotEval		Caribou Creek	63.6383314	-150.9354432
DENA-GRTS-238	NotEval			62.4028367	-151.8993483
DENA-GRTS-239	NotEval		Glacier Creek	63.3077880	-150.3209158
DENA-GRTS-240	NotEval			63.3281999	-152.4667563
DENA-GRTS-241	NotEval			63.7903633	-151.1304257
DENA-GRTS-242	NotEval			62.3035827	-152.4055609
DENA-GRTS-243	NotEval		Glacier Creek	63.6088054	-150.9402543
DENA-GRTS-244	NotEval			63.2524941	-151.9860547
DENA-GRTS-245	NotEval			63.8306775	-151.3863847
DENA-GRTS-246	NotEval		Cripple Creek	62.5603567	-151.5436764
DENA-GRTS-247	NotEval			63.2839415	-149.9152947
DENA-GRTS-248	NotEval			63.2590924	-152.3006064

Table 6. GRTS site list for Wrangell-St. Elias NP&P. Under “EvalStatus”, Sites are listed as either “Target”, “Nontarget” or “NotEval.” “NotEval” indicates the site has yet to be fully evaluated, either with remotely sensed imagery or in the field. “EvalReason” gives the reason a site was designated Nontarget. The reasons listed are Lake, Private (on private land), Too big (unsafe), Doesn’t exist , and No access (can’t land helicopter or otherwise get access to site). “Name” refers to the attributed name from the National Hydrography Dataset (NHD) or a name provided by the CAKN in cases where sites have already been sampled; not all segments have names in the NHD. WRST-GRTS-001 through WRST-GRTS-200 is the Accessible stratum. WRST-GRTS-201 through WRST-GRTS-400 is the Inaccessible stratum. Latitude and longitude are NAD83, and are given in digital minutes.

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-001	Not Eval			W140° 00.35818'	N59° 49.77762'
WRST-GRTS-002	Target		Jack Creek	W143° 00.6279'	N62° 25.55238'
WRST-GRTS-003	Nontarget	Private		W145° 17.92046'	N62° 16.86603'
WRST-GRTS-004	Target		Notch Creek trib	W142° 18.94255'	N62° 11.67273'
WRST-GRTS-005	Nontarget	Private		W144° 03.43723'	N62° 41.79337'
WRST-GRTS-006	Target		Sanford River trib	W144° 37.81688'	N62° 14.2154'
WRST-GRTS-007	Nontarget	Lake		W142° 59.47656'	N61° 20.16287'
WRST-GRTS-008	Target		McCarthy Creek	W142° 47.15217'	N61° 29.734'
WRST-GRTS-009	Nontarget	Private		W143° 28.26518'	N62° 25.02145'
WRST-GRTS-010	Target			W143° 37.83166'	N62° 20.24128'
WRST-GRTS-011	Nontarget	Lake		W140° 53.24992'	N59° 47.31853'
WRST-GRTS-012	Target		Bryan Creek	W141° 55.23408'	N62° 01.3986'
WRST-GRTS-013	Target			W143° 42.8833'	N62° 28.74776'
WRST-GRTS-014	Nontarget	Private	Nugget Creek	W143° 43.92598'	N61° 38.64549'
WRST-GRTS-015	Nontarget	Too big	Jacksina Creek	W142° 54.13438'	N62° 20.04394'
WRST-GRTS-016	Nontarget	Lake		W143° 32.64807'	N61° 11.60936'
WRST-GRTS-017	Nontarget	Lake		W140° 11.162'	N59° 44.18306'
WRST-GRTS-018	Target		Jack Creek trib	W143° 07.07264'	N62° 27.01548'
WRST-GRTS-019	Nontarget	Lake		W142° 51.68853'	N60° 52.98009'
WRST-GRTS-020	Target		Notch Creek	W142° 20.89741'	N62° 12.18147'
WRST-GRTS-021	Target		Caribou Creek	W143° 35.66389'	N62° 35.71882'
WRST-GRTS-022	Nontarget	Private		W144° 14.94282'	N61° 39.44002'
WRST-GRTS-023	Nontarget	Private		W143° 18.38982'	N61° 22.26942'
WRST-GRTS-024	Target			W141° 42.04037'	N62° 01.13603'
WRST-GRTS-025	Nontarget	Too big		W143° 40.86685'	N62° 33.1378'
WRST-GRTS-026	Target			W143° 22.06784'	N62° 15.21048'
WRST-GRTS-027	Nontarget	Lake		W140° 59.03814'	N60° 07.9812'
WRST-GRTS-028	Target		Beaver Creek	W141° 23.99539'	N61° 59.62819'
WRST-GRTS-029	Target			W143° 21.6615'	N62° 26.15299'
WRST-GRTS-030	Target		Strelina Creek	W144° 01.6681'	N61° 33.57514'
WRST-GRTS-031	Target		Platinum Creek	W142° 54.01128'	N62° 29.64642'
WRST-GRTS-032	Target		Crystal Creek	W143° 27.44807'	N61° 21.66522'
WRST-GRTS-033	Nontarget	Lake		W140° 00.90778'	N59° 46.61547'
WRST-GRTS-034	Not Eval			W144° 47.50757'	N62° 29.32416'
WRST-GRTS-035	Nontarget	Doesn't exist		W141° 54.24388'	N61° 07.62072'
WRST-GRTS-036	Target		Solo Creek trib	W141° 45.29238'	N61° 47.30439'
WRST-GRTS-037	Target		Tanada Creek	W143° 44.79083'	N62° 36.32088'
WRST-GRTS-038	Nontarget	Too big		W144° 15.3577'	N61° 43.41113'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-039	Nontarget	Too big		W142° 46.09226'	N61° 21.82677'
WRST-GRTS-040	Target		Bryan Creek	W142° 02.41739'	N62° 02.44483'
WRST-GRTS-041	Nontarget	Too big		W143° 38.73262'	N62° 30.29827'
WRST-GRTS-042	Target		Rock Creek	W143° 56.96734'	N61° 41.75801'
WRST-GRTS-043	Target			W141° 09.16431'	N61° 50.16893'
WRST-GRTS-044	Nontarget	Too big		W144° 31.69161'	N61° 01.8163'
WRST-GRTS-045	Target		Lost Creek	W143° 09.2958'	N62° 32.88134'
WRST-GRTS-046	Target			W145° 20.75578'	N62° 06.55718'
WRST-GRTS-047	Nontarget	Doesn't exist		W142° 40.26546'	N62° 24.72947'
WRST-GRTS-048	Nontarget	Lake		W144° 14.19124'	N61° 12.6983'
WRST-GRTS-049	Nontarget	Private		W144° 44.65705'	N62° 29.83769'
WRST-GRTS-050	Target			W144° 33.50928'	N62° 13.19899'
WRST-GRTS-051	Nontarget	Lake		W142° 59.02975'	N61° 12.07838'
WRST-GRTS-052	Nontarget	Too big		W142° 21.26336'	N61° 28.6583'
WRST-GRTS-053	Target		Trail Creek	W143° 16.17033'	N62° 35.75674'
WRST-GRTS-054	Target		Black Mtn East	W143° 42.94948'	N62° 17.3895'
WRST-GRTS-055	Not Eval			W142° 44.54569'	N61° 26.31753'
WRST-GRTS-056	Target			W141° 21.54268'	N61° 58.5118'
WRST-GRTS-057	Nontarget	Too big		W143° 41.96984'	N62° 24.68983'
WRST-GRTS-058	Not Eval		Sheep Creek	W143° 50.45429'	N61° 33.96058'
WRST-GRTS-059	Target		Little Creek	W141° 07.65791'	N62° 02.62097'
WRST-GRTS-060	Target			W143° 56.67308'	N61° 27.75193'
WRST-GRTS-061	Nontarget	Lake		W143° 20.49462'	N62° 30.44023'
WRST-GRTS-062	Target			W144° 54.13368'	N62° 25.28902'
WRST-GRTS-063	Target		Bond Creek	W142° 49.65167'	N62° 16.15784'
WRST-GRTS-064	Nontarget	Doesn't exist		W144° 16.7042'	N61° 30.7376'
WRST-GRTS-065	Not Eval			W143° 24.45428'	N62° 35.13796'
WRST-GRTS-066	Target			W144° 33.19324'	N62° 15.53053'
WRST-GRTS-067	Nontarget	Lake		W142° 59.32852'	N61° 20.40181'
WRST-GRTS-068	Target		Glacier Creek	W142° 22.83222'	N61° 27.16387'
WRST-GRTS-069	Target		Goat Creek	W143° 22.10933'	N62° 22.43543'
WRST-GRTS-070	Nontarget	Private		W144° 07.46666'	N61° 35.1954'
WRST-GRTS-071	Target			W142° 40.56304'	N62° 25.58682'
WRST-GRTS-072	Nontarget	Private		W143° 44.06434'	N61° 25.95352'
WRST-GRTS-073	Target		Natal Creek	W143° 38.8013'	N62° 38.3796'
WRST-GRTS-074	Nontarget	Private		W144° 06.41471'	N61° 43.99264'
WRST-GRTS-075	Nontarget	Too big		W143° 15.61643'	N61° 21.2076'
WRST-GRTS-076	Nontarget	Private		W141° 51.25759'	N62° 05.34395'
WRST-GRTS-077	Target			W143° 12.34963'	N62° 31.4532'
WRST-GRTS-078	Not Eval			W145° 22.47'	N62° 08.43844'
WRST-GRTS-079	Target		Cooper Creek	W142° 36.1746'	N62° 22.38278'
WRST-GRTS-080	Not Eval		Crystal Creek	W143° 23.71102'	N61° 23.26771'
WRST-GRTS-081	Nontarget	Too big		W140° 19.70504'	N59° 42.31798'
WRST-GRTS-082	Nontarget	Private		W144° 50.63835'	N62° 02.74121'
WRST-GRTS-083	Target			W142° 15.95584'	N61° 11.78271'
WRST-GRTS-084	Nontarget	Too big		W142° 12.7719'	N61° 31.53076'
WRST-GRTS-085	Target			W143° 39.90403'	N62° 39.92102'
WRST-GRTS-086	Nontarget	Too big		W144° 34.70639'	N61° 58.76491'
WRST-GRTS-087	Nontarget	Doesn't exist		W142° 42.02362'	N61° 22.1272'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-088	Target		Bryan Creek	W142° 01.1318'	N62° 02.37669'
WRST-GRTS-089	Not Eval			W143° 37.37053'	N62° 31.1056'
WRST-GRTS-090	Not Eval		Kluvesna River	W143° 56.92968'	N61° 44.55213'
WRST-GRTS-091	Nontarget	Lake		W141° 15.48338'	N61° 47.84233'
WRST-GRTS-092	Nontarget	Private		W143° 46.2773'	N61° 28.45769'
WRST-GRTS-093	Target		Chalk Creek	W143° 10.05098'	N62° 30.04753'
WRST-GRTS-094	Not Eval			W144° 57.91566'	N62° 04.34108'
WRST-GRTS-095	Target			W141° 59.27546'	N62° 22.92047'
WRST-GRTS-096	Target			W144° 08.73132'	N61° 18.35937'
WRST-GRTS-097	Nontarget	Private		W144° 33.61107'	N62° 35.39496'
WRST-GRTS-098	Target			W144° 38.16122'	N62° 13.73327'
WRST-GRTS-099	Nontarget	Too big		W142° 57.29617'	N61° 25.51371'
WRST-GRTS-100	Target		Toby Creek	W142° 18.1667'	N61° 29.00986'
WRST-GRTS-101	Target		Rock Creek	W143° 27.14532'	N62° 33.79971'
WRST-GRTS-102	Nontarget	Too big		W143° 41.72703'	N62° 18.3338'
WRST-GRTS-103	Nontarget	Doesn't exist		W142° 38.02917'	N61° 21.12619'
WRST-GRTS-104	Not Eval		Geohenda Creek	W141° 58.58799'	N61° 56.27983'
WRST-GRTS-105	Nontarget	Too big		W143° 41.69798'	N62° 24.2598'
WRST-GRTS-106	Target		Trail Creek	W143° 44.21888'	N61° 35.48923'
WRST-GRTS-107	Target			W142° 02.63339'	N62° 22.27706'
WRST-GRTS-108	Nontarget	Private		W144° 04.01803'	N61° 30.53543'
WRST-GRTS-109	Nontarget	Lake		W143° 15.79129'	N62° 30.91761'
WRST-GRTS-110	Nontarget	Private		W144° 52.73997'	N62° 24.3988'
WRST-GRTS-111	Nontarget	Too big		W142° 54.13194'	N62° 16.51737'
WRST-GRTS-112	Nontarget	Private		W144° 30.13025'	N61° 23.94286'
WRST-GRTS-113	Nontarget	Lake		W140° 04.61784'	N59° 50.20303'
WRST-GRTS-114	Target			W142° 57.28939'	N62° 24.78023'
WRST-GRTS-115	Not Eval			W145° 18.86491'	N62° 02.41076'
WRST-GRTS-116	Target		Notch Creek	W142° 27.78111'	N62° 14.74318'
WRST-GRTS-117	Target			W143° 28.31355'	N62° 36.05651'
WRST-GRTS-118	Target			W144° 34.20716'	N62° 14.12986'
WRST-GRTS-119	Not Eval			W143° 06.98147'	N61° 23.91512'
WRST-GRTS-120	Target		Chathenda Creek	W141° 46.8728'	N62° 05.98048'
WRST-GRTS-121	Target			W143° 27.01575'	N62° 27.48529'
WRST-GRTS-122	Target		Goat Creek	W143° 22.91697'	N62° 19.42246'
WRST-GRTS-123	Not Eval			W141° 00.5384'	N59° 46.76465'
WRST-GRTS-124	Target			W141° 38.64419'	N62° 00.89719'
WRST-GRTS-125	Nontarget	Lake		W143° 21.89473'	N62° 23.4577'
WRST-GRTS-126	Target		Strelna Cr	W143° 56.03714'	N61° 35.99672'
WRST-GRTS-127	Nontarget	Too big		W142° 40.43243'	N62° 26.88567'
WRST-GRTS-128	Nontarget	Too big		W143° 43.30043'	N61° 24.68916'
WRST-GRTS-129	Nontarget	Lake		W140° 14.1285'	N59° 46.97'
WRST-GRTS-130	Target		Jack Creek	W143° 04.94145'	N62° 27.32538'
WRST-GRTS-131	Target			W142° 59.1159'	N60° 48.68962'
WRST-GRTS-132	Nontarget	Lake		W142° 03.42279'	N61° 37.55042'
WRST-GRTS-133	Not Eval		Caribou Creek	W143° 45.54862'	N62° 36.74042'
WRST-GRTS-134	Nontarget	Too big		W144° 08.25117'	N61° 42.8707'
WRST-GRTS-135	Target		Chitutu Creek	W142° 36.34017'	N61° 17.82005'
WRST-GRTS-136	Target		Glacier Creek	W141° 51.87278'	N62° 07.10951'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-137	Target			W143° 39.3687'	N62° 34.74177'
WRST-GRTS-138	Target		Pass Creek	W143° 17.22174'	N62° 17.9367'
WRST-GRTS-139	Not Eval			W141° 13.16766'	N60° 07.04707'
WRST-GRTS-140	Target		Beaver Creek	W141° 17.40835'	N61° 59.00718'
WRST-GRTS-141	Not Eval			W143° 14.23953'	N62° 32.76919'
WRST-GRTS-142	Target			W144° 58.21125'	N62° 15.19111'
WRST-GRTS-143	Target		Ninemile Creek	W142° 32.68164'	N62° 19.86393'
WRST-GRTS-144	Nontarget	Too big		W143° 24.82676'	N61° 21.72253'
WRST-GRTS-145	Target		Platinum Creek	W143° 02.87591'	N62° 34.97959'
WRST-GRTS-146	Not Eval		Cheshnina River	W144° 17.41302'	N61° 48.39109'
WRST-GRTS-147	Nontarget	Too big		W142° 39.88948'	N61° 23.03967'
WRST-GRTS-148	Nontarget	Lake		W141° 22.24862'	N61° 47.21962'
WRST-GRTS-149	Target		Tanada Creek	W143° 20.14716'	N62° 29.23736'
WRST-GRTS-150	Nontarget	Private		W145° 15.12689'	N62° 10.06664'
WRST-GRTS-151	Nontarget	Doesn't exist		W142° 55.51025'	N61° 59.97591'
WRST-GRTS-152	Target		Golconda Creek	W143° 26.49555'	N61° 00.94528'
WRST-GRTS-153	Nontarget	Lake		W143° 28.17992'	N62° 31.43746'
WRST-GRTS-154	Target			W143° 39.66415'	N62° 21.82395'
WRST-GRTS-155	Target		Sheep Gulch	W142° 30.65668'	N61° 19.56675'
WRST-GRTS-156	Target			W142° 01.23288'	N62° 01.94214'
WRST-GRTS-157	Target		Trail Creek	W143° 14.7795'	N62° 33.63365'
WRST-GRTS-158	Nontarget	Too big		W144° 53.86934'	N62° 17.34507'
WRST-GRTS-159	Nontarget	Too big		W142° 54.26822'	N62° 15.73343'
WRST-GRTS-160	Target			W144° 23.1546'	N61° 10.4265'
WRST-GRTS-161	Not Eval			W140° 08.35434'	N59° 51.08007'
WRST-GRTS-162	Target			W143° 07.32058'	N62° 33.13927'
WRST-GRTS-163	Target			W141° 23.90479'	N60° 58.07819'
WRST-GRTS-164	Target		Cooper Creek	W142° 30.11853'	N62° 17.37478'
WRST-GRTS-165	Nontarget	Lake		W143° 32.39133'	N62° 25.51291'
WRST-GRTS-166	Target			W143° 21.99076'	N62° 17.88901'
WRST-GRTS-167	Nontarget	Too big		W140° 51.29035'	N59° 44.97341'
WRST-GRTS-168	Target		Beaver Creek	W141° 29.74175'	N61° 59.74273'
WRST-GRTS-169	Nontarget	Doesn't exist		W140° 17.64586'	N59° 47.06106'
WRST-GRTS-170	Target			W142° 57.57213'	N62° 30.77557'
WRST-GRTS-171	Nontarget	No access		W142° 24.18343'	N61° 08.98981'
WRST-GRTS-172	Not Eval			W141° 47.92069'	N61° 46.9318'
WRST-GRTS-173	Nontarget	Too big		W143° 47.6662'	N62° 32.40627'
WRST-GRTS-174	Target			W143° 22.45631'	N61° 31.55985'
WRST-GRTS-175	Target		Ptarmigan Creek	W141° 08.69787'	N61° 52.35575'
WRST-GRTS-176	Target		Snag Creek	W141° 30.50675'	N62° 11.48652'
WRST-GRTS-177	Not Eval			W139° 45.37095'	N59° 53.57222'
WRST-GRTS-178	Target			W144° 31.28863'	N62° 11.4842'
WRST-GRTS-179	Nontarget	Too big		W142° 52.19487'	N61° 12.69044'
WRST-GRTS-180	Nontarget	Too big		W142° 14.28476'	N61° 31.21979'
WRST-GRTS-181	Target			W143° 43.55279'	N62° 33.37823'
WRST-GRTS-182	Nontarget	Private		W143° 47.3449'	N61° 34.95297'
WRST-GRTS-183	Target			W141° 12.66469'	N61° 50.44517'
WRST-GRTS-184	Target		Chokosna R	W143° 44.73992'	N61° 26.56977'
WRST-GRTS-185	Nontarget	Too big		W143° 48.49215'	N62° 37.49476'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-186	Nontarget	Too big		W144° 46.86784'	N62° 17.27721'
WRST-GRTS-187	Nontarget	Private		W142° 54.37079'	N61° 25.63418'
WRST-GRTS-188	Nontarget	Lake		W142° 27.55308'	N61° 36.50058'
WRST-GRTS-189	Target		Caribou Creek	W143° 31.25035'	N62° 34.50374'
WRST-GRTS-190	Target			W143° 49.50205'	N62° 19.4214'
WRST-GRTS-191	Target		Chitutu Creek	W142° 39.87923'	N61° 19.96238'
WRST-GRTS-192	Not Eval		Geohenda Creek	W141° 57.96285'	N61° 54.55843'
WRST-GRTS-193	Target			W143° 38.15449'	N62° 28.95505'
WRST-GRTS-194	Nontarget	Doesn't exist		W143° 46.10246'	N61° 35.64927'
WRST-GRTS-195	Not Eval		Jack Creek	W142° 53.73239'	N62° 23.21441'
WRST-GRTS-196	Nontarget	Too big		W143° 58.32132'	N61° 32.33964'
WRST-GRTS-197	Not Eval			W143° 06.83026'	N62° 25.4722'
WRST-GRTS-198	Nontarget	Too big		W145° 05.47653'	N62° 16.2692'
WRST-GRTS-199	Target		Nikonda Creek	W142° 51.33071'	N62° 11.11822'
WRST-GRTS-200	Nontarget	Lake		W144° 22.11061'	N61° 11.15322'
WRST-GRTS-201	Not Eval			W141° 00.80472'	N59° 48.15811'
WRST-GRTS-202	Target			W144° 40.55324'	N62° 19.21487'
WRST-GRTS-203	Nontarget	Too big		W143° 31.32625'	N61° 20.73611'
WRST-GRTS-204	Target			W142° 43.18411'	N60° 55.14528'
WRST-GRTS-205	Target			W144° 00.53716'	N62° 32.73254'
WRST-GRTS-206	Not Eval		Carden Creek	W141° 05.11972'	N62° 16.66655'
WRST-GRTS-207	Nontarget	Too big		W144° 36.95709'	N61° 50.95615'
WRST-GRTS-208	Target		Holmes Creek	W141° 19.94149'	N61° 39.63858'
WRST-GRTS-209	Nontarget	Lake		W144° 02.16949'	N62° 39.30304'
WRST-GRTS-210	Nontarget	Doesn't exist		W141° 28.72675'	N61° 45.3236'
WRST-GRTS-211	Nontarget	Private		W144° 32.08011'	N61° 22.80338'
WRST-GRTS-212	Nontarget	Too big		W142° 13.39708'	N61° 10.94757'
WRST-GRTS-213	Target		Canyon Creek	W143° 08.55827'	N62° 22.13539'
WRST-GRTS-214	Target		Bow Creek	W142° 02.84531'	N61° 59.26739'
WRST-GRTS-215	Target			W144° 47.07718'	N61° 57.56991'
WRST-GRTS-216	Nontarget	Too big		W142° 40.82347'	N61° 15.02613'
WRST-GRTS-217	Target			W142° 57.82942'	N62° 07.73679'
WRST-GRTS-218	Nontarget	Too big		W141° 51.69386'	N62° 28.57163'
WRST-GRTS-219	Target			W143° 06.11938'	N61° 13.56131'
WRST-GRTS-220	Target			W142° 34.22832'	N60° 54.23598'
WRST-GRTS-221	Nontarget	Too big		W143° 57.68502'	N62° 41.60657'
WRST-GRTS-222	Target		Brian Creek	W141° 41.68993'	N62° 18.11686'
WRST-GRTS-223	Target		Sheep Gulch	W144° 27.1729'	N61° 57.16724'
WRST-GRTS-224	Target		Clear Stream	W142° 00.42094'	N61° 06.60106'
WRST-GRTS-225	Target			W144° 29.48459'	N62° 01.62091'
WRST-GRTS-226	Target		Carl Creek	W141° 35.31661'	N62° 02.41424'
WRST-GRTS-227	Not Eval			W144° 33.56978'	N61° 17.91262'
WRST-GRTS-228	Target		Hunter Creek	W142° 36.21473'	N61° 05.96216'
WRST-GRTS-229	Nontarget	Too big		W142° 47.09143'	N62° 25.3791'
WRST-GRTS-230	Target			W142° 04.40982'	N62° 03.69341'
WRST-GRTS-231	Not Eval			W143° 37.70149'	N60° 55.99487'
WRST-GRTS-232	Target			W142° 13.37609'	N61° 27.34089'
WRST-GRTS-233	Target			W143° 38.16599'	N62° 10.10284'
WRST-GRTS-234	Target			W142° 17.25556'	N62° 20.26309'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-235	Target			W143° 57.09709'	N61° 08.00623'
WRST-GRTS-236	Target		Granite Creek	W142° 16.92127'	N60° 43.57083'
WRST-GRTS-237	Nontarget	Doesn't exist		W144° 09.66281'	N62° 33.20889'
WRST-GRTS-238	Nontarget	Too big		W141° 17.54848'	N62° 21.0778'
WRST-GRTS-239	Nontarget	Too big		W143° 58.40802'	N61° 29.64387'
WRST-GRTS-240	Not Eval		East Fork Kiagna River	W142° 13.20263'	N60° 58.13284'
WRST-GRTS-241	Target			W144° 27.9124'	N62° 20.1644'
WRST-GRTS-242	Target		Beaver Creek	W141° 09.35398'	N61° 59.86195'
WRST-GRTS-243	Nontarget	Too big		W144° 04.42081'	N61° 24.90951'
WRST-GRTS-244	Target			W142° 19.43199'	N61° 07.95799'
WRST-GRTS-245	Not Eval			W144° 38.11181'	N62° 28.39134'
WRST-GRTS-246	Target		Monahan Creek	W143° 20.73815'	N61° 00.48617'
WRST-GRTS-247	Target			W143° 15.56532'	N60° 55.4336'
WRST-GRTS-248	Nontarget	Too big		W142° 30.93391'	N61° 34.29054'
WRST-GRTS-249	Nontarget	Doesn't exist		W143° 45.41864'	N62° 28.56703'
WRST-GRTS-250	Target		Edge Creek	W141° 54.40669'	N62° 21.71412'
WRST-GRTS-251	Target		Hanagita River	W143° 40.62001'	N61° 12.91222'
WRST-GRTS-252	Nontarget	Doesn't exist		W141° 47.00528'	N61° 40.70809'
WRST-GRTS-253	Not Eval			W144° 26.82105'	N62° 37.47318'
WRST-GRTS-254	Nontarget	Too big		W141° 34.6815'	N62° 28.99097'
WRST-GRTS-255	Target		Fall Creek	W143° 12.73597'	N61° 27.59485'
WRST-GRTS-256	Nontarget	Too big		W141° 42.38191'	N61° 00.70222'
WRST-GRTS-257	Target			W143° 40.43805'	N62° 20.96253'
WRST-GRTS-258	Nontarget	Too big		W141° 06.83051'	N61° 53.53327'
WRST-GRTS-259	Nontarget	Private		W144° 46.57756'	N61° 47.09935'
WRST-GRTS-260	Nontarget	Doesn't exist		W142° 47.07588'	N61° 05.98707'
WRST-GRTS-261	Nontarget	Private		W144° 55.41166'	N62° 04.14911'
WRST-GRTS-262	Target		Klu River	W143° 26.15107'	N61° 08.53945'
WRST-GRTS-263	Nontarget	Too big		W144° 08.80527'	N60° 59.69047'
WRST-GRTS-264	Target		Frederika Creek	W142° 11.8752'	N61° 41.30593'
WRST-GRTS-265	Nontarget	Lake		W143° 48.16982'	N62° 31.22519'
WRST-GRTS-266	Not Eval		Cottonwood Creek	W141° 14.95616'	N62° 11.93426'
WRST-GRTS-267	Not Eval		Dadina River	W144° 38.8234'	N61° 55.8218'
WRST-GRTS-268	Not Eval		Traver Creek	W141° 04.63622'	N61° 38.33719'
WRST-GRTS-269	Nontarget	Lake		W143° 11.69741'	N62° 33.01547'
WRST-GRTS-270	Target		Chavolda Creek	W141° 57.9882'	N62° 07.65613'
WRST-GRTS-271	Target			W144° 52.93678'	N61° 57.96501'
WRST-GRTS-272	Nontarget	Too big		W142° 57.21748'	N61° 22.34526'
WRST-GRTS-273	Target			W143° 58.49077'	N62° 36.91347'
WRST-GRTS-274	Not Eval			W141° 22.66556'	N62° 11.71908'
WRST-GRTS-275	Not Eval			W144° 27.51935'	N61° 51.65611'
WRST-GRTS-276	Target		Granite Creek	W141° 50.67206'	N60° 59.16839'
WRST-GRTS-277	Target			W144° 38.71898'	N62° 29.40945'
WRST-GRTS-278	Not Eval			W142° 33.85365'	N62° 04.59016'
WRST-GRTS-279	Nontarget	Too big		W143° 53.06883'	N60° 59.13602'
WRST-GRTS-280	Nontarget	No access		W142° 19.07721'	N61° 30.13414'
WRST-GRTS-281	Target			W143° 28.48272'	N62° 16.77139'
WRST-GRTS-282	Not Eval			W142° 20.37405'	N62° 23.98849'
WRST-GRTS-283	Target		Sangaina Creek	W143° 56.78439'	N61° 10.59073'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-284	Not Eval			W142° 04.46165'	N60° 44.17441'
WRST-GRTS-285	Target			W144° 28.20687'	N62° 27.12487'
WRST-GRTS-286	Not Eval		Snag Creek	W141° 02.04241'	N62° 25.2827'
WRST-GRTS-287	Not Eval		Rock Creek	W143° 56.49596'	N61° 40.56059'
WRST-GRTS-288	Target			W141° 59.84262'	N61° 06.40716'
WRST-GRTS-289	Target		Sheep Glacier strm trib	W144° 20.0096'	N62° 19.36104'
WRST-GRTS-290	Not Eval		Baultoff Creek	W141° 01.90579'	N62° 05.33081'
WRST-GRTS-291	Nontarget	Private		W144° 22.26933'	N61° 22.66177'
WRST-GRTS-292	Not Eval			W142° 36.35999'	N60° 59.78844'
WRST-GRTS-293	Not Eval		Boulder Creek	W144° 31.44207'	N62° 35.19367'
WRST-GRTS-294	Not Eval			W143° 09.9593'	N61° 07.0473'
WRST-GRTS-295	Not Eval			W143° 26.76725'	N60° 57.34614'
WRST-GRTS-296	Target			W142° 41.72294'	N61° 36.80185'
WRST-GRTS-297	Not Eval			W144° 00.4397'	N62° 22.73814'
WRST-GRTS-298	Not Eval			W142° 02.87735'	N62° 17.54024'
WRST-GRTS-299	Not Eval		Kluvesna River	W143° 55.05496'	N61° 45.81893'
WRST-GRTS-300	Nontarget	Too big		W141° 39.31035'	N61° 42.00202'
WRST-GRTS-301	Not Eval			W144° 16.66174'	N62° 32.65959'
WRST-GRTS-302	Target		trib of NF White R.	W141° 44.27972'	N61° 51.50809'
WRST-GRTS-303	Nontarget	Lake		W143° 45.1353'	N61° 45.96872'
WRST-GRTS-304	Not Eval			W141° 45.31535'	N60° 56.13388'
WRST-GRTS-305	Target			W143° 53.65786'	N62° 17.98726'
WRST-GRTS-306	Not Eval			W141° 25.51754'	N61° 47.58958'
WRST-GRTS-307	Nontarget	Private		W145° 05.88098'	N61° 59.10739'
WRST-GRTS-308	Nontarget	Doesn't exist		W142° 45.18111'	N61° 08.20079'
WRST-GRTS-309	Nontarget	Private		W144° 47.56943'	N62° 01.25874'
WRST-GRTS-310	Target			W143° 47.9396'	N61° 16.37638'
WRST-GRTS-311	Not Eval			W144° 05.87053'	N60° 55.72333'
WRST-GRTS-312	Not Eval		Lucia Stream	W139° 55.30224'	N59° 57.99333'
WRST-GRTS-313	Not Eval			W143° 12.9205'	N62° 03.24551'
WRST-GRTS-314	Nontarget	No access		W144° 42.04099'	N62° 19.64045'
WRST-GRTS-315	Not Eval		Dora Creek	W143° 49.82998'	N61° 23.46237'
WRST-GRTS-316	Nontarget	Too big		W142° 55.56228'	N60° 53.27733'
WRST-GRTS-317	Nontarget	Too big		W143° 45.42344'	N62° 23.45822'
WRST-GRTS-318	Not Eval		Ivereson Creek	W141° 08.85595'	N62° 09.86231'
WRST-GRTS-319	Not Eval		Chichokna River	W144° 28.13158'	N61° 56.5358'
WRST-GRTS-320	Not Eval		Cub Creek	W141° 11.42882'	N61° 40.81065'
WRST-GRTS-321	Not Eval			W144° 17.03249'	N62° 41.80264'
WRST-GRTS-322	Not Eval		NF White River	W141° 36.48298'	N61° 47.75428'
WRST-GRTS-323	Not Eval			W144° 04.48213'	N61° 08.57919'
WRST-GRTS-324	Target		Young Creek	W142° 20.40757'	N61° 12.30428'
WRST-GRTS-325	Target		Jacksina Creek	W143° 03.69892'	N62° 19.10055'
WRST-GRTS-326	Nontarget	Too big		W142° 05.33126'	N62° 11.29554'
WRST-GRTS-327	Nontarget	Too big		W143° 48.33273'	N60° 56.4455'
WRST-GRTS-328	Nontarget	Too big		W142° 44.62193'	N61° 17.12395'
WRST-GRTS-329	Target		Tumble Creek	W143° 23.33931'	N62° 10.97282'
WRST-GRTS-330	Nontarget	Too big		W141° 53.83373'	N62° 26.39705'
WRST-GRTS-331	Nontarget	Too big		W143° 23.15111'	N61° 20.39606'
WRST-GRTS-332	Not Eval		Kiagna R.	W142° 19.51231'	N60° 50.37936'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-333	Not Eval			W144° 13.63152'	N62° 33.87143'
WRST-GRTS-334	Not Eval		Brian Creek	W141° 39.91797'	N62° 22.39567'
WRST-GRTS-335	Nontarget	Private		W144° 23.1279'	N61° 34.93292'
WRST-GRTS-336	Not Eval		Goat Creek	W141° 55.0072'	N60° 54.50512'
WRST-GRTS-337	Target			W144° 33.50667'	N62° 02.95219'
WRST-GRTS-338	Not Eval		Gravel Creek	W141° 07.58518'	N62° 03.94745'
WRST-GRTS-339	Not Eval		Tebay R.	W144° 02.85554'	N61° 18.00906'
WRST-GRTS-340	Not Eval			W142° 26.33392'	N61° 00.24205'
WRST-GRTS-341	Not Eval			W144° 41.12432'	N62° 26.66467'
WRST-GRTS-342	Not Eval		William Creek	W142° 24.71469'	N62° 12.49887'
WRST-GRTS-343	Not Eval			W143° 45.52222'	N60° 50.22172'
WRST-GRTS-344	Not Eval			W142° 37.28029'	N61° 33.36556'
WRST-GRTS-345	Target			W144° 04.61375'	N62° 28.35224'
WRST-GRTS-346	Nontarget	Lake		W141° 21.05686'	N62° 25.20772'
WRST-GRTS-347	Target		Lakina River	W143° 22.94699'	N61° 32.05283'
WRST-GRTS-348	Not Eval			W141° 23.25392'	N60° 53.61276'
WRST-GRTS-349	Nontarget	Private		W145° 10.77163'	N62° 05.48111'
WRST-GRTS-350	Nontarget	Too big		W143° 19.18129'	N61° 10.511'
WRST-GRTS-351	Nontarget	Too big		W144° 35.64595'	N60° 59.73121'
WRST-GRTS-352	Target			W142° 25.30822'	N61° 39.21736'
WRST-GRTS-353	Not Eval			W144° 08.1506'	N62° 41.27554'
WRST-GRTS-354	Not Eval		Ophir Creek	W141° 31.87169'	N61° 57.2005'
WRST-GRTS-355	Target			W143° 34.00423'	N61° 32.27447'
WRST-GRTS-356	Target		Copper Creek	W142° 23.93746'	N61° 19.92233'
WRST-GRTS-357	Not Eval			W144° 59.26819'	N62° 12.61545'
WRST-GRTS-358	Nontarget	Too big		W143° 32.91549'	N61° 18.8386'
WRST-GRTS-359	Nontarget	Too big		W144° 24.25803'	N61° 01.56182'
WRST-GRTS-360	Not Eval			W140° 39.25209'	N60° 07.67833'
WRST-GRTS-361	Target		Jacksina Creek	W143° 04.98825'	N62° 18.45945'
WRST-GRTS-362	Target			W144° 38.28876'	N62° 18.4269'
WRST-GRTS-363	Nontarget	No access		W143° 16.4531'	N61° 16.64722'
WRST-GRTS-364	Nontarget	Doesn't exist		W142° 58.52826'	N60° 53.32426'
WRST-GRTS-365	Not Eval			W144° 15.26793'	N62° 39.06141'
WRST-GRTS-366	Not Eval		Ophir Creek	W141° 31.39598'	N61° 57.59893'
WRST-GRTS-367	Not Eval			W144° 24.07425'	N61° 10.21375'
WRST-GRTS-368	Nontarget	Too big		W142° 27.05409'	N61° 07.62573'
WRST-GRTS-369	Target			W143° 22.25868'	N62° 09.42976'
WRST-GRTS-370	Target			W142° 34.21159'	N62° 26.11219'
WRST-GRTS-371	Target			W143° 04.93493'	N61° 19.42159'
WRST-GRTS-372	Target			W142° 44.02304'	N60° 47.96355'
WRST-GRTS-373	Not Eval			W143° 49.39291'	N62° 07.84278'
WRST-GRTS-374	Nontarget	Too big		W141° 06.5651'	N61° 58.54821'
WRST-GRTS-375	Target		Bridge Cr	W144° 08.28254'	N61° 18.08173'
WRST-GRTS-376	Not Eval		Kiagna R.	W142° 20.06316'	N60° 57.52395'
WRST-GRTS-377	Not Eval			W143° 18.09468'	N62° 03.08394'
WRST-GRTS-378	Target			W142° 03.99132'	N62° 26.33889'
WRST-GRTS-379	Target		Hanagita R	W143° 45.46104'	N61° 13.53649'
WRST-GRTS-380	Not Eval			W141° 00.67242'	N61° 39.60406'
WRST-GRTS-381	Not Eval			W143° 50.26899'	N62° 08.63873'

Table 6, continued

Sitecode	SiteEval	EvalReason	Name	Longitude	Latitude
WRST-GRTS-382	Not Eval			W141° 13.70955'	N61° 53.37123'
WRST-GRTS-383	Not Eval			W144° 15.69'	N61° 25.53492'
WRST-GRTS-384	Nontarget	Too big		W142° 53.77152'	N61° 09.42839'
WRST-GRTS-385	Nontarget	Doesn't exist		W143° 56.01611'	N62° 28.49361'
WRST-GRTS-386	Target			W141° 56.71788'	N62° 15.49909'
WRST-GRTS-387	Nontarget	Private		W144° 12.51636'	N61° 44.81473'
WRST-GRTS-388	Not Eval			W141° 25.78708'	N61° 41.80102'
WRST-GRTS-389	Nontarget	Too big		W144° 01.51897'	N62° 40.64775'
WRST-GRTS-390	Not Eval			W141° 42.36014'	N61° 54.97675'
WRST-GRTS-391	Nontarget	Private		W144° 25.12737'	N61° 23.96051'
WRST-GRTS-392	Nontarget	No access		W142° 34.43406'	N61° 15.10132'
WRST-GRTS-393	Nontarget	Lake		W143° 27.35137'	N62° 32.56482'
WRST-GRTS-394	Nontarget	Doesn't exist		W141° 07.62037'	N61° 44.08366'
WRST-GRTS-395	Not Eval			W144° 58.5923'	N61° 52.34706'
WRST-GRTS-396	Not Eval			W142° 47.00989'	N61° 01.4293'
WRST-GRTS-397	Not Eval			W144° 58.52821'	N62° 21.59501'
WRST-GRTS-398	Target			W143° 33.82324'	N61° 24.61357'
WRST-GRTS-399	Nontarget	Private		W144° 25.12578'	N60° 59.6325'
WRST-GRTS-400	Not Eval			W141° 16.21988'	N60° 06.77482'

Table 7. GRTS site list for Yukon-Charley Rivers NP. Under “EvalStatus”, Sites are listed as either “Target”, “Nontarget” or “NotEval.” “NotEval” indicates the site has yet to be fully evaluated, either with remotely sensed imagery or in the field. “EvalReason” gives the reason a site was designated Nontarget. The reasons listed are Lake, Private (on private land), Too big (unsafe), Doesn’t exist , and No access (can’t land helicopter or otherwise get access to site). “Name” refers to the attributed name from the National Hydrography Dataset (NHD) or a name provided by the CAKN in cases where sites have already been sampled; not all segments have names in the NHD. YUCH-GRTS-001 through YUCH-GRTS-101 is the Accessible stratum. YUCH-GRTS-102 through YUCH-GRTS-202 is the Inaccessible stratum. Latitude and longitude are NAD83, and are given in digital minutes.

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
YUCH-GRTS-001	Target		upper Charley trib	64.56287	-143.212122
YUCH-GRTS-002	Nontarget	Too big	Yukon River	65.32382	-142.346426
YUCH-GRTS-003	Target		Coal Creek	65.343121	-143.111524
YUCH-GRTS-004	Nontarget	Too big	Yukon River	65.071722	-141.380444
YUCH-GRTS-005	Target		Flume Creek	64.991978	-142.426114
YUCH-GRTS-006	NotEval		Yukon side channel	65.2816	-141.980854
YUCH-GRTS-007	Target		Andrew Creek	65.36752	-143.024735
YUCH-GRTS-008	NotEval		Tatonduk tributary	64.990298	-141.306813
YUCH-GRTS-009	NotEval		Yukon trib	65.318858	-142.024476
YUCH-GRTS-010	Target		Woodchopper Creek	65.290454	-143.438093
YUCH-GRTS-011	NotEval		Yukon trib E of Nation R.	65.171533	-141.62202
YUCH-GRTS-012	NotEval		Yukon trib W of Tatonduk R.	65.028369	-141.385233
YUCH-GRTS-013	NotEval		Yukon side channel/trib	65.320002	-142.269219
YUCH-GRTS-014	Nontarget	Too big	Yukon River	65.409832	-143.520518
YUCH-GRTS-015	Nontarget	Too big	Yukon River	65.209041	-141.835014
YUCH-GRTS-016	Nontarget	Too big		65.469608	-143.623917
YUCH-GRTS-017	Target		upper Charley trib	64.574784	-143.22188
YUCH-GRTS-018	NotEval		Yukon side channel/trib	65.332424	-142.358515
YUCH-GRTS-019	NotEval		Edwards Creek	65.367155	-143.122732
YUCH-GRTS-020	NotEval		Yukon trib nr. Montauk Bluff	65.096823	-141.445427
YUCH-GRTS-021	NotEval		upper Flume Creek	64.962707	-142.457626
YUCH-GRTS-022	Nontarget	Too big	Yukon River	65.29379	-142.062029
YUCH-GRTS-023	NotEval		Yukon River trib	65.096069	-141.57399
YUCH-GRTS-024	NotEval		Tatonduk distributary	65.009433	-141.320915
YUCH-GRTS-025	NotEval		Yukon River trib	65.311976	-142.017208
YUCH-GRTS-026	NotEval		Green Gulch	65.292126	-143.446491
YUCH-GRTS-027	NotEval			65.178729	-141.663696
YUCH-GRTS-028	NotEval			64.914638	-141.211566
YUCH-GRTS-029	NotEval			65.333693	-142.224807
YUCH-GRTS-030	NotEval			65.44017	-143.570407
YUCH-GRTS-031	NotEval			65.192868	-141.859269
YUCH-GRTS-032	NotEval			65.427362	-143.611413
YUCH-GRTS-033	NotEval			64.566907	-143.275678
YUCH-GRTS-034	NotEval			65.296406	-142.104695
YUCH-GRTS-035	Target		Coal Creek @airstrip	65.311577	-143.129652
YUCH-GRTS-036	NotEval			65.090021	-141.475124
YUCH-GRTS-037	NotEval			65.33391	-142.679098
YUCH-GRTS-038	NotEval			65.357102	-143.21263
YUCH-GRTS-039	NotEval			65.142933	-141.635575
YUCH-GRTS-040	NotEval			65.064864	-141.52779
YUCH-GRTS-041	NotEval			65.291093	-141.894169
YUCH-GRTS-042	NotEval			65.378883	-143.387145
YUCH-GRTS-043	NotEval			65.171383	-141.59992

Table 7, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
YUCH-GRTS-044	NotEval			65.55961	-143.707758
YUCH-GRTS-045	NotEval			65.411287	-142.642316
YUCH-GRTS-046	NotEval			65.308042	-142.789388
YUCH-GRTS-047	NotEval			65.174253	-141.869662
YUCH-GRTS-048	NotEval			65.586414	-143.866838
YUCH-GRTS-049	NotEval			64.828793	-143.438692
YUCH-GRTS-050	NotEval			65.271742	-141.991099
YUCH-GRTS-051	NotEval			65.328754	-143.027144
YUCH-GRTS-052	NotEval			64.950285	-141.118453
YUCH-GRTS-053	NotEval			65.313747	-142.391801
YUCH-GRTS-054	NotEval			65.341505	-143.322525
YUCH-GRTS-055	NotEval			65.117749	-141.677018
YUCH-GRTS-056	NotEval			65.02906	-141.418087
YUCH-GRTS-057	NotEval			65.315076	-142.089033
YUCH-GRTS-058	NotEval			65.449433	-143.56156
YUCH-GRTS-059	NotEval			65.236119	-141.810666
YUCH-GRTS-060	NotEval			65.544292	-143.677869
YUCH-GRTS-061	NotEval			65.332615	-142.420211
YUCH-GRTS-062	NotEval			65.312152	-142.873025
YUCH-GRTS-063	NotEval			65.173007	-141.781554
YUCH-GRTS-064	NotEval			65.588739	-143.945897
YUCH-GRTS-065	NotEval			65.333478	-142.691307
YUCH-GRTS-066	NotEval			65.286885	-142.002706
YUCH-GRTS-067	NotEval			65.090585	-141.56501
YUCH-GRTS-068	NotEval			65.007005	-141.35036
YUCH-GRTS-069	NotEval			65.391654	-142.59262
YUCH-GRTS-070	NotEval			65.326632	-142.809059
YUCH-GRTS-071	NotEval			65.222369	-141.860132
YUCH-GRTS-072	NotEval			65.459496	-143.717454
YUCH-GRTS-073	NotEval			64.800097	-143.482258
YUCH-GRTS-074	NotEval			65.270497	-141.928865
YUCH-GRTS-075	NotEval			65.351392	-143.055476
YUCH-GRTS-076	NotEval			65.115619	-141.434906
YUCH-GRTS-077	NotEval			65.336506	-142.109265
YUCH-GRTS-078	NotEval			65.359089	-143.386842
YUCH-GRTS-079	NotEval			65.190111	-141.80665
YUCH-GRTS-080	NotEval			65.509568	-143.665244
YUCH-GRTS-081	NotEval			65.31353	-142.037618
YUCH-GRTS-082	NotEval			65.30019	-143.405781
YUCH-GRTS-083	NotEval			65.144949	-141.587484
YUCH-GRTS-084	NotEval			65.05218	-141.362187
YUCH-GRTS-085	NotEval			65.338589	-142.466858
YUCH-GRTS-086	NotEval			65.35386	-143.111387
YUCH-GRTS-087	NotEval			65.058365	-141.378615
YUCH-GRTS-088	NotEval			65.58016	-143.966723
YUCH-GRTS-089	NotEval		Waterfall Creek	65.2715	-141.071549
YUCH-GRTS-090	NotEval		Charley River trib	65.275	-142.755076
YUCH-GRTS-091	NotEval		Kandik River sidechannel	65.379222	-142.472628
YUCH-GRTS-092	NotEval		Seventymile River	64.96567	-142.712354
YUCH-GRTS-093	NotEval		trib of Cathedral Creek	65.175968	-141.114297
YUCH-GRTS-094	NotEval		Hanna Creek	65.084913	-143.25402
YUCH-GRTS-095	NotEval		Headwater stream nr. Hard Luck	65.287807	-141.771395
YUCH-GRTS-096	NotEval		Charley River	64.651177	-143.738556

Table 7, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
YUCH-GRTS-097	NotEval		Tyrena Creek	65.074908	-141.715286
YUCH-GRTS-098	NotEval		Washington Creek	65.267133	-142.306762
YUCH-GRTS-099	Target		Seventymile trib	64.929093	-142.91106
YUCH-GRTS-100	NotEval		trib of Webber Creek	65.336845	-143.51907
YUCH-GRTS-101	NotEval		trib of Threemile Creek	65.465424	-142.663678
YUCH-GRTS-102	NotEval		Fourth of July Creek	65.132289	-141.989822
YUCH-GRTS-103	NotEval		trib of Charley River	64.764441	-143.563717
YUCH-GRTS-104	NotEval		trib of Crescent Creek	64.803964	-144.027183
YUCH-GRTS-105	NotEval		Waterfall Creek	65.294568	-141.125969
YUCH-GRTS-106	NotEval		Charley River	65.115664	-143.044558
YUCH-GRTS-107	NotEval		Judge Creek	65.464021	-142.245168
YUCH-GRTS-108	NotEval		upper Flume Creek	64.904094	-142.557397
YUCH-GRTS-109	NotEval		Stream on Three Castle Mountain	65.204724	-141.206987
YUCH-GRTS-110	NotEval		Hanna Creek	65.142222	-143.431558
YUCH-GRTS-111	NotEval		Kandik River trib	65.430101	-141.847407
YUCH-GRTS-112	NotEval		high elevation trib of Charley trib	64.624334	-143.361509
YUCH-GRTS-113	NotEval		trib of Nation River	65.169276	-141.432107
YUCH-GRTS-114	NotEval		Bonanza Creek	65.211442	-142.632097
YUCH-GRTS-115	Target		Cedar Creek	64.876502	-143.186677
YUCH-GRTS-116	NotEval		upper Woodchopper Creek	65.178634	-143.724283
YUCH-GRTS-117	NotEval		trib of Edwards Creek	65.387183	-143.162184
YUCH-GRTS-118	NotEval		Fisher Creek	65.079187	-142.473355
YUCH-GRTS-119	NotEval		Copper Creek sidechannel/trib	64.772162	-142.859351
YUCH-GRTS-120	NotEval		Crescent Creek	64.890595	-143.99065
YUCH-GRTS-121	NotEval		trib of Nation River	65.311783	-141.63695
YUCH-GRTS-122	NotEval		Drayham Creek	65.073568	-143.01455
YUCH-GRTS-123	Target		trib of Kandik River	65.404411	-142.162839
YUCH-GRTS-124	NotEval		high elev stream near 3 Fingers	64.622627	-143.123426
YUCH-GRTS-125	NotEval		stream near Hillard Peak	64.964809	-141.035612
YUCH-GRTS-126	NotEval		Colorado Creek	65.257675	-143.261527
YUCH-GRTS-127	NotEval		trib of Charley River	64.950671	-143.385653
YUCH-GRTS-128	Target		Woodchopper Creek	65.234713	-143.553405
YUCH-GRTS-129	NotEval			65.263276	-141.642095
YUCH-GRTS-130	NotEval			65.262532	-142.442229
YUCH-GRTS-131	NotEval			64.677398	-143.643663
YUCH-GRTS-132	NotEval			65.235674	-143.856686
YUCH-GRTS-133	NotEval			65.210761	-142.84655
YUCH-GRTS-134	NotEval			65.137075	-142.697517
YUCH-GRTS-135	NotEval			64.774784	-143.188002
YUCH-GRTS-136	NotEval			65.028651	-143.653405
YUCH-GRTS-137	NotEval			65.284412	-141.533544
YUCH-GRTS-138	NotEval			65.151814	-142.783552
YUCH-GRTS-139	NotEval			65.466116	-142.093322
YUCH-GRTS-140	NotEval			64.637268	-143.319344
YUCH-GRTS-141	NotEval			65.051031	-141.552815
YUCH-GRTS-142	NotEval			65.387526	-143.362393
YUCH-GRTS-143	NotEval			64.948982	-143.501364
YUCH-GRTS-144	NotEval			65.243962	-143.854434
YUCH-GRTS-145	NotEval			65.401413	-143.015655
YUCH-GRTS-146	NotEval			65.257986	-142.027077
YUCH-GRTS-147	NotEval			64.826749	-143.345478
YUCH-GRTS-148	NotEval			64.769046	-143.963544
YUCH-GRTS-149	NotEval			65.262697	-143.006821

Table 7, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
YUCH-GRTS-150	NotEval			64.986462	-142.631779
YUCH-GRTS-151	NotEval			64.680632	-143.200909
YUCH-GRTS-152	NotEval			64.626969	-143.989717
YUCH-GRTS-153	NotEval			65.321135	-141.015366
YUCH-GRTS-154	NotEval			65.060399	-142.794633
YUCH-GRTS-155	NotEval			65.44619	-142.262943
YUCH-GRTS-156	NotEval			64.554307	-143.296618
YUCH-GRTS-157	NotEval			65.184777	-141.306757
YUCH-GRTS-158	NotEval			65.188869	-143.466567
YUCH-GRTS-159	NotEval			64.925925	-143.306694
YUCH-GRTS-160	NotEval			65.533897	-143.520646
YUCH-GRTS-161	NotEval			65.213654	-141.491889
YUCH-GRTS-162	NotEval			65.180414	-142.481426
YUCH-GRTS-163	NotEval			64.835978	-143.217325
YUCH-GRTS-164	NotEval			65.084679	-143.844112
YUCH-GRTS-165	NotEval			65.380853	-143.083641
YUCH-GRTS-166	NotEval			65.123772	-142.449868
YUCH-GRTS-167	NotEval			64.738413	-143.02676
YUCH-GRTS-168	NotEval			64.900944	-143.749124
YUCH-GRTS-169	NotEval			65.135497	-141.184698
YUCH-GRTS-170	NotEval			65.090324	-142.746273
YUCH-GRTS-171	NotEval			65.438327	-141.959847
YUCH-GRTS-172	NotEval			64.580582	-143.741945
YUCH-GRTS-173	NotEval			64.980459	-141.470309
YUCH-GRTS-174	NotEval			65.243235	-143.426686
YUCH-GRTS-175	NotEval			64.928526	-143.559815
YUCH-GRTS-176	NotEval			65.398838	-143.692133
YUCH-GRTS-177	NotEval			65.42892	-142.966517
YUCH-GRTS-178	NotEval			65.267053	-141.896451
YUCH-GRTS-179	NotEval			64.737316	-143.451599
YUCH-GRTS-180	NotEval			64.737856	-143.934167
YUCH-GRTS-181	NotEval			65.252483	-142.968309
YUCH-GRTS-182	NotEval			65.031712	-142.433764
YUCH-GRTS-183	NotEval			64.78405	-142.813667
YUCH-GRTS-184	NotEval			64.671119	-143.978286
YUCH-GRTS-185	NotEval			65.257674	-141.213407
YUCH-GRTS-186	NotEval			65.107728	-143.103057
YUCH-GRTS-187	NotEval			65.459295	-142.531958
YUCH-GRTS-188	NotEval			64.807848	-142.740367
YUCH-GRTS-189	NotEval			65.053475	-141.149556
YUCH-GRTS-190	NotEval			65.058667	-143.239162
YUCH-GRTS-191	NotEval			65.334143	-141.755853
YUCH-GRTS-192	NotEval			64.575807	-143.371229
YUCH-GRTS-193	NotEval			65.223705	-141.376326
YUCH-GRTS-194	NotEval			65.292284	-142.251499
YUCH-GRTS-195	NotEval			64.96693	-142.804602
YUCH-GRTS-196	NotEval			65.411044	-143.762026
YUCH-GRTS-197	NotEval			65.437234	-143.446567
YUCH-GRTS-198	NotEval			65.177446	-142.141329
YUCH-GRTS-199	NotEval			64.816271	-143.538557
YUCH-GRTS-200	NotEval			64.935003	-143.891352
YUCH-GRTS-201	NotEval			65.29094	-141.63248
YUCH-GRTS-202	NotEval			65.022296	-143.113107

Table 7, continued

Sitecode	EvalStatus	EvalReason	Name	Latitude	Longitude
YUCH-GRTS-203	NotEval			65.436944	-142.119028
YUCH-GRTS-204	NotEval			64.559364	-143.145033
YUCH-GRTS-205	NotEval			65.017269	-141.121959
YUCH-GRTS-206	NotEval			65.240906	-143.324915
YUCH-GRTS-207	NotEval			64.992394	-143.223058
YUCH-GRTS-208	NotEval			65.274903	-143.737299
YUCH-GRTS-209	NotEval			65.221086	-141.655424
YUCH-GRTS-210	NotEval			65.175353	-142.447095
YUCH-GRTS-211	NotEval			64.733866	-143.679211
YUCH-GRTS-212	NotEval			64.783645	-143.845773
YUCH-GRTS-213	NotEval			65.225675	-142.684475
YUCH-GRTS-214	NotEval			65.024421	-142.672672
YUCH-GRTS-215	NotEval			64.779433	-143.115489
YUCH-GRTS-216	NotEval			64.970114	-143.686688
YUCH-GRTS-217	NotEval			65.336299	-141.255623
YUCH-GRTS-218	NotEval			65.099257	-143.146959
YUCH-GRTS-219	NotEval			65.459724	-142.225109
YUCH-GRTS-220	NotEval			64.500843	-143.094563
YUCH-GRTS-221	NotEval			64.922478	-141.10635
YUCH-GRTS-222	NotEval			65.242811	-143.159433
YUCH-GRTS-223	NotEval			64.928241	-143.395158
YUCH-GRTS-224	NotEval			65.456268	-143.548504
YUCH-GRTS-225	NotEval			65.09752	-141.787304
YUCH-GRTS-226	NotEval			65.161412	-142.558125
YUCH-GRTS-227	NotEval			64.888885	-142.865425
YUCH-GRTS-228	NotEval			65.06568	-143.636475
YUCH-GRTS-229	NotEval			65.214468	-142.762829
YUCH-GRTS-230	NotEval			65.147552	-142.542637
YUCH-GRTS-231	NotEval			64.640559	-143.058464
YUCH-GRTS-232	NotEval			65.030164	-143.881944
YUCH-GRTS-233	NotEval			65.209918	-141.054774
YUCH-GRTS-234	NotEval			65.131303	-143.570859
YUCH-GRTS-235	NotEval			65.316822	-142.18149
YUCH-GRTS-236	NotEval			64.629481	-143.56108
YUCH-GRTS-237	NotEval			65.041392	-141.81435
YUCH-GRTS-238	NotEval			65.226826	-143.492442
YUCH-GRTS-239	NotEval			64.915156	-143.501562
YUCH-GRTS-240	NotEval			65.382046	-143.576762
YUCH-GRTS-241	NotEval			65.420676	-142.782519
YUCH-GRTS-242	NotEval			65.136469	-141.918979
YUCH-GRTS-243	NotEval			64.676523	-143.488904
YUCH-GRTS-244	NotEval			64.86955	-143.971353
YUCH-GRTS-245	NotEval			65.276285	-142.893659
YUCH-GRTS-246	NotEval			65.397361	-142.428539
YUCH-GRTS-247	NotEval			64.894756	-142.702628
YUCH-GRTS-248	NotEval			64.594031	-143.967927

SOP 3: Continuous Monitoring of Temperature

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) provides step-by-step instructions for the deployment of continuous temperature data recording units in streams. This SOP is designed to be compatible with the standards for stream temperature data collection in Alaska as outlined in Mauger *et al.* (2014). These instructions are specific to the HOBO Water Temp Pro v2 logger, which is the logger currently used by the CAKN stream monitoring program. Other loggers will also work; however, the steps outlined below may not be relevant in those cases. However, only loggers with an accuracy of 0.25°C or less and a minimum measurement range of -4°C to 37°C should be used.

Required Equipment

1. HOBO Water Temp Pro v2 data logger, two per site (Part # U22-001 from Onset Computer)
2. Computer loaded with HOBOWare Pro software
3. HOBO Optic USB Base Station (Part # BASE-U-4)
4. Base Station adaptor for Pro v2 (Part # COUPLER2-C)
5. NIST-certified thermometer
6. Two circulating water baths or small coolers.
7. Boot (White) for WT Pro (Part # BOOT-WHT), two per site
8. 3/32” plastic coated cable (8-10 feet per site)
9. 3/16” double copper cable sleeve, (4 per site)
10. 1/8” wire rope clips (4 per site)

11. 5/16" nut driver
12. Thin steel wire (~20 gauge seems to work)
13. Heavy duty lineman's pliers
14. Parrot-beak wire cutters (strong enough to cut the cable)

Procedures

Testing HOBO loggers

Before and after deployment, loggers should be tested using a NIST-certified thermometer. Testing before deployment is used to ensure that only loggers that meet the minimum standard of 0.25°C are deployed in the field. It also provides a way to weed out loggers that are defective in other ways (*e.g.*, fail to record data). Testing after deployment is important to ensure that the minimum accuracy applies to all data collected during deployment and to check for drift. This is easiest to do in the lab. However, testing can also be carried out in the field if necessary.

To test loggers, they should be launched using the procedure outlined below ("*Launch HOBO data logger*"). Check that the internal logger time matches the time on the clock you will be using to track the testing procedure. The logging interval should be set to 1 minute. The goal is to test the loggers at both 0°C and ~20°. If you have access to a lab with controlled-temperature water baths, those are preferable to the method outlined here. Fill a small cooler with an ice/water mixture and mix. The final temperature should be close to 0°C. Next fill another small cooler with room-temperature water and mix well. The final temperature should be close to 20°C, although the exact value is not critical. For efficiency, you can test multiple loggers at once, starting half in the 0°C bath and half in the 20°C. Place loggers in the water bath, making sure they are fully submerged. Record the exact time and a reading with the NIST-certified thermometer. Allow loggers to record data for 20-30 minutes, stirring the bath occasionally to maintain a consistent temperature. Record at least 2 more measurements with the NIST-certified thermometer (*e.g.*, 1/2 way through and at the end of the test). Record the exact time you make each measurement. Next, switch the loggers to the other water bath and repeat the process.

Next, download the data using the procedure outlined below ("*Retrieval*"). Ignore the data recorded in the first 5 minutes after deployment to allow for logger equilibration. Compare the data recorded by the logger to the measurements you made with the NIST-certified thermometer. If any logger fails the pre-deployment test (*i.e.* the recorded temperature varies by more than 0.25°C from the measured temperature, repeat the test on that logger. If the logger fails a second time, **do not** deploy the logger, and contact the manufacturer (Onset Computer for the Hobo Pro v2). If any logger fails the test post-deployment, repeat the test. If it fails a second time, **do not** re-deploy that logger. In this case the collected data should be carefully evaluated.

Launch HOBO data loggers

The HOBO Water Temp Pro v2 data loggers are configured and launched using the Optic USB Base Station and the HOBOWare Pro software. The loggers can be launched in the office (with a delayed start time if desired), or if a field laptop is available, launched on site. The latter is preferable. To configure and launch the loggers, follow these steps:

1. Launch the Hoboware Pro software by double clicking on the shortcut icon located on the computer desktop. If there is no shortcut on the desktop, launch Hoboware Pro by navigating to C:/Program Files/Onset Computer Corporation/Hoboware Pro/ and double clicking the HobowarePro.exe icon. At the bottom of the Hoboware window on the left you will see “Dev: No device selected”. On the bottom right you will see “No Devices Connected”.
2. Plug the USB connection from the Base Station into a USB port on the computer. Note that the USB ports located on Dell flatscreen monitors appear to be incompatible with the Base Station, so you should use a port on the computer itself. You should hear the chime indicating that the computer has recognized the USB connection.
3. Attach a data logger to the Base Station as follows: Align the “Comm. Alignment” arrow on the data logger with the “Align” arrow on the coupler, and gently but firmly push the logger into the coupler until you hear a click. You should also hear the recognition chime from the computer. The Hoboware window will now show “Dev: HOBO U22-001 Water Temp, S/N _____” at the lower left, with the unique 7-digit serial number (S/N) of the connected logger displayed, or the optional label given to the logger when it was launched. At the lower right you will see “1 device connected”.
4. Click on the “Device” drop-down menu at the upper left of the window and select “Launch”. The “Select Device” window will pop up. “HOBO U22-001 Water Temp, S/N: XXXXXX” should be the default selection. Click OK.
5. The “Launch Logger” pop-up screen will appear. Make sure that “Battery State” shows “Good”. If it does not, DO NOT LAUNCH the logger. Instead, the logger must be returned to Onset Computer to be exchanged. If you are launching a new logger, change the “Description” using the following naming convention “CAKN-Stream_Name-XXXXXXX” where Stream_Name refers to the site where the logger is to be deployed, and “XXXXXXX” refers to the serial number of the unit itself (which is displayed as the default in the “Description” window. If the logger has been previously deployed, you will only need to change the “Stream_Name”.
6. Under “Configure Sensors”, make sure that both “Temperature” and “Logger’s Battery Voltage” are checked.
7. Under “Deployment”, use the “Logging Interval” dropdown menu to set the desired logging interval. For most purposes, an interval of one hour is sufficient. A one hour logging interval provides for nearly 3 years of data collection. The logging interval should not be set at greater than one hour as this can introduce bias into recorded values of daily maximum and minimum temperatures.
8. Use the “Start Logging” dropdown menu to set the launch options. If you are launching in the field, set the unit to start logging at the next whole hour (*i.e.*, if it is 2:15, set the launch options to start logging at 3:00). Although it is not recommended, you may also set the launch options in the office prior to leaving for the field. In this case, set the delay

for far enough in the future that you are certain the Hobo will be deployed before logging commences.

9. Click “Start” to launch the logger. DO not remove the logger from the Optic USB Base Station or unplug the USB until the launch is complete.

Site selection

Look for deep runs or lateral meander pools that are in the thalweg. You are looking for an area that is well-mixed and receives a constant influx of the main current. It’s also important to choose a stable location to minimize the chance of either losing the logger or of logger burial. Make sure the spot is deep enough to remain wetted at baseflow. This can be tricky if you’re there early in the year and are unfamiliar with the site. That’s one reason we like the leading edge of lateral meander pools, as they are less likely to dry out over the summer in perennial streams. Shaded deep runs are ideal if present. We haven’t yet figured out how to reliably deploy temperature loggers in dynamic braided systems like glacially-dominated rivers. You should also look for a shore anchor (generally a tree or substantial willow). If there’s nothing like that available, other possibilities for a shore anchor are a piece of rebar driven into the ground or a small fluke or screw anchor. You should avoid deploying temperature loggers without a shore anchor except in streams with very gentle and stable flow and where there is little or no possibility that passers-by will see the logger. To ensure that the proposed deployment site is well mixed, take five measurements across the stream with a NIST-certified thermometer, or a temperature probe that has been checked against a NIST-certified thermometer. The temperature should be consistent within $\pm 0.25^{\circ}\text{C}$. For a more detailed discussion of logger placement, refer to Mauger *et al.* (2014).

Deploy HOBOS

1. If it is not already labeled, use a Sharpie to write the following in large letters on the outside of the protective boot:

“DO NOT REMOVE

NPS/CAKN

Your name

Your phone number”
2. Insert the HOBO logger into boot and place the cap over the large end. The end of the logger with the attachment loop should be visible. It often helps to brace the big end of the logger against a rock or tree and push hard to make sure the logger is fully seated in the boot and that the attachment loop is completely accessible.
3. Slide the vinyl-coated cable through a copper cable sleeve, then through attachment loop on the logger and back through cable sleeve. Cinch up to make loop reasonably small, but large enough that wire cutters will fit into the loop (important during retrieval of the logger). Leave about 1-2 inches of free end protruding. Remove nuts from a wire clip. Take wire clip “apart”, slide over both pieces of cable, near copper sleeve, and

reassemble. Tighten nuts using 5/16" nut driver. Test by pulling on loop to make sure there is no slippage.

4. Find a good-sized rock (or fill a small mesh bag with rocks) and use 20 gage wire to secure the logger to the rock. "Dog bone" shaped oblong rocks seem to work best (wire doesn't slip off the end). Wrap a sufficiently long piece of wire tightly a couple of times around the logger, then, holding the logger against the rock, wrap the wire around the rock and twist to tighten with lineman's pliers. Now wrap a second piece of wire around the rock and logger and twist to tighten with lineman's pliers. Other methods of anchoring the logger are also possible. For example, the USFWS places the logger in a length of perforated white PVC pipe with capped ends. The PVC is attached to a length of heavy chain that serves to anchor it in place on the bottom, and the chain is then attached to the cable that is attached to the shore anchor.
5. Place the HOBO-rock assembly in the stream, logger side facing down so it is not visible. I like to cover the unit with other pieces of large cobble, both to hide it from public view, and to provide additional anchoring. Slide the other end of the cable through another copper cable sleeve, loop it around your chosen shore anchor (tree, rebar, etc.), back through the copper cable sleeve and cut to an appropriate length. Use the wire clip as before to secure the end. Use mud, sticks, whatever, to cover and disguise the cable as completely as possible.
6. Repeat this process for the second logger. It is generally a good idea to use separate shore anchors and instream anchors to minimize the chance that both loggers will be lost during a high-floe event. However, if that is not practical, both loggers can be attached to the same shore anchor, as long as they are independently attached (separate cable). Always use separate instream anchors.

Mark logger location

Use the Trimble (or other GPS) to collect a location as close as possible to the anchor location or the stream side near the loggers. If the shore anchors for the two loggers are more than about a meter apart, it's a good idea to record separate GPS locations for each logger. Under the "Streams" data dictionary is an option for "HOBO location". Give the location file a suitable name (e.g., "savage river hobos"). Photograph the location, and record detailed directions on how to find the HOBOS in the field notebook.

Retrieval

1. If you are replacing the existing loggers at a location, use the parrot-beak wirecutters to snip the cable loop attached to the logger, but leave the shore anchor loops intact for re-use with the new loggers. If the loggers will not be replaced, both loops should be cut and all material removed from the site.
2. Before uploading data from HOBO data loggers, check to make sure that the HOBOWare Pro software is installed on the computer you are using. You will also need the HOBO Optic USB Base Station (Part #BASE-U-4 from Onset Computer) and the appropriate

coupling adapters (Part #COUPLER2-B for the U20 water level logger, and Part #COUPLER2-C for the Water Temp Pro v2 temperature logger).

3. Remove logger from its protective boot. This can be tricky due to accumulated sediment inside the boot, especially if the logger has been deployed for a long time. After removing the cap, brace the attachment loop on something solid (like the surface of your desk), grasp the boot and push hard!
4. Plug the USB connection from the Base Station into a USB port on the computer. Note that the USB ports located on Dell flatscreen monitors appear to be incompatible with the Base Station, so you should use a port on the computer itself. You should hear the chime indicating that the computer has recognized the USB connection.
5. Attach the appropriate coupler to the end of the Base Station
6. Launch the Hoboware Pro software by double clicking on the shortcut icon located on the desktop. If there is no shortcut on the desktop, launch Hoboware Pro by navigating to C:/Program Files/Onset Computer Corporation/Hoboware Pro/ and double clicking the HobowarePro.exe icon. At the bottom of the Hoboware window on the left you will see “Dev:No device selected”. On the bottom right you will see “No Devices Connected”.
7. Align the “Comm. Alignment” arrow on the data logger with the “Align” arrow on the coupler, and gently but firmly push the logger into the coupler until you hear a click. You should also hear the recognition chime from the computer. The Hoboware window will now show “Ready.” And “Dev: No Device Selected” at the lower left. At the lower right you will see “1 device connected”.
8. From the “Device” menu at the upper left, select “Readout”. The “Select Device” window will pop up. “Hobo U22-001 Water Temp, S/N: XXXXXX” should be the default selection. Click “OK”. A new window (“Readout Logger”) will pop up showing the progress of the device readout.
9. Next, a “Save” window will appear. Navigate to the *J:\Monitoring\Streams\Data\Hobotemp Data (or \Water Level Data* if uploading from a water level logger). If no current year folder exists, create one. The File name prompt will display the optional label corresponding to the logger, or the serial number if no label was designated. The file extension should be “.hobo”.
10. Click on “Save”. The “Plot Setup” window will appear. Click on “Plot” to see the data displayed.
11. From the “File” menu at the upper left, select “Export Points as Excel Text...” The “Export Options” window will appear. Select “Export to a single file” and click on “Export”.
12. A “Save” window will appear. Navigate to the same folder as in Step 7 and click “Save”.

13. Repeat steps 6-10 for additional loggers if any. If data from more than one type of logger are being uploaded, be sure to change the coupler AND THE DESTINATION FILE as necessary.
14. In the demobilization inventory form, record the date and time of the upload, the serial number and/or label of each logger, as well as the destination folder location and names of all .hobo and .xls files.
15. Clean protective cases and loggers to remove dirt and sand. Return loggers and cases to the appropriate storage location in the warehouse.

References

- Mauger, S., R. Shaftel, E.J. Trammell, M. Geist, and D. Bogan. 2014. Stream temperature data collection standards and protocol for Alaska: minimum standards to generate data useful for regional-scale analyses. Cook Inletkeeper, Homer, AK and Alaska Natural Heritage Program, UAA, Anchorage, AK. 53 pp.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 4: Training

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

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Introduction

This SOP describes the annual training procedures for personnel involved in the CAKN stream monitoring program, as well as other training that may be required from time to time. Training should be carried out well in advance of the upcoming field season and should be completed by the end of May. This training includes both federally-required safety training and training specifically designed for stream monitoring. Training includes the proper use and calibration of YSI multi-parameter sondes, the GPS unit/field computer, the Tablet PC or Toughbook, the Smith-Root LR-24 backpack electrofishing unit, the Flo-Mate flowmeter and the digital SLR camera and Nodal Ninja panoramic head. Training also includes proper procedures involved in navigating to and evaluating a site, establishing a sampling reach, taking physical habitat measurements, and collecting and processing water quality, macroinvertebrate and diatom samples. We have designed a three-stage observer training program that includes orientation, skill development, and practical testing. This SOP was adapted directly from SOP 9: Training Personnel in Larsen *et al.* (2011).

Required Safety Training

Our primary concern in the stream monitoring program is the health and safety of our personnel. To ensure the safety of our field crews we require a high degree of training before crewmembers are allowed into the field. The following safety courses are required of all crewmembers involved in the field operations. Each crewmember must be able to show that they possess current certification in the following federal training programs:

1. NPS non-LE firearms certification – certified annually
2. Bear safety training – required annually
3. Interagency B-3 aircraft safety – if aircraft of any kind are scheduled for use during the field season (required every 3 years)

4. Interagency Helicopter Crew Member training (S-271) – if helicopters are to be used during the field season (required every 3 years)
5. CPR/Wilderness First Aid – certified every 2 years
6. ATV Safety – if ATVs are to be used during the field season – one-time certification

The project manager is responsible for the general safety and welfare of the crew while in the field and is required to take the following additional training:

1. Interagency Helicopter Manager (S-372) – certified every 3 years
2. Motorboat Operator Certification Course (MOCC) – one-time certification

Training Program for Stream Monitoring

Effective training of observers is the single most important component of maintaining a viable and effective long term monitoring program. Properly trained observers reduce inter-observer error, help to streamline sampling in the field, reduce sampling errors, and increase our ability to effectively monitor aquatic ecosystems during the short summer field season. Being able to properly collect data, use and maintain equipment, troubleshoot equipment malfunctions, and complete the data collection are essential to the CAKN monitoring effort.

We are committed to developing a high quality training program that ensures personnel are competent and confident in the monitoring process and that will guarantee the continued success of the project. Typically, we think of training as that time spent in a classroom or out in the field demonstrating particular methods to new volunteers. However, in order to be truly effective, it is crucial to integrate training into the entire program. The program has three basic sections: orientation, skill development and practical testing. We are in the preliminary stages of developing this program and have outlined below the major subject areas to be covered in the training program.

Orientation

1. Personnel are required to attend a basic orientation discussion that will outline the training process, schedule, and required readings. The orientation session will cover the following topics:
2. Program overview: a discussion of the goals and measurable objectives of the CAKN stream monitoring program
3. Basic program information – contacts, etc.
4. How to monitor: a general description of the techniques we'll be using to collect data in the field
5. Current monitoring schedule: what is the approximate sampling schedule for the upcoming summer

6. Training schedule: what safety and training classes/sessions are required and when they will be offered
7. Required readings: personnel are asked to read the Stream Monitoring Protocol, which includes a narrative overview of the stream monitoring program, as well as all of the SOPs for the project. Each observer should also familiarize themselves with the common freshwater fish species that may be encountered during field work.

Skill Development

After orientation and careful review of the necessary documents, the observers will begin skill development training. This portion of the training program is primarily conducted in the laboratory and at a local training stream site. The emphasis is on learning and practicing the skills necessary for successfully completing the field sampling. Observers are introduced to data collection techniques; maintaining, using, and storing equipment; and managing field data. We also introduce common problems that may be encountered while using each of the pieces of equipment and go over potential solutions. During this training, basic proficiency will be tested by comparing measurements collected during training sampling trips by trainees and trainers.

General sampling information

1. Pre-season, pre-trip, and daily start-up, including equipment checklist (see SOP 1: Field Season Prep and SOP 5: Field Trip Mobilization)
2. Locating sites (see SOP 8:Field Methods)
3. Evaluating sites and reach establishment (see SOP 8: Field Methods)
4. General Workflow (see SOP 8: Field Methods)
5. Use of data sheets, database and data dictionaries (see SOP 6: Using GPS and SOP 8: Field Methods)
6. Use of Trimble GPS units (through Alaska Regional Office training if available)
7. Photography
8. Monitoring Supplies
9. Monitoring Checklist
10. A Glossary of Terms
11. Supplemental Information

Continuous temperature monitoring

1. Launching data loggers

2. Deploying data loggers
3. Retrieving data loggers

Water Chemistry

1. QA/QC for water samples
2. Chain of custody form requirements
3. Water sample collection
4. Proper labeling of water samples
5. Field filtration of water samples
6. Handling & transporting water samples

Use of the multiparameter sonde

Personnel will practice calibrating and using the YSI QS650 multiparameter sonde. Personnel will read the equipment manuals and practice performing instrument calibration and maintenance (changing dissolved oxygen membranes and filling solution) in the office to gain experience.

Macroinvertebrates

1. Macroinvertebrate sample collection using modified D-nets
2. Macroinvertebrate sample processing - decanting, sieving, transfer, preservation and labeling
3. Sample handling and transport
4. Field repair of nets

Diatoms

1. Diatom sample collection
2. Diatom sample processing – scrubbing, rinsing, measurement, preservation
3. Sample handling and transport

Channel geometry

1. Width and depth measurement
2. Canopy cover measurement with densiometer
3. Substrate measurement with gravelometer
4. Estimation of fish cover and habitat quality

5. Measuring reach gradient

Measuring discharge

1. Selection of a cross-section and set-up
2. Use of the top-setting wading rod
3. Use of the Flo-Mate flowmeter

Site notes

1. Overview of site notes
2. Channel classification
3. Evaluation of water color and clarity
4. Evaluation of reference vs. test site
5. Evaluation of riparian and upland vegetation types
6. Evidence of high flows

Sample Tracking

Train personnel in preparation of sample labels and use of sample tracking forms, and procedures for contingencies, such as loss or compromise of samples.

Data Check and QC

Train personnel in data checking and QC procedures, including use of QC control charts and handling of data that do not meet QC standards.

Data Entry

Train personnel in data entry procedures for each monitoring element.

Practical Testing

Field training is critical for developing the skills and confidence that observers will need to be successful. Observers will be tested by performing a mock sampling event at a nearby stream ecosystem. The newly trained observers will be required to demonstrate proficiency in each aspect of the protocols. This portion of the training program is still in development. We have outlined the general strategy below and intend to have a more detailed training program developed by spring 2013.

1. Briefly review what water quality parameters do and do not tell us about the resource
2. Review safety considerations
3. Review the monitoring procedures the observers will be using
4. Demonstrate the procedures

5. Observers practice the procedures until they are comfortable with them, and trainers are satisfied
6. Summarize monitoring steps
7. Observers and trainers do a monitoring run-through at a local stream, including data check and entry. Results will be compared and discussed. The objective is to ensure that similar observations and results are obtained by all teams and that to the extent possible, discrepancies are resolved before they are discovered in a remote field situation.
8. Answer final questions and concerns regarding field procedures.
9. Return to lab and review lab procedures and data entry, including data check procedures. Project manager reviews results with field crew personnel to ensure consistency and that any discrepancies are resolved and required modifications to the SOP can be made prior to actual field work.

References

- Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, R. McGinnis, H. Kristenson. 2011. Shallow lake limnology monitoring protocol: Central Alaska Network (CAKN) and Arctic Network (ARCN), Version 2.0. Natural Resource Report NPS/AKRO/NRR—2011/347. National Park Service, Fort Collins, Colorado.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 5: Field Trip Mobilization

Revision History Log

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This SOP provides instructions for preparation of all supplies, equipment, and personnel for each field trip made during the monitoring season. Sampling trips are generally multi-day missions in remote sites and hence require forethought and careful planning to ensure all parameters can be appropriately sampled or measured safely. The monitoring season runs from the spring break-up until late September, or whenever streams begin to freeze up. This SOP was adapted directly from SOP 10: Field Trip Mobilization in Larsen *et al.* (2011).

General Preparation and Review

1. Coordinate field transport. This includes helicopters, trucks, boats, and float planes. Consider the location and nature of the streams to be sampled to determine the optimum combination of transportation modes. This may also affect communications.
2. Copy the equipment list shown in SOP 1: Field Season Preparation.
3. Inspect all sampling equipment for damage, dirt, etc. Check off each item as it is packed to verify that all required items are packed.
4. Pack a satellite phone and telephone number directory and park radio with sufficient batteries.
5. Check equipment batteries including GPS, YSI sonde, Tablet PC, Flo-Mate, radios, and digital camera; replace if expired and carry extras.
6. Check camera SD cards and be sure all pictures have been offloaded and the cards are blank
7. Calibrate and adjust all field equipment as necessary. Perform diagnostic tests on each, according to the manufacturer's instructions, to ensure each piece of equipment is functioning properly.
8. Calibrate the multiparameter sonde in the lab. See SOP 7: Calibration and Maintenance of Multiparameter Sondes.
9. Pack equipment and supplies (food, camping equipment) in containers compatible with the planned modes of transportation.

10. Ensure that necessary regional and local maps, photos, and necessary GPS coordinates are accessible.
11. Each member of the field team will be certified in shotgun safety and counter-bear measures and other necessary safety training (according to federal agency standards). See SOP 4: Training for additional information.

Prior to Leaving the Office

1. Conduct health and safety review, per Health and Safety Plan (or equivalent). Review NPS policies and procedures for on-water work and backcountry first aid.
2. Verify first aid certifications. Make sure each field crew leader has current first aid and CPR certifications.
3. Make sure each crew member has read all relevant SOPs and completed necessary training (see SOP 4: Training).
4. Compile and review checklist of personal equipment and supplies.
5. Plan out all lines of communication. Establish a crew leader who is responsible for managing field operations. Establish a health and safety officer, potentially the same as the crew leader.
6. Hold a pre-trip field meeting to discuss the planned route and activities with all participants.
7. Establish field trip plan, including contingencies. Dates for pickup and drop-off of personnel and supplies must be established. The duration of the field trip will be determined based on the requirements of water sample preservation, on logistics of field support, weather forecasts, and personnel availability.
8. Submit trip plan to park headquarters and appropriate park liaisons (chief of resources, inventory and monitoring coordinator etc.)

References

- Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, R. McGinnis, H. Kristenson. 2011. Shallow lake limnology monitoring protocol: Central Alaska Network (CAKN) and Arctic Network (ARCN), Version 2.0. Natural Resource Report NPS/AKRO/NRR—2011/347. National Park Service, Fort Collins, Colorado.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 6: Using the GPS

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This Standard Operating Procedure (SOP) explains the steps that all observers should follow to use WAAS/SBAS capable GPS units to collect data for stream sampling and repeat photo locations. The SOP was adapted in part from SOP 12: Using GPS in Larsen *et al.* (2011).

Purpose

Due to the rapid evolution of commercial software and hardware, it is likely that other GPS units or software will be utilized in the near future. This SOP is current as of 2011, and is meant to be a working document, updated periodically as new technology emerges. While nomenclature may vary slightly depending on what hardware and software are used, this document should provide sufficient guidance on the basic process.

This document is not meant as a substitute for training in use of specific equipment. It is strongly recommended that personnel obtain unit-specific GPS hardware and software training prior to deploying in the field. An excellent training resource currently exists in the person of Joel Cusick in the GIS Department of the NPS Alaska Support Office (AKSO) in Anchorage. The training should include hands-on use, and should be designed to test all appropriate functions and operations prior to going out into the field. Generally, a hands-on GPS training is held each spring in Anchorage, and occasionally in Fairbanks as well. This SOP, therefore, is not intended to be exhaustive or a cookbook regurgitation of operating manual instructions. Instead, it is meant to provide guidance on which options and strategies will produce the most reliable and effective data product. This document is organized in two parts. The first part includes fundamental considerations which are predominantly hardware and software independent. The second part includes an introduction to the Trimble GeoXH current for 2011 with some cookbook steps. This should be considered a starting point prior to unit-specific training and as a rough reference thereafter. It is expected that this section will be frequently updated to reflect the rapid changes in technology.

Prior to Deployment

Certain aspects of a GPS campaign are best considered prior to field work. These include accuracy specifications, survey style, coordinate system and datum. The recommendations provided here represent the most effective choices to achieve sub-meter accuracy using a

handheld GPS unit to record point locations for ground photo sets and stream sampling locations, and requiring occupation time of less than one minute per point.

Recommended settings -

1. Accuracy specifications: less than 1 meter
2. Survey style:
 - a. WAAS-enabled point-positioning, or
 - b. WAAS-enabled feature logging
3. Coordinate system: Geographic (i.e Latitude/Longitude)
4. Datum:
 - a. horizontal: NAD83 (avoid NAD27 and WGS84 - NAD83 CORS96 for units that include this more-specific definition. “NAD_1983_To_WGS_1984_5” in ArcPAD 7.0.1)
 - b. vertical: NAVD88 (avoid using NGVD29)
5. Units:
 - a. Horizontal-
 - i. for UTM coordinate system – meters
 - ii. for Geographic coord system – decimal degrees (retain to 7 decimal places in subsequent tables and text)
 - b. Vertical-
 - i. meters – always
 - ii. HAE
6. Attributes (minimum):
 - a. site name
 - b. site type (e.g. ‘stream’, ‘photo’)
 - c. field technician
 - d. time/date stamp

Notes:Survey Style

WAAS: It is generally impractical to incorporate a full GPS base station on campaigns in the arctic parks due to remote logistics. With no base station support, traditional post-processing to improve accuracy is not possible. Currently, WAAS technology offers the only alternative for sub-meter accuracy without a base station. The Wide Area Augmentation System (WAAS) satellites are geo-stationary satellites launched as part of US DoD's GPS implementation. These WAAS satellites broadcast correction signals allowing real-time corrections to sub-meter specifications for single frequency receivers. Until March 2007, there were no WAAS satellites stationed far enough north to reach the ARCN parks. Since 2007, however, tests have shown that the new WAAS satellites offer coverage at least as far north as the northern portion of the Noatak National Preserve. The Trimble GeoXH is among the handheld units owned by ARCN making use of WAAS. For these reasons, future GPS work should make use of this technology whenever possible.

Point Positioning: Point positioning may be chosen when a) it is desirable to use ArcPAD interactively while acquiring points and b) accuracy specifications may be between 50cm and 1m. In this case, the GPS is recording an instantaneous and autonomous GPS position, and recording it as a feature (currently as a point feature within a shapefile using ArcPAD). In this case, record feature attributes in the shapefile while in the field.

Feature Logging: Choose Feature Logging when a) accuracy specifications need to be as tight as possible or less than 50cm, or b) in the rare cases when GPS base station files from within 50 miles of the study area will be available. Feature logging involves a recorded stream of data for each point feature (and is currently done using TerraSync software). Typically, each feature is logged from a 60 second occupation – recording a position each second for 60 seconds, and then averaging those positions to obtain a final coordinate, and also applying post-processing correction (using GPS base files) when they are available. ****It is important to check the logging rate for point features (currently in TerraSync), and ensure that it is set to 1 second****. The averaging and post-processing both offer higher accuracies, but require more field collection time, and more processing time and steps in the office.

Coordinate system

Many coordinate systems are useful in GIS analyses and for GPS display reference in the field, but coordinates are best logged and stored in latitude and longitude, using decimal degree to 7 decimal places. This eliminates ambiguity for future data users (e.g. "Which coordinate system is this?", "What UTM zone is this?", "Are these units meters or feet?"), and ensures adequate precision to represent the accuracy of the data (i.e. 7 decimal places provides precision to the cm, which is relevant for accuracy specs of less than 1m).

Datum

Always use NAD83. There are a number of reasons for choosing NAD83, the most basic of which are a) accuracy/quality of the model used (especially when compared with NAD27), and stability of the model (compared with WGS84, which is continually revised and relevant for geodetic research, but inappropriate for high-precision mapping).

Units – Vertical

There are generally two choices for vertical coordinates, Height Above Ellipsoid (HAE) and Above Mean Sea Level (MSL). By definition, MSL uses an earth geoid model to adjust elevation depending on the specific horizontal location on the earth. These models are often inaccurate, and are especially inaccurate in Alaska. For that reason, the models are also subject to frequent revision, meaning that MSL solutions do not remain consistent. At this time, HAE is a far better choice because it remains consistent and is unambiguous.

PDOP (position dilution of precision) is a measure of GPS accuracy. Check a software planning utility (such as QuickPlan in Trimble Pathfinder Office, PFO) for the location and dates in which fieldwork will be conducted to identify times of high PDOP. High PDOP indicates poor satellite geometry, which reduces the accuracy of GPS positioning. If possible, conduct GPS work when the PDOP is low, below 6. Otherwise, be certain that a minimum of 6 satellites will be visible during field work.

Battery life is variable among GPS units, but it is advisable to bring spare batteries for units in which batteries are replaced. For rechargeable units like the GeoXH, it is necessary to bring the unit's charging cradle and have access to power for recharging. In cases where recharging is not possible, power can be preserved by switching the unit on only when a data point is to be collected. A GeoXH can often operate for up to 6 consecutive hours between recharges, so several days of GPS work can be accomplished by conserving the unit's power.

In all cases, GPS units should be fully tested at the office before deploying to the field. This involves a brief, mock GPS campaign, where: 1) data points are collected the way they will be in the field, 2) the data are uploaded to computer, 3) the data are checked for both spatial and attribute accuracy, and 4) the data are successfully exported to the end-user format (e.g. ArcGIS shapefile or GeoDatabase, Excel spreadsheet, text file). For landscape-level spatial analyses for freshwater resource inventory and monitoring, an ArcGIS GeoDatabase is recommended. For report inclusion and archiving, an excel spreadsheet of coordinates and attributes, and an accompanying text file from the excel data are recommended.

In the Field

Assuming you have amply scoped your work as described above, there are relatively few additional considerations in the field. The primary consideration is local terrain. In cases where the field location is closely bounded by tall ridges, bluffs or other topographical 'obstacles' to a full view of the sky, it may be difficult to acquire good satellite signals, or enough satellite signals. There is little that can really be done about this, except to wait 15 to 30 minutes to see if the continual change in satellite orbital geometry creates more favorable conditions. As long as there are at least six satellites visible (including a WAAS satellite), it is likely that the data will remain within the accuracy specification. A related problem is 'multipath' or 'double-bounce', where the satellite signal reaches the receiver after reflecting off a topographical feature, like a canyon wall. There is even less that can be done about this, especially since the GPS unit has no way of knowing (or of informing the user) whether the signals it receives are direct from the satellite or are multipath. Since ease of GPS data acquisition is never the driver of site selection, the best thing the field technician can do about these confounding factors is to record information about suspect terrain to be included in the data and metadata.

Point Positioning

If point positioning via ArcPAD is the chosen data collection method, it is critical to ensure that the settings for datum and coordinate system (Section I) and correctly entered in the unit. Invisible to the user, the GPS unit, by default, uses WGS84 geographic coordinates for internal calculation and storage. For point positioning in ArcPAD, these are converted to the selected settings and stored. It is critical to have the settings correct now, in order to avoid the need for re-projection in ArcGIS after upload (which can lead to the introduction of errors). In ArcPAD 7.0.1, the datum conversion choices can be confusing, but you should always use "NAD_1983_To_WGS_1984_5".

Feature Logging

If feature logging via TerraSync is the chosen method, then it is not critical to check the unit, coordinate system and datum settings now. The data within the logged GPS rover files will be stored, by default, in the unit's native WGS84 geographic system. Conversion to NAD83 CORS96 occurs in post-processing after upload.

After Field Work

After field work, the data will need to be uploaded to the office computer, and converted to the end-user format as necessary. This SOP will not address each possible end user format, but instead will focus on initial processing steps, and on archive format and metadata.

Metadata

Metadata are critical for the legacy value of field data. Right now, the most efficient and effective approach is to use a metadata template stored as an editable PDF file, and to then transfer the relevant information from that form to an FGDC compliant metadata form appropriate for the archived GIS shapefile. The reason for the PDF as well as FGDC forms is that the PDF form allows easy inclusion in text, web distribution, and in reports. The metadata PDF should be filled out as soon after field work as possible, and included with any subsequent file transfers. An example PDF GPS Metadata form has been included with this SOP for reference.

GPS Data Collection Documentation (Metadata)		Toolik Field Station GIS 2005, 2011, 2012 University of Alaska Fairbanks Fairbanks, AK 99775-7000 (907) 474-2488 Andrew.Balser@uaf.edu
<u>Basis of Bearings and Coordinates</u>		
Linear unit:	Meters	
Geodetic datum:	WGS84 (G1150-ITRF00)	Epoch: 1997.0
Vertical datum:	NAVD88	
Coordinate System:	Geographic (lat/long)	
Feature Description:	GAL - NGS Benchmark on gravel knob ~1km east of Alaska DOT #5117 Brass cap. Mounted flush with ground	
Rover File Name:	GAL.dat	Base File Name: tool200705042200d.dat -> 0000
Field Technician (who collected data):	Andrew Balser	
PI Name:	Andrew Balser	
GPS Receiver:	Trimble 5700 - Mobile Base	
Antenna:	Zephyr Geodetic	
GPS & Mapping Software:	Trimble Geomatics Office	version 1.63
<u>Mapping Conditions:</u>	partly cloudy with minimal breeze, 5/4/07 22:00 UTC - 5/5/07 01:00 UTC	
<u>Mapping Process:</u>	Set and levelled antenna on benchmark using spike mount (13cm antenna height)	
<u>GPS Quality Settings:</u>	HDOP - n/a	
	SNR - n/a	
	Satellite Elevation Mask - 0.0 deg	
	Logging Rate - 30 seconds	
<u>Post Processing Technician:</u>	Andrew Balser	
<u>GPS Data Processing:</u>	TGO using Toolik Field Station permanent base station (NetRS) 68°37'11.66623"N 149°17'03.63840"W 974.767m (HAB) GAL_Adjustment_report.pdf	

Upload/processing

There are two workflows for this depending on the survey style used. For WAAS-enabled point-positioning, the data need only to be uploaded and ingested into the appropriate software (ArcPAD/ArcGIS at present). The data are, at this point, ‘ready to use’. Remember to keep the data in Geographic coordinates with the specifications from Section I. This will eliminate reprojection and datum uncertainty for current and future end users. This original and unaltered data file should be included as part of the permanent data archive. For WAAS-enabled feature logging, the original data files will need to be uploaded (currently using Pathfinder Office PFO software). The original data files should be saved and stored unaltered as part of the archive. This allows future users to reprocess them from scratch, ensuring that the data have not undergone any manipulation or reprojection. The files should also be post-processed as appropriate. In rare cases where GPS base files are available, they should first be differentially corrected and the base files saved as part of the archive. Data should then be exported as features, where all positions for each feature are averaged and integrated into a single coordinate and attribute set for each feature (currently done in PFO). It is important to note that GPS processing software is usually more reliable than GIS software for ensuring that the datum is truly correct. For this reason, the data should be exported with care to select the correct datum definition in the GPS software. Subsequent datum conversion in GIS software is not always considered reliable. For the same reasons, conversions to the desired coordinate system and datum for immediate use in spatial analyses should also be done with GPS software.

Archive

The following should be included in the final archive:

- Original GPS files – unaltered
- Original GPS base files – unaltered (when applicable)
- GPS Metadata PDF form
- Text table, including site names, coordinates in decimal degrees (7 decimal places) for horizontal and meters for vertical, field technician name and dates of acquisition. The text must also include coordinate system, datum, unit, and survey style descriptions. Frequently the only way future researchers can identify old sites is through information included in a text report. This is critical if that user either can’t access or can’t find the digitally archived data, or if the data became damaged or corrupted over time.

Using the Trimble GeoXH Unit

In addition to the GPS class offered by Joel Cusick, a variety of useful references are available. Three are listed here:

1. GeoExplorer CE Series: Getting Started Guide
2. GPS Mapping for GIS with TerraSync and GeoExplorer CE Series or TerraSync Operation Guide v2.40
3. Basic GPS Data Capture Using TerraSync: A Quick Start Guide

Scheduling Field Days

For your GPS unit to function properly and collect accurate geographic locations there must be at least 4 satellites overhead and preferably more. For practical purposes, we strongly recommend a minimum of 6. As of 2007, the US DoD NAVSTAR system maintains enough satellites and complementary orbits that, even in high-latitude locations, it is rare to experience related to poor satellite constellations. In addition, PDOP (the measurement of relative accuracy) must be less than 6. Schedule your field work at a date and time when the PDOP is <6 and the number of available satellites is ≥ 6 . In order to facilitate your data collection; ask the GIS Coordinator if the most current almanac is available. The almanac is a set of data that is used to predict satellite orbits over approximately a month long period.

To access the current Almanac, follow these steps:

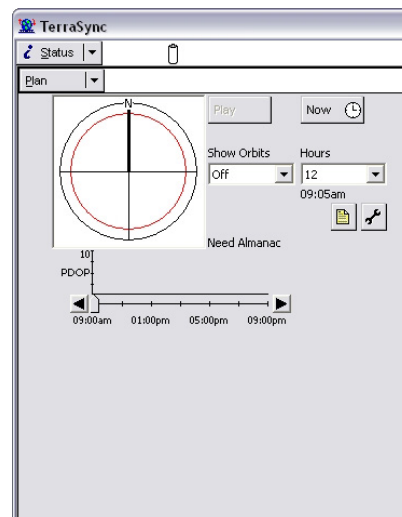
1. Open **Pathfinder Office** by double clicking on the icon on the desktop. The *Select Project* window will appear. For a specific park select the corresponding Project, otherwise close the window and continue.
2. Go into -> click on *Utilities* and choose *Quick Plan* from the drop down menu.
3. Select Date by choosing *Today*, *Tomorrow*, or *Day after Tomorrow* (Click on *Prev Month* or *Next Month* if the wrong month is displayed)
4. If necessary, enter the *Julian* date (see Appendix for definition) in the lower left corner and the *calendar* date in the lower right corner.
5. Press **OK** to close the dialog box.

Edit Point defines the general latitude and longitude location where observations are taken. Any location within 25 miles of the sampling locations should be adequate.

The *Status* window opens summarizing the information discussed in number's 2 and 3. Confirm the information and close the window.

You will now be in the *Plan: session #* window. Click on *Graphs* and choose *Number of SV's and PDOP* to get a graphical image of the number of visible satellites and the PDOP for the specified day and time. If your PDOP is above 6, that's too high and the GPS unit will reject readings. This also occurs when there are less than 4 satellites available. Therefore, you must schedule your field work for a date and time when PDOP is less than 6 and there are 4 or more satellites available.

Alternately, you can open TerraSync on the GeoXH and choose *Status* in the upper left corner drop down menu for short-term and on-the-fly field planning. Then choose *Plan* in the menu



below it. It will give you the PDOP and satellite orbits for up to 12 hours.

Data Dictionaries – Feature Logging with Terrasync

Data Dictionaries are standardized forms used for collecting data in Trimble GPS units. The Stream Monitoring project uses a single data dictionary called Streams. The current version (as of October 2011) is called Streams v1.1

Creating and Editing Data Dictionaries

Data dictionaries can be created and edited either by using the Data Dictionary Editor included in Pathfinder Office, or in TerraSync on the GPS unit.

Pathfinder Office Data Dictionary Editor

It is generally easiest to create or edit data dictionaries before the start of the field season, using Pathfinder Office software.

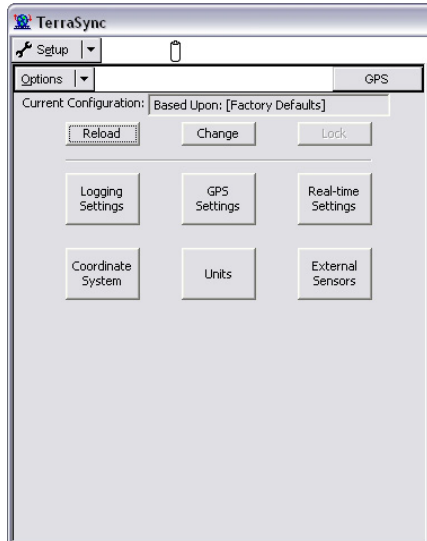
1. Open Pathfinder Office and select *Data Dictionary Editor* from the *Utilities* menu.
2. To create a new dictionary:
 - a. Fill in the Name field in the Untitled – Data Dictionary Editor window. This will be the name of the data dictionary, and should be short and informative. A comment may be added as well, but this is only for on-screen reference; it is not exported with the data.
 - b. Save the file in the appropriate folder (by year) in:
J:\Monitoring\Streams\TrimbleData\Data Dictionaries
*It is easiest if the Data Dictionary Editor name and the file name match
*Save the dictionary often as features and attributes are added
 - c. Click the *New Feature* button at the bottom of the screen
 - d. Enter the feature Properties (in the Properties tab)
 - i. Enter a name for the feature, using a maximum of 8 characters
 - ii. Enter a comment if desired; this is for on-screen reference only; it is not exported with the data
 - iii. Select the Feature Classification type (Point, Line, Polygon)
 - e. Enter the Default Settings (in the Default Settings Tab)
 - i. In general, the Time should be set to 1 second, unless creating large lines or polygons that don't require particularly high resolution.
 - ii. In general, the Minimum Positions can be left at 5
 - f. Enter Symbol settings (in the Symbol Tab) if desired
 - g. When all settings have been entered, select *OK*; the feature will be added to the list of Features
 - h. Attributes can be added to each feature by highlighting the desired feature, and clicking the *New Attribute* button.
 - i. Select the attribute Type (one of the following list), and click *Add*

1. Menu – letters, numbers, or other characters. Can select only one value (use only for fields where entries are limited to a set list of values and no others can be added)
 2. Numeric – numbers only, with decimals possible
 3. Text – letters, numbers, or other characters. Limited only by character limit settings (the maximum is 100 characters).
 4. Date – collects a date value
 5. Time – collects a time value
 6. File Name – collects a file name
 7. Separator –added to break up the list of attributes and increase readability; they are not attributes and do not contain attribute values.
- ii. Name the attribute, using a maximum of 10 characters
 - iii. Enter a comment if desired; this is for on-screen reference only; it is not exported with the data
 - iv. For menu attributes, create a list of options by clicking the *New* button to activate the New Attribute Value window. Add each desired value, limiting the Attribute Value field (the name displayed as the menu option) to 20 characters. Any characters may be used, including spaces.
 *It may be wise to include an “Other” option for unusual circumstances where none of the pre-defined options are appropriate.
 *To set a default menu value, select the *Default* check box when entering the attribute that will serve as a default.
 *To change any of the entered Attribute Values, or to change the default setting, double-click the value to be edited to open the Attribute Value window.
 - v. For numeric attributes, be sure to set the appropriate number of decimal places, and the minimum and maximum values. Take care to set the minimum and maximum values to reasonable levels, allowing for the full range of plausible values.
- i. Features and Attributes may be edited by clicking the appropriate *Edit* buttons.
 - j. When all features and attributes have been entered, be sure to Save the data dictionary file.
3. To edit an existing dictionary:
 - a. Select *Open* from the *File* menu (or click the Open icon on the toolbar) in the Data Dictionary Editor window.
 - b. New features or attributes can be added by clicking the *New Feature* or *New Attribute* buttons
 - c. Existing feature or attributes can be edited by highlighting the feature or attribute to be edited and clicking the appropriate *Edit* button.

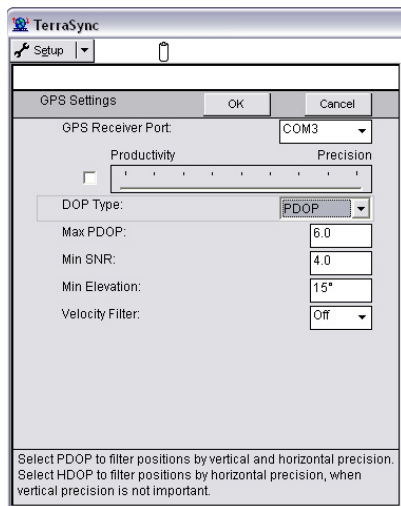
System Settings – Feature Logging with Terrasync

Configuring the GeoXH

In the drop down menu in the upper left corner select *Setup*. Once this is done you should see the following:



1. In Logging Settings change Antenna Height to **1.2 m**.
2. In Real-Time Settings choose **Integrated WAAS**.
3. In GPS Settings change defaults to the following:



4. In *Coordinate System* set the choices to the following:

System: Lat/Long (Geographic)

Datum: NAD83 (CORS96)

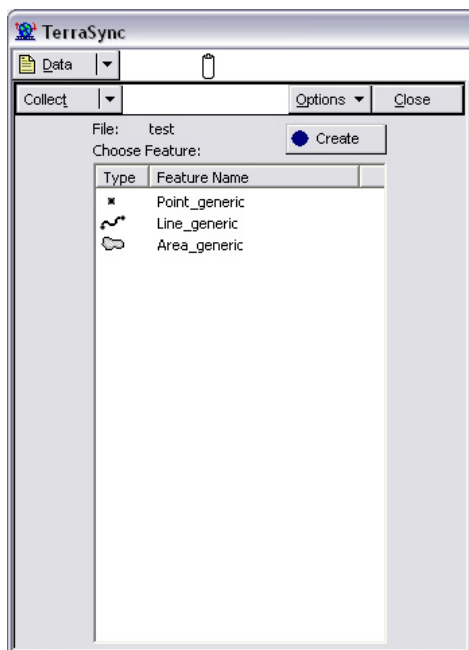
Altitude Reference: Height Above Ellipsoid (HAE)

Altitude Units: meters

5. In *External Sensors* nothing should be checked.

Data Capture – Feature Logging With Terrasync

1. Open TerraSync on the GeoXH.
2. In the dropdown menu in the upper left select Data.
3. If creating a new data file select New in the second dropdown menu.
4. In the File Name blank type a name with the keyboard option. Also select the data dictionary that you want to use in the Dictionary Name dropdown menu. Then click Create. If you were reopening a data file instead of starting a new one, instead of selecting New in the dropdown menu, select Existing File instead. When Choose Existing Data File screen appears, highlight the correct file and click Open. 5
5. Now highlight the Feature Type that you want to collect, and click Create.



6. Click the *Options* button and select *Logging Interval* and choose *1s*.
7. Fill in the data dictionary blank. If the Pause icon is flashing click the *Log* button. You should now see a pencil writing and a number beside it, which is the number of positions collected thus far. The CAKN stream monitoring program generally collects 50 positions

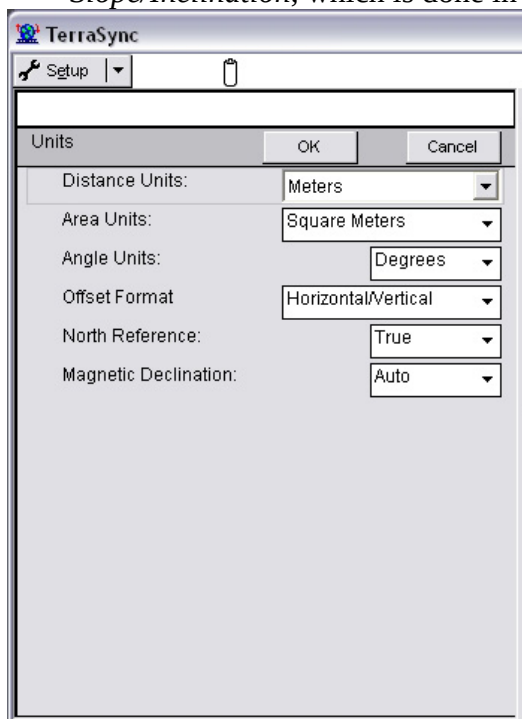
for each point. Positions for lines and polygons will vary. However, if making a polygon don't go past your starting point as this will create more than one polygon.

8. Click *OK* to finish collecting the feature.
9. If you want to collect another feature repeat steps 4-6. If done for the moment click *Close*.

Special Data Capture Methods

Offsets

1. In order to collect offset data you need to select either *Horizontal/Vertical* or *Slope/Inclination*, which is done in the **Setup, Units** window.



2. Then back in the **Data** window, after doing steps 1-6 in the Data Capture section, *pause* the position logging. Click *Options* and select *Offset*.
3. Depending on what offset choice was made, fill in the offset information (distance, bearing, etc.) and click *OK*. Then finish collection the feature positions and click *OK* to finish the feature.

Segmenting Line

While in the process of collecting a line, for an example lets say a trail. The trail has a part that is gravel and part that is paved. You do not want to collect 2 different features, that don't connect on the end. With Segmenting Line one feature is collected that you can attribute differently along the line.

When you come to the spot along the line that you want to attribute differently, click *Options* and select *Segment Line*. The logging positions start over and you are able to rename the line in the comment box. When you are done collecting the feature click *OK*.

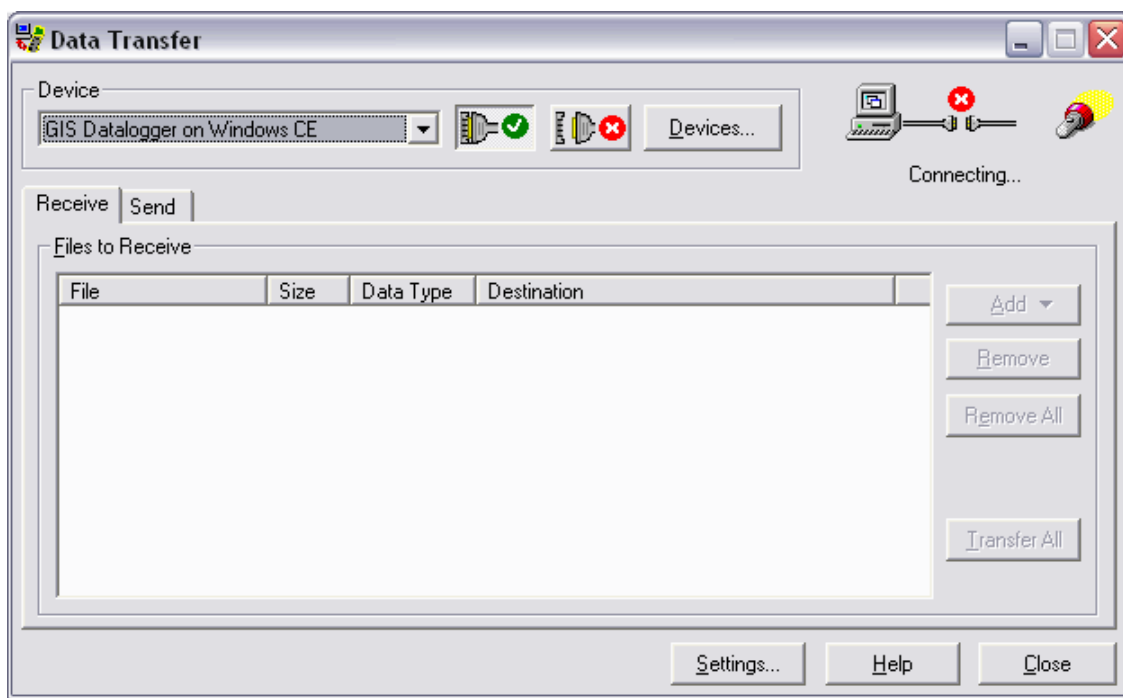
Continue

This function lets you pick up a line and add to it after it was closed. You just need to be in the Data Collect window, click *Options* and select *Continue*.

File Transfer

Before beginning file transfer from the Trimble to the PC, you must have Pathfinder Office and Microsoft ActiveSync already loaded onto the PC.

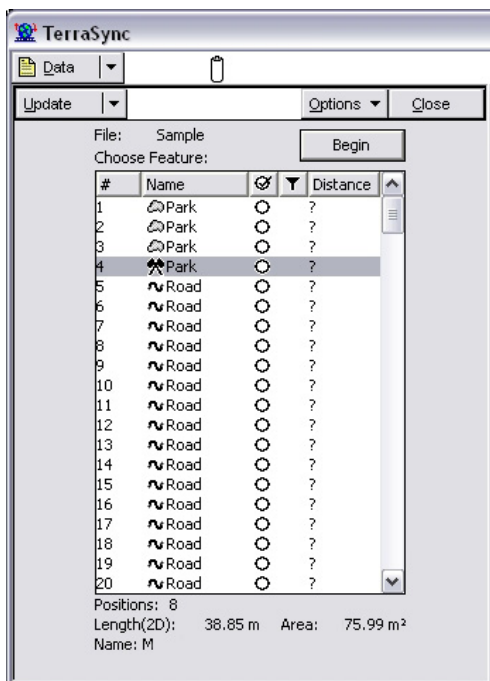
1. Put the GeoXH into the charging cradle. Attach the USB cable to the charging cradle and your PC.
2. Once you have the GeoXH locked into the cradle, Microsoft ActiveSync should automatically start. When a dialog box appears answer **No Partnerships**.
3. Once Microsoft ActiveSync is green and running, *open Pathfinder Office*.
4. In Pathfinder Office, click on *Utilities* and choose *Data Transfer*. A message will appear - *connecting to data logger*. This connection will either happen quickly or it will not work due to problems with the set up. If this occurs, check the cabling and your sequence of events. Also check that the cable is attached to the proper COM port. For the GeoXH this is *GIS Datalogger on Windows CE*.



5. Once the connection is made, check with the GIS coordinator that the Source directory is correct.
6. If you are downloading data from the GeoXH make sure the *Receive* tab is active. If loading data onto the GeoXH the *Send* tab should be active.
7. Next click the *Add* button, then choose the correct file type (data, waypoint, data dictionary, etc.). You may choose more than one file at a time. When all files have been chosen, click *Transfer All*.
8. When the transfer is done, click *Close* and then close all programs.

Navigation

1. First you must have a file on the GeoXH containing features that you can navigate to.
2. Next open TerraSync and open the Data window.
3. Highlight the file that has what you want to navigate to in it, click *Open*.
4. Then highlight the feature you want to navigate to, click *Options* and select *Set Nav Target*. The icon under the Name column should turn into 2 flags crossed over each other.



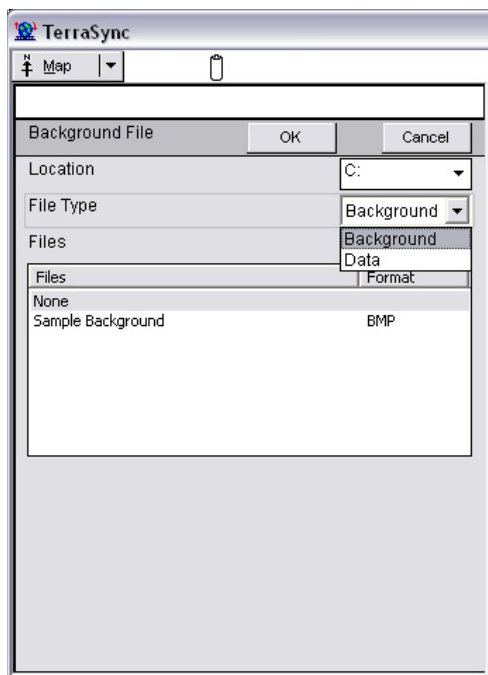
5. Now in the upper left hand corner dropdown box select *Navigation*. You now see a window that gives you bearing, heading, distance, and turn so you can navigate to your feature.

6. To deselect the navigation target, click *Options* and select *Clear Nav Target*.

Map Display

You can display background files or data files in the Map window. The files will be load onto the GeoXH by the GIS Coordinator.

1. First select *Map* in the upper left hand dropdown box.
2. Click *Layers* and select *Background File*.
3. Depending on if you are displaying a background or a data file, click the dropdown menu for *File Type* and select the one you want to use. (Data files examples: waypoint and rover files)



4. Highlight the file you want to display and click *OK*.
5. Your file is now displayed, use the map function buttons to zoom in and out and pan.

Differential Correction

This is done using Pathfinder Office software after the rover file is transferred to the desktop computer. As with everything, before you start double check that the coordinate system is correct.

1. Click on Utilities and choose Differential Correction.
2. Browse for the rover file that you want to correct.

3. Click Internet Search, New.
4. Select “Copy the most up-to-date list from Trimble’s Internet site”, and select from it, click OK. Under confirm setup click Yes.
5. Highlight the base provider that is closest to where the data were collected and click OK.
6. When base provider of the same name already exists. Overwrite existing base provider? Click Yes.
7. Provider Properties, click OK.
8. In the Confirm Selected Base Files box, click OK if you have a 100% coverage. If not, repeat steps 5-7, with the next closest base station until you get 100%.
9. Reference Position leave default values and click OK.
10. Make sure the output folder is correct, and click OK.

Exporting to Shapefiles

Check to see that coordinate system, units and datum are set to Lat/Long (geographic), decimal degrees, NAD83 (CORS96).

1. In Pathfinder Office click on *Utilities*, choose *Export*.
2. Browse to the file that needs to be exported. Also, make sure that the output folder is correct. Click the *Properties* button, then click the *Attributes* tab. The following should be checked: **All Feature Types** – PDOP, Correction Status, Receiver Type, Date Recorded, Time Recorded, Update Status, Data File Name, Filtered Positions, Data Dictionary Name; **Line Features** – Length (2D), Average Horiz. Precision, Worst Horiz. Precision; **Point Features** – Horizontal Precision, Standard Deviation, Position; **Area Features** – Area (2D), Average Horiz. Precision, and Worst Horiz. Precision. Click OK. Click OK again in the Export box, when everything is set.
3. Once a shapefile is exported you will want to rename that file right away using ArcCatalog. You want to do this because when a file is exported it is given a name like point_ge or what the feature was called in the data dictionary, and if you are going to be exporting more than one file the previous one will be overwritten.
4. After the shapefile is made, open ArcToolbox. Scroll to Data Management Tools; Projections, and click on *Define Projection Wizard (shapefiles)*. Browse to your file and set the coordinate system that you collected the feature in.

Glossary of Terms

Elevation Mask: Sets cut-off elevation for satellites (the unit will not gather positions from satellites lower than the degree set). Should be a minimum of 1 degree above the Base Station Mask with 15 degrees recommended. . This is most important during the planning stages. If you are working in locations with obstructions you can set the mask higher so that only those

satellites higher in the sky will be used for data collection. You can also allow for these situations by checking the azimuth position of satellites in Quick Plan

SNR Mask: Signal strength or Signal to Noise Ratio. If it's too high you won't get good data. The range is 0-99. If you raise the SNR mask you can receive more satellites but the data isn't as good. The default is 6.

PDOP Mask: Position Dilution of Precision. It is an indication of the accuracy of the calculated position based on the location of the satellites in the constellation. If satellite positions do not allow the use of coordinate geometry, then accurate ground locations can not be triangulated from them.

Less than 4 = very good; 5 to 8 = adequate; more than 8 stay home.

Julian Date: Day of the year between the range of 1 and 365. For example, the Julian Date for February 2 is #33. February 2 is the calendar date.

Feature: The thing about which you wish to collect data. Examples include buildings, woodlots, roads, trails, etc.

Attributes: Descriptive characteristics of features

Points, Lines, and Polygons: Geographic terms related to scale that describe how features are drawn. Points are single dimensional, lines have length, and polygons have area.

Differential Correction: Increases the accuracy of the data files by correcting errors associated with the satellites. (See Pathfinder Office help – differential GPS)

BoB: Beacon-on-a-Belt is a real time correction receiver.

GeoXH ICONS



Real-time WAAS: The GPS is picking up real-time corrections from WAAS



⌘ Battery power for the GPS.



Shows that the GPS is logging positions. The number is the amount of positions.

References

Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, R. McGinnis, H. Kristenson. 2011. Shallow lake limnology monitoring protocol: Central Alaska Network (CAKN) and Arctic Network (ARCN), Version 2.0. Natural Resource Report NPS/AKRO/NRR—2011/347. National Park Service, Fort Collins, Colorado.

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 7: Multiparameter Sonde Calibration and Maintenance

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Introduction

The multi-meter sensors for pH, conductivity and dissolved oxygen (DO) should be calibrated before leaving for the field, and the pH and conductivity sensors should be calibrated every few days while out in the field. Turbidity should only be calibrated in the lab, and is generally only done in the spring, before deployment. If there are fluctuating or otherwise unexpected readings occurring, additional calibration can be performed as necessary. On sampling trips where there are large changes in the barometric pressure, more frequent calibration may be required, particularly for the DO sensors.

Calibration procedures are detailed in the YSI Environmental Operations Manual, copies of which are kept in the lab, which is the primary reference for the following instructions for calibration. Another excellent resource is YSI’s “Calibration, Maintenance & Troubleshooting Tips”. The basic calibration steps are outlined below. Be sure to rinse the calibration cup, bulkhead and probes with the appropriate solution before each calibration step. Used or expired standards can be used for the first 2 rinses, but use fresh solution for the final rinse.

Sondes can be calibrated using the YSI MDS 650 handheld computer, or the StreamlineENV software program can be used to calibrate and archive calibration records using a laptop.

For tracking calibration results, a [Sonde Calibration Form](#) has been developed. A form should be filled out every time a calibration is performed using the MDS 650. Completed forms should be added to the Sonde Log Book and noted in the log for each instrument calibrated.

Calibrating Sondes using MDS 650

1. Connect a MDS 650 field computer to the Sonde, and turn on the power.
2. Calibrate the Conductivity probe:
 - a. Fill the calibration cup with 1500 $\mu\text{S}/\text{cm}$ standard solution, making sure that there is enough fluid to cover the entire conductivity probe. Standards lower than 1000 $\mu\text{S}/\text{cm}$ should not be used for calibration, even if expected field values will be lower, as the potential for contamination during calibration is too high. The calibration curve is very

stable, so it's not a problem to calibrate at a much higher level than is measured in the field.

- b. From the MDS Main menu, select Sonde menu, select Calibrate
- c. Select Conductivity from the Calibrate menu, and select SpCond
- d. Enter the standard value (i.e. 1.5 mS/cm) and press enter
- e. Watch for the values to stabilize, and enter the value in the calibration form as the start value, then press enter to calibrate.
- f. Verify the new post-calibration value, record it in the calibration form, and press enter to continue.
- g. If a message screen appears with the message "Out of range Accept Anyway?", press no and check to make sure that the probe is entirely submerged in calibration solution. Repeat steps d-h. If problems persist, contact YSI.

3. Calibrate the pH probe:

- a. Make sure that the pH mV reading is displayed on the report screen. If it is not, add it by selecting Sonde menu, selecting Report setup, and selecting pH mV.
- b. Fill the calibration cup with pH 7 buffer solution, so that the tip of the probe (with the glass bulb) is completely submerged.
- c. From the Sonde menu, select Calibrate
- d. Select ISE1 pH from the Calibration menu, and select 2-point
- e. Enter the first value as 7 (or whatever the appropriate value would be depending on the specific buffer and its temperature (appropriate pH values can be found on the standard bottle)).
- f. Watch for the values to stabilize and enter the value in the calibration form as the start value, then press enter to calibrate
- g. Verify the new post-calibration value and record it in the calibration form, along with the pH mV reading
- h. Fill the calibration cup with pH 10 buffer solution, so that the tip of the probe (with the glass bulb) is completely submerged.
- i. Enter the second pH value as 10 (or whatever the appropriate value would be depending on the specific buffer and its temperature).
- j. Watch for the values to stabilize and enter the value in the calibration form as the start value, then press enter to calibrate
- k. Write down the pH mV in the calibration form
- l. Check the slope of the pH mV (the difference between the mV readings for the pH 7 and the pH 10 solutions); it should be 165-180. Record it in the calibration form.

4. Calibrate the DO probe:

- a. Add a small amount (1/8") of water to the bottom of the calibration cup, and insert the sonde. Do not fully tighten the cup, so that it vents to the atmosphere. Make sure that the DO membrane is NOT submersed in water, but is just in air that's saturated with water. If using the Optic DO probe, make sure that there are no water droplets on the membrane or the temperature probe.
- b. Allow the sonde to sit for 10 minutes (up to 15 minutes for the Optic DO probe) to allow the air in the cup to become moisture saturated and for the temperature to equilibrate.
- c. Take a reading by selecting Sonde run from the main menu and waiting for the DO measurements to stabilize. Record the DO%, DO mg/L, and DO ch values in the calibration form.
- d. Select Sonde menu on the MDS 650, select Calibrate, select Dissolved Oxy
- e. Select Dosat%, and enter the barometric pressure. This can be taken directly from the MDS if it has the barometer feature. If there is no barometer feature on the MDS, use the

following tool to calculate the absolute barometric pressure (double click on the table to activate the Excel format) from corrected pressure data.

Barometer reading (http://climate.gi.alaska.edu/) in inches:	29.95
Barometer reading (http://climate.gi.alaska.edu/) in mm:	760.73
Local Altitude in feet above sea level:	450
True barometric pressure in mm of Hg:	749.48
Only the value in red needs to be entered for a new calculation.	

- f. Allow the sonde to calibrate (it may take up to a minute), and press Enter when instructed to return to the calibrate menu.
- g. Record the DO%, DO mg/L, and DO ch values in the calibration form. The DO% should be close to 100, and the DO ch values (the charge across the membrane) should be between about 35 and 50, with 40 being about optimal. If the charge is outside of this range, the membrane/electrolyte in the probe may need to be replaced, or the electrodes may need to be sanded. See the Care, Maintenance, and Storage of YSI 6-Series Probes and Sondes section of the manual for instructions, or online reference https://www.ysi.com/DocumentServer/DocumentServer?docID=YSI_T601

Turbidity Probe

Some of the YSI Sondes have a turbidity probe installed. The calibration of turbidity probes is not as straightforward as the rest of the probes, and is not performed as frequently. This document contains the steps required for performing routine turbidity calibrations. Refer to the YSI 6-Series User Manual (copies are kept in the lab), and also YSI's documents "Calibration, Maintenance & Troubleshooting Tips" and the Turbidity section of "Calibration Tips" for additional information.

Each sonde should be calibrated in the calibration cup supplied with the sonde. Alternatively, the probe guard may be installed, and the entire unit can be calibrated in a container large enough to accommodate the probe guard. The YSI 6920 V2 units should either be calibrated entirely with the probe guard installed, or be calibrated in the calibration cup, and then repeat the 0 calibration with the probe guard installed.

Turbidity calibrations are very linear across the range of standard concentrations, so there is no need for the use of very low or very high standards for calibration. YSI recommends the use of 126 NTU standard solution for calibration purposes. The calibration should be a two-point calibration, using a zero standard (such as DI water) for the first point and the 126 NTU standard solution for the second point.

For deployments in very low turbidity environments, there are ways to optimize the turbidity sensor, especially if negative values are being recorded. The most significant modification is setting a zero-offset. Refer to the Turbidity section of "Calibration Tips" for details.

Calibration Procedures

1. Ensure that the sonde is clean before calibrating.
2. To reduce potential contaminant sources, remove any unnecessary probes. Only the Turbidity probe and the temperature probe are required for calibration.

3. Wipe the optics with a KimWipe or lint-free cloth to ensure that they are free of any debris or fingerprints. Ensure that the wiper and pad are clean.
4. Install a new pad (and wiper, if necessary), before the calibration.
 - a. To replace the wiper, loosen the set screw and remove the wiper. Place a new wiper such that the setscrew seats on the flat of the wiper shaft. Gently press the wiper against the face of the probe until the foam pad is compressed to about half of the original thickness, then tighten the setscrew. There should be a gap of about 0.02" between the wiper arm body and the face of the probe (just enough of a gap for a business card to slide in).
 - b. To replace the pad, remove the wiper, replace the pad, and reinstall the wiper.
5. Test the functionality of the turbidity sensor
 - a. Hold your finger over the optics while the sonde is in discrete run mode at a one-second rate. The readings should reach full scale (~1000 NTU) within about 12 seconds. Clean the optics afterwards to make sure that there are no fingerprints left behind.
 - b. Verify the wiper function. It should wipe twice in one direction, then once back in the other direction. The wiper should park directly across from the optics.
6. Calibrate the probe
 - a. In the Sonde Menu, choose Calibrate – Turbidity – 2 point
 - b. Rinse the calibration cup and sonde 3 times with DI water (fill the cup, screw it on to the sonde, and shake)
 - c. Fill the calibration cup with 0 NTU standard (DI water), pouring it down the side of the cup to avoid aeration or development of air bubbles.
 - d. Put the sonde into the calibration cup, and engage one thread (do not screw it on completely)
 - e. Confirm that the temperature probe is submerged in the standard (the exposed metal thermistor probe at the bottom of the C/T probe)
 - f. Check for air bubbles, and run the wiper.
 - g. Wait at least 12 seconds after the wiper stops running before proceeding with the calibration
 - h. When a stable turbidity reading is achieved, press enter to calibrate
 - i. Pour out the 0 standard, and wipe the probes clean and dry
 - j. Pour an inch of 126 NTU standard into the calibration cup, attach it to the sonde, and shake to rinse. Repeat three times. Note that used standard from a previous calibration may be used for the rinsing process, and the standard from the last rinse may be saved for future rinsing use. Be sure to store used standard in a clearly-marked container, designated for rinsing purposes only.
 - k. Fill the calibration cup with 126 NTU standard, pouring it down the side of the cup to avoid aeration or development of air bubbles.

- l. Place the sonde back in the calibration cup, engaging one thread
- m. Confirm that the temperature probe is submerged in the standard
- n. Run the wiper, and visually inspect for air bubbles
- o. When the turbidity readings have been stable for at least 12 seconds, press enter to calibrate
- p. Keep the used 126 NTU standard for future rinsing use.
- q. Rinse the calibration cup and sensors

Calibration using StreamlineENV

Adding Sondes to the Device Manager

1. Open the StreamlineENV program and select Device Manager from the Tools menu
2. Connect the Sonde to the computer and click the Test button on the Device Manager. This will test the connection, and read the basic information about the Sonde.
3. Enter a name for the Sonde (usually consisting of the code of the park where it will be deployed and the Sonde model number)

Calibrating Sondes

1. Open the StreamlineENV program and select Device Manager from the Tools menu
2. Connect the Sonde to the computer and click the Auto (YSI) button on the Device Manager. This will identify the Sonde (as long as it has been added as a device to the program).
3. Click on the Configuration Manager button, and click the Read Sonde Configuration button.
4. Click the Open Template button, and choose the calibration file for the appropriate YSI model (i.e. use the “600 XLM Configuration” file for any of the 600 XLM models). This configuration is set up for use during Calibration, as opposed to deployment; the main difference is that the Auto-Sleep function is turned off for calibration so that sensor readings can be monitored in real time to verify stability at the time of calibration.
5. Click the Write Configuration Settings to Sonde button.
6. Click the Read Configuration Settings button
7. Make necessary changes to the configuration
 - a. Under the System tab, enter the GLP file to match the internal S/N listed below. Note that the template must have been written and read in order to display the correct S/N; if it has not been written and read, it will retain the S/N of the unit on which the template was created.
 - b. Verify that the Sonde date/time is synchronized to the computer (the box should be checked under the System tab).
 - c. Look through the remaining tabs to verify that they match the Calibration screen shots for the 6920v2.

- d. If any changes are made in the configuration, click the Write Configuration Settings to Sonde button again.
8. Click the Calibration button.
9. Click the New Calibration option in the Sensor Calibration panel.
10. Fill in the details for the Summary Report, especially the date and the technician fields. For calibrations performed before field deployment, identify the calibration as “In”. For post-deployment calibrations, identify the calibration as “Out”.
11. Select the desired probe for calibration, and continue with the specific instructions.

DO sensor

- When calibrating Rapid Pulse DO sensors, ensure that the probe has been kept in a moisture-saturated environment for 10 minutes before performing the calibration. To create this environment, add a small amount of water to the calibration cup, and set the probe into the cup. Do not tighten the calibration cup; it must be vented to the atmosphere. Ensure that the DO probe is not touching the water in the cup.
 - Calibration of the ROX Optical DO sensor is essentially the same as the Rapid Pulse, but before beginning, dry off the temperature sensor and the Optical DO membrane so that there are no water droplets present. Allow the probe to stabilize in a moisture-saturated environment for 15 minutes before performing the calibration.
1. Click the Dissolved Oxy option in the Sensor Calibration panel
 2. Refer to the directions in the information panel of the Streamline Window
 3. Click the DO Sat % option in the Sensor Calibration panel
 4. Enter the barometric pressure for the calibration location (it is convenient to use one of the 650 MDS units that have a barometer)
 5. Wait for the sensor to stabilize
 - o Streamline allows 40 seconds for stabilization before displaying the DO readings for Rapid Pulse sensors.
 - o Once the readings are displayed in the graph, watch for the values to stabilize. The readings should be stable for at least 30 seconds before the calibration is performed. This may take several minutes, or even longer if the cell has not been used in some time.
 - o If this is the first calibration since the membrane was changed on a Rapid Pulse probe, allow the measurements to run for 10 minutes before calibration.
 6. Click the Calibrate button. Watch the measurements for a while after the calibration to make sure that they are stable.
 7. Click the Continue button. Do not save the chart to file. Enter any comments about the calibration; this will be included in the Calibration Summary Report.
 8. Click the Previous Menu option in the Sensor Calibration panel to calibrate the next probe.

Conductivity sensor

- Rinse and fill the calibration cup with 1500 uS standard solution. Rinse the probes with standard, as well. Expired or used solution can be used for the initial rinses. Make sure that the conductivity probe is fully immersed in standard; the conductivity cells must be completely filled for proper calibration.
1. Click the Conductivity option in the Sensor Calibration panel
 2. Refer to the directions in the information panel of the Streamline Window
 3. Click the SpCond option in the Sensor Calibration panel
 4. Enter the conductivity of the standard in mS (1.5)
 5. Watch the graph and wait for the sensor to return stable readings
 6. Click the Calibrate button. Watch the measurements for a while after the calibration to make sure that they are stable.
 7. Click the Continue button. Do not save the chart to file. Enter any comments about the calibration; this will be included in the Calibration Summary Report.
 8. Click the Previous Menu option in the Sensor Calibration panel to calibrate the next probe.

pH sensor

1. Rinse and fill the calibration cup with pH 7 buffer. Rinse the probes with buffer, as well. The glass bulb on the pH probe must be completely submerged, with no air bubbles adhered to it.
1. Click the ISE1 pH option in the Sensor Calibration panel
2. Refer to the directions in the information panel of the Streamline Window
3. Click the 2 Point option in the Sensor Calibration panel
4. Enter the pH of the lower pH buffer (7)
5. Watch the graph and wait for the sensor to return stable readings
6. Click the Calibrate button. Watch the measurements for a while after the calibration to make sure that they are stable.
7. Click the Continue button. Do not save the chart to file. Enter any comments about the calibration (specify which standard is being referenced, if applicable, as all of the comments for both points are lumped together in the summary file); this will be included in the Calibration Summary Report.
8. Discard the lower pH buffer, rinse the calibration cup and probes with the higher buffer, and fill the calibration cup with the higher buffer.
9. Enter the pH of the higher pH buffer (10)
10. Watch the graph and wait for the sensor to return stable readings
11. Click the Calibrate button. Watch the measurements for a while after the calibration to make sure that they are stable.

12. Click the Continue button. Do not save the chart to file. Enter any comments about the calibration, referencing the standard.
13. Click the Previous Menu option in the Sensor Calibration panel, and click it again to return to the main calibration menu.

When finished with all calibrations, use the Deployment Wizard to set the Sonde to Idle mode (low battery use), to conserve batteries until the Sonde is prepared for deployment. See the Stop Logging portion of the Downloading Sondes section for detailed instructions on setting to Idle mode.

Review the Calibration Results

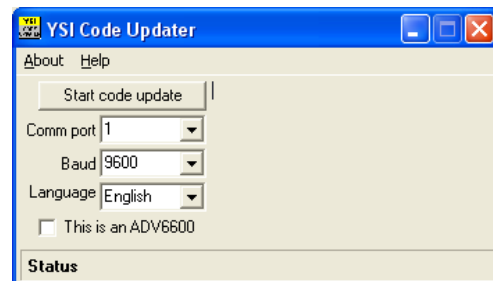
When you return to the main calibration menu, it triggers the generation of a Calibration Summary Report. The Calibration Summary is saved on the actual Sonde, for future reference. It can also be saved in a variety of formats in different locations. For long-term archiving of Calibration Records, the summary should be saved to a folder, so that it is not just on the Sonde.

1. Archive the Calibration Record
 - a. Save the record as both a .pdf and .xls type
 - b. Each instrument has a folder on the J drive in which calibration reports can be saved:
J:\Monitoring\Water_Quality_Macroinvert\Field_Data\Streamline\CalibrationReports
 - c. If the laptop is not connected to the network, calibration reports can be saved in the following folder on the C drive of the laptop, then transferred to the network later, either by connecting the laptop to the network or by using a thumb drive:
C:\Documents and Settings\All Users\Streamline\CalibrationReports
2. Check the values for each probe
 - a. DO – Rapid Pulse
 - i. The DO Charge should be between 25 and 75 (35-50 is better, with 40 being optimal)
 - ii. The DO Gain in the calibration constants section should be between -0.7 and +1.4.
 - b. DO – ROX Optical
 - i. Note that the Sonde will only read 100% saturation if the barometric pressure is 760 mmHg. To determine the actual DO is %, divide the barometer reading by 760 and then multiply that number by 100.
 - ii. The ODO Gain in the calibration constants section should be between 0.85 and 1.15.
 - c. Conductivity
 - i. Check that the conductivity cell constant is 5 ± 0.45
 - d. pH
 - i. The mV values for pH7 should be 0 ± 50
 - ii. The mV values for pH10 should be -180 ± 50

- iii. The pH slope should be between 165 and 180 (note that Streamline calculates the slope from pH7 to pH10 as negative; consider the absolute value of the calculation).

Updating Firmware

- Before preparing Sondes for deployment, ensure that the most recent firmware has been installed on the Sondes.
 - Note that all files residing on the Sonde must be downloaded; they will be deleted in the process of the firmware update.
1. Download the YSI Code Updater from <http://www.ysi.com/software.php>, and install it in C:\Program Files\YSI Code Updater.
 2. Open the Device Manager in Streamline, and press the Firmware Update button.
 3. Click the Browse button and verify that the path is correct.
 4. Click the Update button, and enter the settings shown in the window to the right.
 5. Click the Start code update button.
 6. When the update is complete, close the YSI Code Updater window.



Configuring Sondes for Deployment

At present, the CAKN Stream Monitoring Program has no sondes deployed on a seasonal or permanent basis. However, the program plans to deploy sondes in the future; therefore, instructions for preparing and configuring sondes for extended deployment are included here.

600 XLM

1. Open the Device Manager in Streamline, and use the Auto (YSI) button to recognize the Sonde
2. Click the Tools button and select the Configuration Manager button.
3. Read the Sonde Configuration, then click the Open Template button.
4. Select the appropriate template from the dropdown list, making sure that it is the Deployment template for the correct Sonde model (i.e. 600 XLM Deployment), and wait for the template to be applied.
5. Click the Write Configuration settings to Sonde button and wait for it to update, then again click the Read Sonde Configuration button before making changes to the template.

- a. Make the following changes to the template, to customize it to the instrument and the new sampling event.

Device Manager/Setup: DENA 600 XLM

Explorer Calibration Configuration Manager Template Manager Firmware Update Return

Sonde Configuration

Discrete Sampling **Unattended Sampling** System Report Sensor Advanced Calibration Constants

The device is not logging - the parameters below may be modified.

Sampling Interval (hh:mm:ss) 01:00:00

Start Date (mm/dd/yyyy) 05/07/2010

Start Time (hh:mm:ss) 13:00:00

Duration (days) 180

File name (maximum of 8 alphanumeric characters) DENA600

Site name (maximum of 30 characters) LABTEST

Power and Memory Estimates (Click 'Write Configuration settings to Sonde' to refresh)

Battery voltage 6.9 volts

Battery Life 113. days

Free Memory 813. days

First Sample 40.0 minutes

Use these commands to read/write the configuration from/to the sonde

Read Sonde Configuration

Write Configuration settings to sonde

Use these commands to load/save the configuration settings from/to a template file on your computer.

Open Template

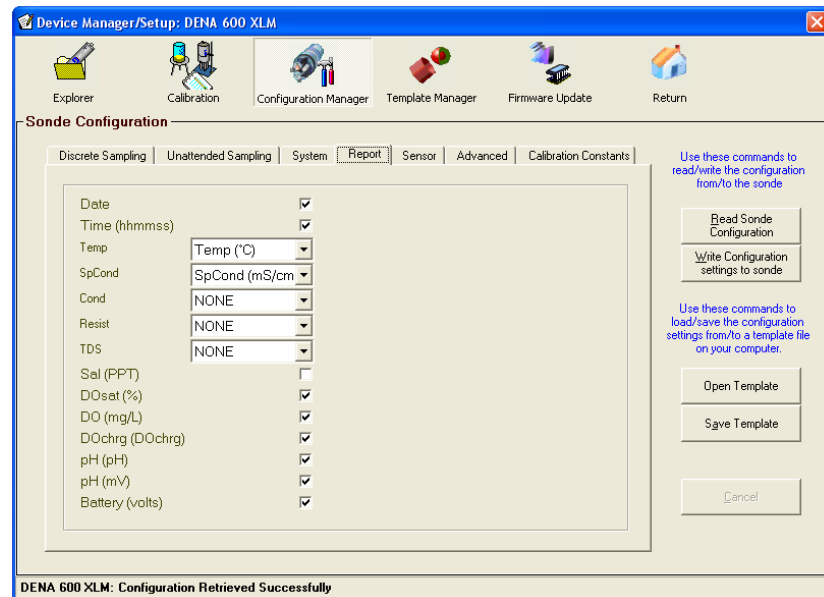
Save Template

Cancel

Template loaded successfully

- b. In the Discrete Sampling tab, change the filename to be the park and the sonde model (i.e. DENA600), and change the sitename to be the stream sitecode where the sonde will be deployed. If the specific sitecodes are not known at the time of configuration, the park code can be entered followed by 1 or 2. Be sure to keep good notes of the actual location for each Sonde at the time of deployment. Verify the settings in the Unattended Sampling tab, making sure that the Sampling interval is set for 1 hour, and that the appropriate start date and time are entered. Make sure that the new filename and sitename entered in the Discrete Sampling tab carried over.
- c. Under the System tab, select Synchronize Sonde date and time to computer. Change the GLP file to match the Circuit Board Serial Number listed below (note that if the template has not been written and then reread to the Sonde before this step, the Serial number from the template will be retained).

- d. Verify the settings in the Report tab. All of the check boxes should be selected, except for Sal. Temp should be set to °C, SpCond should be set to mS/cm, and Cond, Resist, and TDS should be set to NONE.



- e. Under the Sensor tab, all of the sensors should be selected except for ISE2 Orp.
- f. The Advanced tab should be set up as follows:
- Setup: check the boxes for VT100 Emulation, Auto Sleep RS232, Auto Sleep SDI12; leave all the other check boxes empty.
 - Sensor: The DO temp co % should be set to 1.1% for the Rapid Pulse sensors. The DO Warm Up time should be set to 40 seconds. All of the other values should be set to 0, as they are not applicable for the XLM units.

- iii. Data Filter: this should be left blank for the XLM units, because they do not have optical probes installed.

- g. Nothing is changed in the Calibration Constants tab.
- h. Check the start time and date again before finalizing the configuration. If the template was not written and reread to the sonde before the time/date was set, the start time will probably change to be an hour after the current time/date.
- i. When everything has been set correctly, click Write Configuration settings to sonde.

6920

Follow the same process as for the 600 XLM, but choose the 6920v1 Deployment template. There are some significant differences in the settings for the 6920 units:

1. The DO temp co %/C should be set to 1.1 for the Rapid Pulse probes. If the probes are changed to optical probes, they should be adjusted accordingly. The current settings for the ROX probes are 1.27%, unless they have the brass anti-fouling caps on the end of the sensor, in which case they should be set to 1.5%.
2. The data filters should be set for Time Constraints for all optical probes. Click the Enabled check-box next to Time Constraint, and enter a value of 30. Generally the only optical probes installed on the 6920 units are Turbidity.

3. The 6920 units are equipped with depth sensors, but because they are held at the surface, the depth data is of little value. If the depth is to be tracked, the latitude and altitude for the deployment site should be entered into the appropriate fields.
4. Check that the DO Warm Up is set to 40 for the Rapid Pulse sensors.

6920 V2

Follow the same process as for the 600 XLM, but choose the 6920v2 Deployment template. There are some significant differences in the settings for the 6920 v2 units:

1. The Optical DO temp co %/C should be set to 1.27%, unless they have the brass anti-fouling caps on the end of the sensor, in which case they should be set to 1.5%.
2. The data filters should be set for Time Constraints for all optical probes. Click the Enabled check-box next to Time Constraint, and enter a value of 30. Both Turbidity and Dissolved Oxygen optical probes should have this setting enabled. If both probes are present on a unit, either one can be chosen to serve as the Time Constraint probe.
3. For the Optical DO sensors, the warm up time should be set to 40 seconds.

Activating the Sondes for Deployment

1. Configure the Sonde with the appropriate deployment template as described, and click the Return button to clear the COM port. Keep the sonde connected to the computer.
2. Open the Deployment Wizard under the Tool menu, and click Next to reach the device selection window.
3. Select the appropriate YSI unit, and click Next.
4. Make sure the sonde is connected to the computer, check the box for changing the parameters, and click Next.
5. In the Deployment Type window, select the Autonomous or unattended deployment option, and click Next.
6. Enter the sampling interval for 1 hour, and set the start date and time as applicable. For duration, select the longest possible length of deployment. Enter the park code and sonde type for the File, and enter the lake name (if known) for the Site. If the lake names are not known at the time of setup, just enter 1 and 2 after the park code, and make sure that detailed notes are taken on the deployment location for each sonde. Set the option to synchronize the sonde date and time to computer. Click Next.
7. Verify the parameter list. Date and Time should be selected. Temp should be set to °C, SpCond should be set to µS/cm. Cond, Resist and TDS should all be set to NONE. All the rest of the items should be selected, except for Sal and Orp. Click Next.

8. When the Wizard has finished Optimizing the Sonde configuration, close the wizard and return to the Device Manager.
9. Open the Configuration Manager, and click the Read Sonde Configuration button.
10. Check the settings in all the tabs to make sure nothing was changed in the optimization process. Streamline tends to make some standard changes to the configuration, and one way to make sure that everything is OK is to again load the Deployment Template. It will come up with a message that it can't change some of the parameters while logging is activated, but it will apply all the rest of the settings. Be sure to check that the GLP file (System tab) reads correctly. The settings can also be changed manually. Some of the main things to look for include:
 - a. In the System tab, check the box to synchronize the time and date of the Sonde to the computer.
 - b. In the Advanced tab, make sure the DO Warm Up time is set to 40 seconds, and the Wait for DO box is checked.
 - c. In the Data Filter section of the Advanced tab, make sure that the Enable filter check box is empty.
 - d. For units with depth sensors, make sure the latitude and altitude are entered correctly.
11. After all necessary changes to the configuration have been made, click the Write Configuration Settings to Sonde button, then click the Return button to clear the COM port
12. Disconnect the Sonde, and screw the protective cap for the cable connection into place.

There are a couple of ways to activate logging on the Sonde. Once the configuration has been set up, the Deployment Wizard can be used to activate the sonde. Unfortunately, in order to start logging using the Wizard, the program runs an Optimizer, which changes some of the settings in the configuration. Once the sonde has been activated, however, it is possible to go back into the configuration and change these features. It may work to activate the Sonde first, and then apply a template to complete the configuration. The other option for activation is to use the 650 MDS. The sonde can be configured with Streamline, and when it's time to activate, it can be attached to the MDS and logging can be activated.

Downloading Sondes

The active logging by the Sonde can be stopped either before or after the download of the data. For mid-season downloads, it's easiest just to download the data while the unit is still logging. At the end of the season, however, the logging can be stopped as soon as is convenient, and then the data can be downloaded at any time.

Stop Logging

1. Open the Deployment Wizard
2. Select the appropriate Sonde from the list
3. Click Next to reach the Deployment Type window
4. Select the Cancel Deployments (Idle mode) from the options and click Next
5. Note that the Device Manager window cannot be open at the same time as the Deployment Wizard is being used to stop logging.

Download Data

1. Open the Device Manager and click on the Explorer button if it is not already active.
2. Click the Refresh File icon beneath the file list. Note that if the logging has not been stopped, the last entry in the downloaded file will be the last entry before the file list was refreshed.
3. Check the box next to the data file/s to be downloaded (data files are designated with the .dat extension), highlight the DataDownloads folder in the Destination Window, and click the Upload Selected Files icon. Note that the DataDownloads shortcut leads to a folder on the CAKN drive:

J:\Monitoring\Streams\Field_Data\Streamline\DataDownloads
4. After the data has been downloaded, it should be moved to the appropriate folder and named according to protocol (see Continuous Monitoring SOP for details).
 - J:\Monitoring\Streams\Field_Data\Continuous_Data\Sonde_data
 - Model_PARK-XXX_YEAR_Serial# ex: YSI600XLM_DENA-018_2009_09C101468.dat
5. The data files on the Sonde should be deleted once they are downloaded and archived. It is best to leave them on the unit for a while if possible, until the downloads are verified and secure. One good approach is to delete the Sonde files during the process of preparing the Sondes for long-term storage in the fall.
 - a. In the Explorer window in the Device Manager, click the Delete icon to delete the files
 - b. Note that when the Delete function is used, it will delete all of the files listed as being on the Sonde, not just the ones that are checked.
6. Click the Return button to clear the port before trying to stop the next logger.

Preparing Sondes for Longterm Storage

We currently have 4 different models of the YSI Sondes, and each requires slightly different treatment in preparation for storage. The general steps are listed below, followed by specific treatments for some of the Sonde models and Probes with different features. Refer to the YSI Tech Note for the Care, Maintenance, and Storage of YSI 6-Series Probes and Sondes for additional calibration information.

Sonde Preparation

1. Wash the exterior casings of the Sonde (with the calibration cup still attached over the probes) using clean tap water and a sponge. Scrub the probe guard that was attached to the unit during deployment, inside and out, using a long-handled scrub brush.
2. Check for debris in the cable connector socket and use pressurized air to clean out the socket if necessary.
3. Remove the calibration cup from the first Sonde and clean the outside of the sensor probes with clean tap water and a sponge. Take care not to touch the rapid pulse DO sensor membrane if there is one present.

4. Clean the conductivity probe ports using clean tap water and one of the black brushes provided in the YSI maintenance kits. Insert the brush completely into each of the two holes at the tip of the probe 10-15 times.
5. Use a swab and clean tap water to clean the pH sensor tip, including the glass bulb. Take care not to wedge the swab too tightly between the glass bulb and the probe casing.
6. Ensure that the logger has been stopped.
 - a. Connect the Sonde to a MDS 650 unit. Under the Sonde Menu, select Run – Unattended Sample – Stop Logging and confirm the stop.
 - b. Return to the Sonde Menu, and select Status to verify that the logging status is Inactive.
7. If there are optical probes on the unit, clean the optics (there is an option on the run screen).
8. Test the pH and conductivity probes using calibration standards. Record the readings, and calibrate the sensors. Take note of any unusual readings, so that probes can be sent away for repair or replacement in preparation for the next season.
9. Remove the pH probe using the metal installation tool from YSI. Clean the probe further if necessary. Fill a pH probe storage container with pH 4 buffer solution, insert the probe, and secure using the ring cap with an O-ring. Label the probe with the serial number of the unit from which it was taken. Ensure the connection socket on the probe is clean and dry, then cap with one of the clear plastic sleeves provided. Note that the probes cannot be removed from the 600QS. See Special Treatments section below for further instructions.
10. Remove the turbidity probe if present. Clean the probe further if necessary. Label the probe with the serial number of the unit from which it was taken. This probe is stored dry. If desired, this probe can also be left attached to the bulkhead and stored wet with the DO and Conductivity probes, but storing dry minimizes probe degradation.
11. Check the remaining probes to make sure they are clean. If there is a rapid pulse DO probe, check to make sure that the membrane is intact and filled with electrolyte. If the membrane is damaged or otherwise compromised, remove it and replace the electrolyte and membrane. Do not store a rapid pulse DO probe without a membrane installed or with low levels of electrolyte.
12. Ensure that the sockets in the bulkhead dry completely before inserting plugs. If there is moisture in the sockets, drape the remaining probes loosely with wet paper towel and slide a plastic bag over the probes, keeping the remaining probes humid while allowing the empty sockets to dry thoroughly. Compressed air can also be used to help dry the sockets. Once they are completely dry, insert port plugs into the sockets and tighten them securely. Do not over-tighten the plugs, as they can break inside the socket.
13. Test the DO probe by adding a small amount of water to the bottom of the storage cup and setting the Sonde in without twisting the cap on. Allow the unit to sit for 10 minutes so that the air can saturate with water. Calibrate the probe. If there are unusual readings, replace the membrane and re-check. Take note of any persistently unusual readings, so that probes can be sent away for repair or replacement in preparation for the next season.

14. Fill the storage cup with clean tap water, and screw it tightly to the bulkhead to prevent evaporation and drying. For long-term storage, the DO sensor should be submersed in water, not just be kept in a humid environment. Tap water is better than DI or distilled water.
15. Remove the batteries from the Sonde.
16. Store the Sonde hanging by its bail in a cool, dry place.
17. It is a good idea to check on the Sondes periodically while they are in storage to make sure that the caps still contain sufficient water levels. Add water if necessary.

Special Treatments and Considerations

- The 6920 version 1 unit has depth sensors, including a pressure port accessed by small holes on either side of the unit just above the bulkhead. This should be flushed with clean tap water using one of the syringes provided in the YSI maintenance kit. Push the water into one hole using the syringe until the water being expelled from the other hole runs clean.
- The 600QS units do not have removable probes. The unit and probes should be cleaned as described above, and the probes tested against calibration solutions. The Nalgene bottle provided for storage should be filled with 350 mL of 2M KCl, and the bulkhead end inserted (with the probe guard attached) into the bottle so that all of the probes are submerged in solution. The ring cap should be tightened, using an O-ring to ensure a good seal. The area around the ring cap (including the adjacent parts of the Sonde unit above and the bottle below) should be wrapped with parafilm to further limit evaporation. Replacement O-rings are available from YSI (item number 063241). 2M KCl is available from VWR (100219-982 for 1L; 100219-992 for 500 mL; manufactured by Teknova).

References

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 8: Field Methods

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) provides step-by-step instructions for all procedures that will occur during the collection of field data from streams, with the exception of capturing and processing fish using minnow traps, angling and electrofishing. Included in this SOP are instructions for assessing and establishing a sampling reach, establishing a reach monument, collecting water chemistry data with a sonde, collecting and processing water samples, collecting and processing macroinvertebrate and benthic diatom samples, conducting channel surveys, measuring discharge and reach slope, and documenting the reach with panoramic photography. The procedures outlined here are essential for the successful implementation of the CAKN Flowing Waters program. Each crewmember needs to carefully review and understand this entire protocol, including all related SOPs, data sheets and instructions. Related SOPs include SOP 6: Using GPS; SOP 7: Multiparameter Sonde Calibration and Maintenance; SOP 5: Field trip Mobilization; SOP 10: Spherical Panoramic Photography; SOP 11: Decontamination; and SOP 12: Field Trip Demobilization. These methods are in large part adapted from the EPA National Rivers and Streams Assessment Field Operations Manual (EPA 2013a), which should be consulted as needed for clarification.

Outline of data collection workflow

- Both crewmembers evaluate site and define study reach. This does not apply for repeat site visits where reach is already established.
- Establish reach monument with Trimble.
- Measure *in situ* water chemistry with sonde.
- Collect water sample.
- Crewmember 1 does macroinvertebrate sampling while crewmember 2 processes water chemistry samples, organizes macroinvertebrate and diatom processing gear, labels sample jars (including inside labels on RITR paper) and then collects rocks for diatoms.

- Crewmember 1 processes macroinvertebrate sample while crewmember 2 processes diatom sample.
- Both crewmembers conduct channel survey (+ active layer transect if applicable).
- Both crewmembers measure discharge if applicable.
- Both crewmembers measure reach gradient.
- Crewmember 1 does panoramic photo(s) while Crewmember 2 does site notes.
- Both crewmembers check to make sure all data have been collected.

Before leaving for the field

Before leaving for a multi-site field trip, check the gear list below to ensure that all necessary gear is present and in working order.

- Charge satellite phone battery and spare battery fully
- Charge King radio battery and spare battery fully if applicable
- Charge ATG radio battery fully if applicable
- Charge Trimble unit fully
- Make sure correct data dictionary is loaded into the Trimble
- Charge digital camera battery and spare battery fully
- Make sure camera memory cards have been downloaded and pictures deleted
- Calibrate multiparameter sonde
- Check out a shotgun if desired
- Notify appropriate Park Ranger and/or Dispatcher before going into the field
- Arrange flight following if appropriate
- Arrange daily call in and check in procedures
- Review backcountry safety plan
- Make sure vehicle and/or boat has been reserved (if necessary)
- Make sure Aviation Safety Plan has been submitted and approved (if flying)
- Make sure housing arrangements have been made (if necessary)

Required gear:

First Aid kit

Bug spray

Bug shirts for each crewmember (optional)

ATG radio preset to correct local frequency (WRST 122.9 except Northway 123.6, Tok 122.8, DENA 122.9, YUCH 122.8)

Satellite phone + spare battery

(King radio preprogrammed to appropriate park frequencies + spare battery case)

Normally this will be obtained from the park

Bear spray + holster for each crewmember

Remington 870 shotgun + at least 6 shells (optional)

If working in backcountry - emergency survival kit + tent

Spare batteries (4 'C', 4 'AA', 4 'D')

Trimble GeoXH with clickit cradle, cable and external battery. Sampling locations should be entered into the Trimble as waypoints (identified by site code). Current data dictionary should also be loaded. See SOP 6: Using GPS.

Backup GPS (Garmin eTrex or equivalent)
 RITR field notebook
 RITR Supplemental Data sheets
 Communications information sheet
 Research permit for appropriate park unit
 Mechanical pencils (multiple)
 Sharpies (multiple)
 Metal storage clipboard or equivalent
 Nikon D-40X or equivalent with at least a 1 gigabyte SD card, 18-70mm lens and 16mm fisheye lens, plus spare camera battery and spare SD card
 Manfrotto carbon fiber tripod
 Nodal Ninja 5 camera mount for panoramic photography, preset for the camera-lens combination you have
 Multiparameter sonde (YSI 600QS or equivalent)
 Conductivity calibration solution, at least 1500 μ S/cm. 15 mS/cm is preferred. Calibration of the YSI QS650 sonde requires ~500 mL/calibration, and the unit should be calibrated ~every 3 days in the field. Always order more than you think you will need for the season! Oakton conductivity standards can be ordered from Cole-Parmer, VWR and many other scientific suppliers.
 pH calibration solutions – 4.0, 7.0 and 10.0. In general only pH 7 and 10 standards will be used, since most streams have pH above 7. Therefore, you will generally not need to order more than 500 mL of pH 4.0 standard unless you anticipate sampling a large number of acidic streams. pH calibrations of the YSI QS650 sonde require ~250 mL/ calibration and the unit should be calibrated ~every 3 days in the field. Always order more than you think you will need for the season! Oakton pH standards can be ordered from Cole-Parmer, VWR and many other scientific suppliers.
 1 liter clean Nalgene for collecting water chemistry sample
 Acid washed sample bottles (sent each year from CCAL):
 1 500 mL per site
 1 250 mL per site
 1 125 mL per site
 Water chemistry kit:
 1 liter plastic Erlenmeyer vacuum flask
 Magnetic filter apparatus (HACH, Inc)
 Manual vacuum pump with pressure gauge (HACH, Inc)
 47 mm diameter GF-F filters (at least 3 per site)
 47 mm diameter, 0.45 micron pore size Whatman polycarbonate filters (at least 5 per site)
 Clean filter forceps (stored in a 15 mL Falcon tube)
 Small cooler for field transport of water samples (with dry ice if available)
 Large cooler for storage and transport of water samples (with dry ice if available)
 Periphyton kit:
 1 liter graduated Nalgene for periphyton
 At least 2 medium stiffness toothbrushes and/or fingernail brushes
 Scraping tool (chisel)
 At least 2 12 cm² rubber templates (2 5/8" x 1 11/16" x 3/32" bathtub drain gaskets)
 Lugol's solution (Carolina Biological Supply), 2 mL per site
 60 mL syringe with short piece of flexible tubing attached
 Modified D-net (500 μ m nylon mesh) with detachable extendable handle
 At least one spare net and handle
 Soil sieve (500 μ m mesh - #35) with bottom pan and lid
 In sieve:
 At least 2 pairs of forceps
 At least 2 small plastic spoons
 Sharpie(s)
 Pencil(s)
 Pre-printed RITR internal labels (at least 6/site)
 Pump-type insecticide sprayer
 2 14-liter buckets with pour spouts
 2 white plastic dish tubs
 At least 6 500 mL HDPE Nalgene sample bottles per site, with tops, 4 filled with 95% ethanol

At least 2 50 mL Falcon tubes with lid per site
 Preprinted RITR internal labels, 10 per site
 Gravelometer (USGS standard)
 30 meter tape
 100 meter tape
 Spherical densiometer (convex)
 Stadia rod or 3 meter (3 piece) marked 1" PVC or 2 x 2 meter marked 1" PVC (2 piece)
 [transit level or equiv. + tripod]
 AND/OR
 [hydrostatic level setup – marked tubing, 4 hose clamps]
 AND/OR
 [clinometer]
 Topsetting wading rod, metric
 Flowmeter (Flo-Mate or equivalent)
 Active layer probe tool, marked to 5 cm intervals
 Multi-pocketed field vest
 Heavy-duty Gore-Tex waders for each crewmember. Guide-quality waders are recommended.
 Non-felt-soled wading boots for each crewmember. Guide-quality wading boots are recommended. Korker
 wading boots, supplied with interchangeable soles, are recommended in case safety
 considerations necessitate a felt-soled boot. Low-rise Xtra-Tuf rubber boots ("Alaska sneakers")
 make excellent non-felt-soled wading boots for many streams.
 Shoulder-length rubber gloves, connected with cloth "bungee"
 Neoprene fishing gloves ("Glacier Gloves") – at least 1 pair per crewmember

Field Operations

Site evaluation and reach selection

Use Trimble to navigate to GPS coordinates of target site (see SOP 6: Using GPS). If the site has been sampled before, these coordinates will be the bottom of the reach (unless noted otherwise in the site notes for that site). Consult the site notes to determine the reach length applied during previous visits. If this is the first time the site has been sampled, proceed as outlined here:

If the target coordinates are accessible, walk upstream a distance equivalent to the approximate reach length (40 times the wetted width – take three to five representative measurements if not sure of visual estimate).

Evaluate the suitability of the reach:

Avoid major tributary junctions

Ensure that the reach is accessible along its entire length

Avoid braided channels if possible

Assess whether most of the reach is safely wadeable

Ensure that the reach appears representative of the larger stream segment

If necessary, alter reach endpoints to generate a reach that still includes the GPS coordinates of the site. If that is not possible, move reach endpoints as necessary to define a useable reach in the general vicinity.

Establishing the Reach Monument

The reach monument should be established on the streambank at transect A if at all possible. If it is necessary to establish the reach monument in another location (due to poor satellite coverage, for example), be sure to make a careful note of the fact under the Reach Monument “Comments” section in the Trimble data dictionary. For example, “Reach monument is 50 meters upstream of transect A, midway between transects B and C”. Also record this information on the supplemental data sheet.

Once the sampling reach has been selected, turn on the Trimble if it is not already on. Start TerraSync. In the top dropdown menu in the upper left of the screen select “Data”, then select “New” from the dropdown menu directly underneath. The Create New Data File window will appear. Check that File Type is “Rover” and Location is “Default”. Use the keyboard to enter the site name and site code in the following format:

Sitecode Sitename Date

DENA-019 EF Toklat 15-Aug-09

For sites on the GRTS list, the sitecode format is DENA-GRTS-030. Make sure the most current “Streams” Data Dictionary is selected under the Dictionary Name menu. Click “Create”. (Note that if you are reopening an existing file, select “Existing File” instead of “New”, then select the correct file name).

Under the Feature Type menu, select “Site Marker”. Make sure Antenna Height is “0” (this is the default). Make sure the Logging Interval is set to 3 seconds. Place the Trimble in the desired location for the Reach Monument and click “Create”. Leave the Trimble unit undisturbed until it has collected at least 100 positions (5 minutes). If you can leave it longer, do so. It’s a good practice to immediately start collecting positions for the Reach Monument as soon as you have determined the sampling reach. This will allow you to collect position information while you are unpacking gear and getting ready to start sampling, and will generally ensure that you are able to collect a sufficient number of positions to generate an accurate monument. Click “OK” to finish position collection. Include any notes about the location of the reach monument (*e.g.*, where is it with respect to the sampling reach) in the “Comments” field.

In Situ Water Chemistry

Water chemistry data should be recorded either before other data collection begins, or upstream of any ongoing data collection. In situ water chemistry data can be entered in the appropriate section of the “Site Marker” menu.

Turn on the multiparameter sonde. These instructions are for the YSI 600QS, but should be broadly applicable to most types of sondes. Remove the probe from the protective sleeve. The YSI 600 QS is protected by a 500 mL Nalgene bottle with an O-ring in the cap. This arrangement is delicate and the O-ring is easily broken. The best way to deal with it is to leave the cap and O-ring attached to the probe, and unscrew and remove the Nalgene bottle.

Water chemistry should be measured in a well-mixed location in the stream. Ideally you will measure the water chemistry in or near the thalweg. If this is not safe or practical, ensure that you

choose an area with adequate mixing. Do not measure water chemistry in pools, eddies, sidechannels, or in shallow water along the bank. Avoid taking measurements near (downstream of) tributary junctions, even small ones, as the water chemistry of tributaries may be substantially different from that of the mainstem, and mixing may not be complete for some distance downstream.

Immerse the probe in the water. Be sure that the conductivity port on the side is completely submerged. Ideally the sonde will be submerged far enough so that the sensors are at approximately 50% of total water depth. The sonde controller should be at the main menu, with “Sonde Run” highlighted. Press the Enter button (←) to start collecting data. Allow the sonde to stabilize (no change in data value for any parameter for 30 seconds) for at least 3 minutes before recording readings. The pH sensor may take longer to stabilize in some situations. Record the following data, either in the Trimble data dictionary using the “Water Chemistry” submenu, or in a notebook:

- Temperature (°C)
- Specific conductivity (μS/cm)
- Dissolved Oxygen (% saturation)
- Dissolved Oxygen (mg/L)
- DO charge
- pH

Make note of any potential problems, for example an unstable or unusual reading, either in the “Comment” field in the Water Chemistry submenu, or in the notebook.

Collecting and Processing Water Samples

Necessary Equipment

1 liter Nalgene bottle for collecting water chemistry sample

Disposable nitrile gloves, 1 pair per site

Acid washed sample bottles (sent each year from CCAL), per sample:

- 1 500 mL

- 1 250 mL

- 1 125 mL

Spare set of acid-washed sample bottles

Hach filter apparatus:

- Manual vacuum pump with pressure gauge and attached Tygon tubing

- Plastic 1-L Erlenmeyer filtering flask

- Magnetic filter holder

47 mm 0.45 micron polycarbonate membrane filters

Clean filter forceps (stored in a Falcon tube)

Cooler (with dry ice if practical)

In the collection and processing of water samples, it is essential to avoid contamination of the samples. Keep fingers away from the rims of bottles and caps, even with gloves on. Take care not to allow airborne particulates (including dust, insects, pollen, etc.) to fall into sample bottles.

Do not allow water from clothing, trees, etc. to drip into sample bottles. Use acid-washed sample bottles shipped from the CCAL lab only. Avoid processing water samples in heavy rain.

Each water chemistry sample requires 3 sample bottles, each of which contains water that is processed differently. The 500 mL bottle is for unfiltered water and will be frozen, the 250 mL bottle is for water that has been filtered through a 0.45 µm filter and will be frozen, and the 125 mL bottle is for water that has been filtered and will be refrigerated. All 3 sample bottles should be labeled on the provided tape label with the following information, using a Sharpie:

Site number (e.g., “WRST-019”)

Site name (e.g., “Willow Creek”)

Date (in the format “17-August-2009”)

In addition, each of the differently-sized bottles should be labeled as follows:

The 500 mL bottle should be labeled “Unfiltered and frozen”

The 250 mL bottle should be labeled “Filtered and frozen”

The 125 mL bottle should be labeled “Filtered and not frozen”

DO NOT INCLUDE INTERNAL LABELS!

Collecting water samples

Collect a bulk water sample using the 1-L Nalgene bottle. Water chemistry samples should be collected from a well-mixed location in the stream. Ideally you will collect the water chemistry samples in or near the thalweg, at approximately 50% of the total depth. If this is not practical, ensure that you choose an area with adequate mixing. Do not collect water chemistry samples from pools, eddies, sidechannels or from shallow water along the bank. Avoid taking samples near (downstream of) tributary junctions, even small ones, as the water chemistry of tributaries may be substantially different from that of the mainstem, and mixing may not be complete for some distance downstream. If either you or the other crewmember is or has been wading in the stream, be sure to collect the water sample upstream of that activity. Remove the top from the Nalgene and rinse the bottle **AT LEAST THREE TIMES** with stream water. To rinse, fill the bottle completely by submerging it, and then empty it back into the stream. Be sure that the cap (which should be attached to the bottle) is fully submerged as well. Be careful not to touch the edges or inside of either the bottle or the cap. After rinsing, submerge the bottle to approximately ½ of the water depth, let it fill completely, then carefully replace the cap.

Carefully remove the caps from both the 1-L Nalgene and the labeled 500 mL sample bottle and pour water into the 500 mL sample bottle. Keep your fingers away from the rim of the cap and the rim of the bottle at all times. Do not fill above the “shoulder” of the bottle. Overfilled bottles can crack when frozen, due to the expansion of water as it freezes. It’s better to err on the side of less water than to risk bottle cracking, which renders the sample useless for analysis. Replace the cap and tighten firmly. If you have a cooler with dry ice, place the sample bottle in the cooler immediately. Otherwise, keep it cool in the stream (be careful to secure the bottle so it doesn’t

float away!) until ready to leave the site, then place in the cooler. Once back at camp (or wherever you have a freezer), freeze immediately. Be sure to indicate how the sample was treated in the appropriate section of the Site Marker submenu. The options for the “500 mL sample taken?” are “Yes” and “No”, There is also a menu with selections for treatment of the sample: “No,” “Yes, frozen at site” “Yes, frozen at camp”.

Filtration of water samples

Next, set up the filtering apparatus. First, thoroughly (3x) rinse the plastic Erlenmeyer filter flask and both halves of the magnetic filter holder with stream water. Set the Erlenmeyer flask on flat ground so it will be stable. Insert the lower portion of the magnetic filter holder into the mouth of the flask and press down so that it is firmly seated. Do not touch the rim or spout of the filter holder or Erlenmeyer flask or the gridded surface of the filter holder. Use the forceps to gently remove a 0.45 µm membrane filter from the filter package. Lay it down on top of the gridded surface. Do not touch the filter with your fingers. Be careful not to rip the filter, as they are delicate, especially when wet. The filter should be centered, with no portion outside the “lip” around the grid. Immediately put the forceps back in the Falcon tube, tips down. Place the top of the filter unit over the bottom and allow it to snap into place. Be sure it is seated properly or it will not seal.

Attach the vacuum pump to the flask by firmly pressing the Tygon tubing onto the side arm of the filter flask. A good seal is necessary for proper functioning of the filter unit. First, pour about 25-50 mL of sample water into the top of the filter unit, and use the manual vacuum pump to pull the water through the filter and into the flask. Carefully remove the filter unit from the top of the flask and discard the filtrate. This serves to rinse the filter and reduce contamination of the filtered samples. Reseat the filter unit in the mouth of the flask, and carefully pour ~300 mL of sample water from the Nalgene bottle into the top of the filter unit. You will need a total of approximately 400-450 mL of filtered sample, so add more unfiltered water to the filter unit as the level recedes. Once you have completed the filtering process, carefully remove the filter unit from the Erlenmeyer flask and transfer an appropriate amount of filtrate to both the 250 mL sample bottle and the 125 mL sample bottle.

Keep your fingers away from the rim of the Erlenmeyer flask, the rim of the cap and the rim of the sample bottle at all times. Do not fill the 250 mL sample bottle above the “shoulder” of the bottle. Overfilled bottles can crack when frozen due to the expansion of water as it freezes. It’s better to err on the side of less water than to risk bottle cracking, which renders the sample useless for analysis. The 125 mL sample bottle can be filled to the top, as it will not be frozen. Replace the cap on each bottle and tighten firmly. If you have a cooler with dry ice, place the 250 mL sample bottle in the cooler immediately. Otherwise, keep it cool in the stream (be careful to secure the bottle so it doesn’t float away!) until ready to leave the site, then place in the cooler. Once back at camp (or wherever you have a freezer), freeze the 250 mL sample immediately. Be sure to indicate how the sample was treated in the appropriate section (“250 mL sample filtered?”, “250 mL sample frozen?”) of the Site Marker submenu. The 125 mL sample should be kept cool and in the dark, but not frozen.

Collecting and Processing Macroinvertebrate Samples

Necessary equipment

Trimble GPS unit

Modified D-net sampler or equivalent, with 500 μm mesh
2 14-liter plastic buckets with pour spouts
2 white plastic dishtubs
500 μm soil sieve (#35) with bottom pan
Pump-type insecticide sprayer
Small plastic spoon
Forceps (2 pair)
Sharpie
Pencil
Rite-in-the-Rain paper for internal labels
At least 6 500 mL HDPE sample bottles per site, 4 filled with 95% ethanol

Collecting macroinvertebrate samples

A total of 11 macroinvertebrate sub-samples are collected from the reach. These 11 sub-samples are then combined to create a single composite reach sample. Each sub-sample (hereafter referred to as a sample) is collected from a 0.09 m^2 area (the area enclosed by the frame attached to the front of the modified D-frame collection net, approximately equal to 1 square foot). This is also the area enclosed by a Surber sampler, if you are using one. The composite reach sample therefore contains macroinvertebrates collected from a total area of 0.99 m^2 . Macroinvertebrate samples are collected from each of the 11 reach transects, beginning at transect A. Randomly select a start zone (left, middle or right) for transect A, using scraps of paper or a 6-sided die. As you move upstream from transect to transect, the sampling zone will systematically shift in the order Left→Middle→Right→Left and so on. If the designated sampling zone at a particular transect is unsampleable (*e.g.*, a deep pool), sample from the nearest safe location (move either laterally, or if necessary, upstream).

Place the modified D-net on the stream substrate so that the mouth of the net is perpendicular to and facing into the flow of water. The net should be placed haphazardly within the sampling zone (*e.g.*, the left 1/3 of the stream if the sampling zone is Left). If there is no detectable flow, orient the net to most easily facilitate washing benthic material into the net. Make sure that the flow of water through the net and collection cup is unimpeded. If necessary, move the trailing part of the net and/or move cobbles behind the D-frame to ensure uninterrupted flow into the collection cup. Select the exact location you will place the net based on your ability to generate a good “seal” between the bottom portion of the D-net frame and the stream substrate. This is important to minimize the loss of dislodged organisms due to their becoming entrained in flow “around” the net. It is important to retain downward pressure on the net at all times to minimize the loss of material via flow underneath it. Next unfold the sampling frame. It is also important to maintain good contact between the bottom of the sampling frame and the stream bottom, to the extent possible, to minimize the loss of material as cobbles are dislodged. There are a number of ways to approach this problem (maintaining downward pressure on the net and keeping the sampling frame in contact with the stream bottom throughout the sampling procedure). You should experiment with different approaches until you find one you are comfortable with.

Collect invertebrates from within the 0.09 m^2 sampling frame in front of the net as follows. Work from the upstream edge of the sampling plot backward and carefully pick up stones located within the sampling frame, move them to directly in front of the net and then vigorously on all surfaces to remove attached organisms and organic debris. You should count any stone that

intersects with the sampling frame as being within the frame, even if the bulk is located outside the frame. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is cemented into the stream bottom and you are unable to remove it, rub it in place on all exposed surfaces, concentrating on any cracks or indentations. After removing all large stones from within the sampling frame, disturb small substrates (*i.e.* sand or gravel) to a depth of about 10 cm by raking and stirring with your hands. Continue this process until you can see no additional organisms or organic matter being washed into the net. After completing the sample, hold the net vertically (cup down!) and rinse material into the bottom of the cup. If a substantial amount of material is in the net, empty the net into the 14-liter bucket for processing before continuing to the next sample location. Otherwise, move to the next sample location and repeat the above procedure to create a composite sample. Continue this process until all 11 samples have been collected.

Woody debris should be treated like cobbles, and rubbed in front of the net to dislodge macroinvertebrates and organic material. Areas characterized by fine sediment (gravel, sand, silt/mud) should be raked and stirred to a depth of ~10 cm as discussed above.

Processing macroinvertebrate samples

Field processing requires 2 14-liter buckets, at least one white plastic dishtub, a 500 μ m soil sieve, pump sprayer, plastic spoons and forceps, at least one 500 mL HDPE sample jar, and 95% ethanol. The bucket is used to decant organisms and organic matter into the sieve, while retaining inorganic material in the bucket. Before beginning field processing, you should have one 14-liter bucket ~1/2 full of stream water, and one 14-liter bucket filled with water. The pump sprayer should be filled to the maximum fill line and manually pumped to fully charge it. The 500 μ m soil sieve should be placed on the ground near the stream bank. The bottom pan of the soil sieve, containing pencils, sharpies, plastic spoons and forceps, should be placed on the ground nearby. At least one 500 mL sample jar, ~2/3 filled with ethanol, should be placed nearby. The sample jar must be clearly labeled with the following information, using a sharpie:

Site number (*e.g.*, “WRST-019”)

Site name (*e.g.*, “Willow Creek”)

Date (in the format “17-August-2009”)

If multiple sample jars are required due to abundant organic matter, each jar should also be labeled “1 of 4”, “2 of 4”, etc. (for a total of 4 jars, for example). All of this information MUST also be written in pencil on an internal label. The internal label should be a small piece of Rite-in-the-Rain paper. The internal label is extremely important, as it provides a back-up in case the external label becomes unreadable.

The crewmember who is not collecting macroinvertebrates should prepare and label sample jars as well as preparing all processing gear as described above so that it is ready when macroinvertebrate sampling is complete.

To begin processing, the macroinvertebrate sample should be transferred into the 1/2 full 14-liter bucket. Before this step, you should vigorously rinse the net in the stream to wash all organic material into the cup (or lowest part of the net if organic material is abundant). The best way to do this is to find an area in the stream with relatively deep water (*e.g.*, a pool), lower the net (cup

down!) briefly under the water and rapidly “jerk” it completely out of the water. Repeat this step if necessary until all organic material has been washed down into the sample cup. Organic material that “clings” to the net (*e.g.*, black fly larvae) can either be washed down into the cup using the pump sprayer or manually removed from the net and placed in the bucket. To transfer the sample into the bucket, place the entire bottom portion of the net in the bucket and carefully unscrew the sample cup. Empty organic material in the cup into the bucket. Holding the cup upside down over the bucket, use the pump sprayer to dislodge organic material stuck to the mesh. Gently shake the bottom portion of the net to dislodge the majority of the material still in the net. Next, rinse off the threads of the cup and net, and replace the sample cup on the net. Repeat the instream rinsing procedure outlined above, then again transfer organic material to the bucket. Repeat these steps if necessary until all organic material has been removed from the net and transferred to the bucket.

Remove and release from the bucket/dishtub/sample jar any and all vertebrates captured, including fish and amphibians. Note the species and number under the “Comment” field in the data dictionary and in the Field Notes section of the Supplemental Data Sheet.

Decant invertebrates and organic matter from the sample by vigorously but carefully swirling or stirring the contents of the bucket and then pouring suspended material through the 500- μ m sieve. Add more water from the full bucket and repeat this process until no additional organic material can be decanted. Gently transfer the material in the sieve (invertebrates and organic matter) into the labeled, pre-filled sample jar with a plastic spoon and then wash any remaining material in the sieve into the jar with the pump sprayer, using as little water as possible. Do not overfill the sample jar – use additional sample jars as required. It is essential that no more than 30% of the space in any sample jar is occupied with organic material; this ensures that samples will be at least 70% ethanol and will be properly preserved. If you are unsure whether the sample will fit in a single jar, it is best to pre-fill the sample jar with ethanol (to ~70% of the total volume), and then add organic material until the jar is full.

Transfer and rinse the gravel or other inorganic residue remaining in the bucket into one or both of the white plastic dishtubs and cover with water to a depth of approximately 1 cm. Inspect the gravel on the bottom of the tub for any cased caddis flies or other organisms that might remain. Gently remove any remaining organisms by hand, using forceps, and place them in the sample jar. Letting the dishtub “sit” for 10 minutes or so before beginning to search for stray organisms can facilitate the process, as many types of caddis flies will begin to crawl up the sides of the tub during this time, making them easier to see. Periodically agitate the dishtub to redistribute material as you search. If you have collected a large amount of gravel, it is best to serially process the material in moderate amounts. Because it is easiest to detect organisms when they are displayed against the white background of the dishtub, try to keep the amount of gravel in the dishtub at any time relatively low. The most efficient approach is to keep the bulk of the gravel against one edge of the dishtub, and spread (by agitation) a small portion across the remaining area. After inspecting this portion, respread the gravel, inspect the new portion, and repeat until no new organisms are found after about two to three minutes of searching. Discard the gravel.

Make a note (in the “Comments” field and/or in the Field Notes section of the Supplemental Data Sheet) of any unusual features of the macroinvertebrate sample. For example, “2 slimy sculpin captured in net”, “large numbers of rhyacophilids”, “several very large tipulids”, etc.

In the Trimble data dictionary, verify that the macroinvertebrate sample was collected and preserved, and record the sample type (Occupancy or Reach Composite) and the total number of sample jars.

Collecting and Processing Benthic Diatom Samples

Necessary equipment

14-liter bucket or white dishpan for collecting substrate
White dishpan for processing
Pump-type sprayer
1 liter graduated Nalgene
A medium stiffness toothbrush and/or a fingernail brush
Scraping tool (chisel)
A 12 cm² rubber template (5/8" x 1 11/16" x 3/32" tub drain gasket)
A 50 mL Falcon tube with lid
Sharpie
Pencil
Rite-in-the-Rain paper
Lugol's solution
60 mL syringe with short piece of tubing attached

Collecting diatom samples

A total of 11 benthic diatom subsamples are collected from the reach. Each subsample (hereafter referred to as a sample) is collected from a single piece of stream substrate. On each piece of substrate, benthic diatoms are scraped from a 12 cm² area (the area enclosed by the flexible gasket). These 11 sub-samples are then combined to create a single composite reach sample. The composite reach sample therefore contains diatoms collected from a total area of approximately 120 cm². Diatom samples are collected from the same 11 reach transects that macroinvertebrates were collected from, but shifted 1 meter upstream, and one zone over, beginning at transect A. At transect A, shift one zone to the right from the zone where macroinvertebrates were collected (*i.e.*, if macroinvertebrates were collected from the Center zone of transect A, substrate collection for diatom samples will begin in the Right zone, 1 meter upstream of transect A. As you move upstream from transect to transect, the sampling zone will systematically shift in the order Left→Middle→Right→Left and so on.

At each transect, select an appropriate piece of substrate and carefully place it in the bucket or dishtub, ensuring that it remains right-side up. Look for rocks that are reasonably flat and have enough surface area to be easy to work with without being excessively large and heavy. Try to select rocks from water at a consistent depth. A good target is 15-25 cm.

Processing diatom samples

All processing for diatoms should be conducted in a white dishtub to prevent loss of material. The gasket, brushes and scraper should also be kept in the dishpan throughout this procedure. Remove a single piece of substrate from the bucket and place it in the dishtub. Hold the flexible gasket against the rock with one hand to delineate the sampling area. Using the toothbrush or fingernail brush, vigorously scrub the area inside the gasket for at least 30 seconds. The length of time you scrub will depend on the texture of the rock and the amount of periphyton present. Smooth rocks require much less time to completely process. The goal is to completely remove all

attached organic material within the area defined by the gasket. Depending on its size, you may find it easier to hold the rock up in one hand and scrub it with the other – if so, be sure to keep the rock inside the confines of the dishtub so that sample material is not lost. When you have finished scrubbing, place the brush back into the dishpan. Next, use the chisel to thoroughly scrape the area within the gasket. The idea here is to dislodge tightly adherent diatoms that may not be removed using the brushes. When finished scraping, place the chisel back into the dishpan. Finally, gently rinse dislodged material from the rock into the dishpan using a small amount of water (less than 50 mL) from the pump sprayer. Be gentle - you want to completely rinse off all of the material you dislodged from within the sample area without removing additional material from outside the sample area. It is important to be sparing in your water use when rinsing in order to obtain a concentrated diatom sample. This is especially critical in glacial or recently scoured streams where diatom densities are likely to be low. After rinsing, discard the rock.

Repeat the previous step for all 11 pieces of substrate. When you have finished sampling all 11, briefly rinse the brush, scraper and gasket to remove any attached material. Carefully decant all of the liquid in the dishpan into the graduated Nalgene bottle. In necessary, briefly rinse additional material out of the dishpan using the pump sprayer. Close the lid of the Nalgene bottle tightly. In the Trimble data dictionary, verify that the periphyton sample was collected and record the total volume of the sample. Make sure you have a labeled 50 mL Falcon tube ready with its cap removed. The tube should be labeled on the outside with the following information using a Sharpie:

Site number (e.g., “WRST-019”)
Site name (e.g., “Willow Creek”)
Date (in the format “17-August-2009”)

All of this information **MUST** also be written in pencil on an internal label. The internal label should be a small piece of Rite-in-the-Rain paper. The internal label is extremely important, as it provides a back-up in case the external label becomes unreadable.

When the Falcon tube is ready, vigorously shake the Nalgene bottle containing the aggregate sample for approximately 30 seconds to homogenize it. Immediately pour 40 mL of the sample into the Falcon tube. Add approximately 2 mL of Lugol’s solution to the tube. The sample should now be the color of strong iced tea. Cap the sample tightly and store in a cool, dark place.

Special note for sand- or mud-bottom habitats. In some cases it may not be possible to find appropriate pieces of substrate, because most or all of the transect has a sandy or muddy bottom. In these cases an alternate procedure is used to sample periphyton. In a sand or mud-bottom habitat, place the sampling gasket directly on the stream bottom. Use the 60 mL syringe with attached tubing to carefully remove the top ~1 cm of stream-bottom material from within the area defined by the gasket. Transfer the material directly into the 1 L Nalgene bottle. Repeat for as many habitat units as necessary. If both rocks and sand samples are to be combined, process the rock samples as described in Steps 3 and 4 so that all samples are combined into the 1 L Nalgene. Close the lid tightly and record the volume in the Trimble data dictionary as before. Also record in the “Comments” window the exact composition of the sample. For example: “6

rocks + 2 sand-bottom samples” or “all mud bottom – 8 samples”. Finally, record the same information on the Supplemental Data Sheet.

Physical habitat characterization

Necessary Equipment

30-m or 100-m tape, depending on stream width

Gravelometer

2 graduated PVC “moosebeaters”, joined together to create a 2 meter depth stick with 1 cm graduations

Spherical densitometer

Trimble GPS

Overview

These methods are based closely on the EPA National Streams and Rivers Assessment Field Operations Manuals (USEPA 2007, 2013a). Much of the language in this section comes directly from those documents.

There are 5 different components of the CAKN Flowing Waters physical habitat characterization. These include stream discharge, water surface gradient, a thalweg profile, channel characterization at cross-section transects, and a qualitative assessment of other stream characteristics. SOP 10: Discharge Measurement describes procedures for measuring stream discharge in detail; hence, only the latter four components are discussed in this section.

Measurements are made at two scales of resolution along the length of the reach; the results are later aggregated and expressed for the entire reach, a third level of resolution. Figure 1 illustrates the locations within the sampling reach where data for the different components of the physical habitat characterization are obtained. We assess habitat over stream reach lengths that are approximately 40 times their average wetted width at base-flow, but not less than 150 m long. This allows us to adjust the sample reach length to accommodate varying sizes of streams. Many of the channel and riparian features are characterized on 11 cross-sections (transects) spaced at 4 channel-width intervals (*i.e.*, transect spacing = 1/10th the total reach length). A second set of measurements are collected between the transects and will be used to generate a thalweg profile. The thalweg profile measurements must be spaced evenly over the entire sampling reach. In addition, they must be sufficiently close together that they do not “miss” deep areas and habitat units that are in a size range of about a to ½ of the average channel width. Follow these guidelines for choosing the interval between thalweg profile measurements:

- Channel Width < 2.5 m — interval = 1.0 m
- Channel Width 2.5-3.5 m — interval = 1.5 m
- Channel Width > 3.5 m — interval = 0.01 × (reach length)

Following these guidelines, we will make 150 evenly spaced thalweg profile measurements in the smallest category of streams, 15 between each detailed channel cross section. In all of the larger stream sizes, you will make 100 measurements, 10 between each cross section. We specify width measurements only at the 11 regular transect cross-sections and 10 supplemental cross-

sections at the thalweg measurement points midway between each pair of regular transects (a total of 21 wetted widths). If more resolution is desired, width measurements may be made at all 100 or 150 thalweg profile locations.

Because a stream is a noisy environment, it is important to communicate clearly and loudly during data collection and recording. The person recording the data in the Trimble should always repeat back what s/he hears from the person making the measurement to ensure that data are being recorded correctly.

There are separate Feature classes for Transects and Profiles, so it is necessary to switch back and forth as the crew proceeds upstream.

Channel cross-section

At each transect, the following measurements are taken:

- Bankfull width
- Bankfull height
- Wetted width
- 5 depth measurements, spaced across the wetted width
- 5 substrate measurements, spaced across the wetted width
- 6 measurements of canopy cover, one at each bank and 4 in midchannel.

For all channel measurements, one crewmember operates the Trimble and enters data, while the other crewmember collects the actual measurements. All width measurements are made with the measuring tape, except in small streams where it may be easier to use the PVC depth stick. Stretch the tape across the stream (it's often easiest if the crewmember operating the Trimble holds on to the "smart" end of the tape and records the measurement at each transect, so that the other crewmember doesn't have to carry the tape for subsequent activity, making this an exception to the rule stated above). Both crewmembers should work together to identify the location(s) that mark bankfull flow. Identifying the correct location for "bankfull" can be challenging, even for experienced stream scientists, so it's important to be careful and work together. Note that at some streams it may be impossible to determine the location of bankfull flow.

The following guide is taken from Buffington (no date), "Identifying bankfull elevation":

"Bankfull flow is defined as the discharge that just begins to spill out of the channel onto the floodplain (Leopold 1994). Bankfull flow is significant because it is the dominant discharge in sand- and gravel-bed rivers (the discharge that transports the most sediment in the long term) (Wolman and Miller 1960; Andrews and Nankervis 1995; Emmett and Wolman 2001). Many gravel-bed rivers also exhibit a near-bankfull threshold for significant bedload transport and morphologic adjustment (pool scour, bar deposition, bank erosion, etc.); hence it is the channel-forming flow for gravel-bed rivers (Henderson 1963; Parker 1978) and the flow that sets many aquatic habitat characteristics (pool dimensions, substrate size, width-depth ratio, etc.) for fish and macroinvertebrates (e.g., Buffington et al. 2003; 2004).

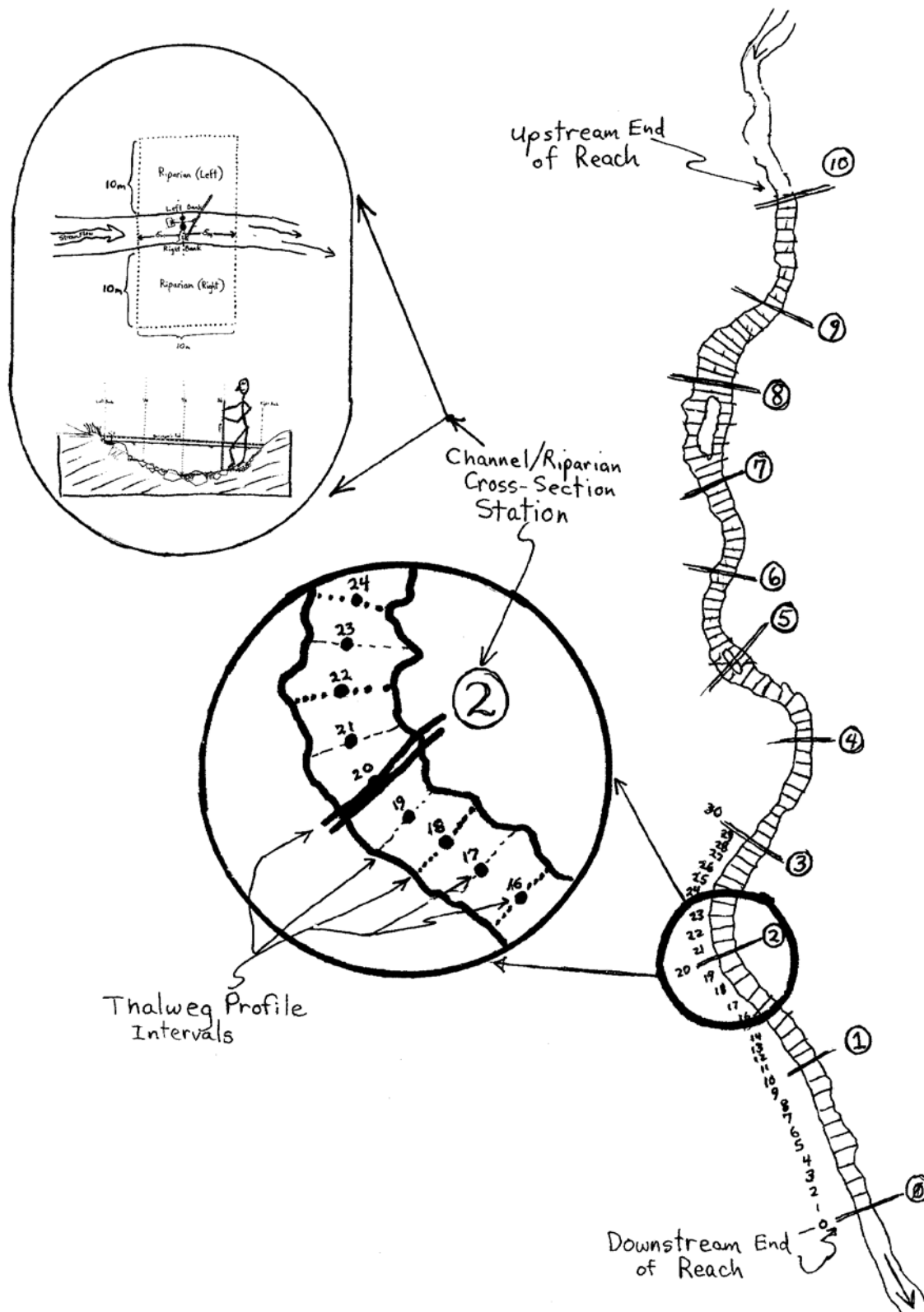


Figure 1. Overview of channel measurements.

There are several indicators that can be used in the field to help locate the bankfull elevation (given in order of reliability):

a) floodplain surface (topographic break between the channel banks and floodplain).

Note that the floodplain surface may not be extensive in incised channels. Incised channels may also exhibit flights of terraces (abandoned floodplains).

b) high-flow markers:

- “trash” line (deposits of leaves, branches, and other detritus)
- mud line
- sand and silt deposits along the upper banks
- stain lines on boulders and other rock
- scour line of roots and banks (cut bank)

Note that the above markers represent one or more high-flow events, which may, or may not, have been the bankfull discharge. Also, note that “trash” left in shrubs and small trees may be misleading. Vegetation may be bent over by the flow and then rebound when the flood waters recede, with the rebound elevation and the consequent elevation of “trash” potentially greater than the actual flood height.

c) vegetation line. The vegetation limit is commonly referred to as the *active channel* (frequent flow level) which typically is a lower elevation than bankfull. Vegetation lines can be influenced by seasonal and annual variation of flow. e.g., vegetation will encroach on the channel and occur at lower elevations during periods of drought, or be scoured to high elevations during high-magnitude floods.

d) bar tops. The flow had to be at least as high as the bar tops to deposit sediment there and build the bars to their current level.

One should use all of the above indicators to help identify the bankfull elevation when conducting channel surveys. Also make use of upstream and downstream indicators and visually project the corresponding bankfull plain through your cross section to corroborate correct local identification of bankfull. If the bankfull elevation is questionable on one side of your cross section, project the one that you have confidence in to the opposite bank.

Strictly speaking, bankfull discharge can only be evaluated for floodplain rivers, although vegetation lines and stain lines are commonly used in non-floodplain rivers to estimate “bankfull-equivalent” flows. The bankfull discharge has an average recurrence interval of about 1.5 years in floodplain rivers in temperate climates (Wolman and Leopold 1957; Leopold *et al.* 1964; Williams 1978).”

Once you have agreed on the location of bankfull flow, stretch the tape across the stream. 1st measure wetted width in meters (to the nearest 0.1 meters). Take the measurement from shore to shore, as nearly perpendicular to the channel as you can. Include overhanging banks (i.e. don’t take the measurement at the bank, but at the back end of the overhang) and backwaters. Also include any midchannel bars, and note the width of the bar. For measurement purposes, ignore

sidechannels that are separated by true (i.e. vegetated) islands, unless the total flow in the sidechannel is more than 15% of total flow, but make a note of their presence. Use the tape to measure bankfull width, and use the graduated PVC to measure bankfull height from the water surface.

Canopy cover is measured at each transect using a convex spherical densitometer. The densitometer must be taped exactly as shown in Figure 2 to limit the number of square grid intersections to 17. Densitometer readings can range from 0 (no canopy cover) to 17 (maximum canopy cover). Six measurements are obtained at each cross-section transect - four measurements in four directions (facing upstream, downstream, towards the left bank, and towards the right bank) at mid-channel and one at each bank, facing toward the bank. The midchannel measurements are used to estimate canopy cover over the channel. The two bank measurements complement your visual estimates of vegetation structure and cover within the riparian zone itself, and are particularly important in wide streams, where riparian canopy may not be detected by the densitometer when standing midstream.

Use the following procedure for obtaining canopy cover data. Densitometer measurements are taken at 0.3 m (1 ft) above the water surface, rather than at waist level, to (1) avoid errors because people differ in height; (2) avoid errors from standing in water of varying depths; and (3) include low overhanging vegetation more consistently in the estimates of cover. Hold the densitometer level (using the bubble level) 0.3 m above the water surface with your face reflected just below the apex of the taped “V”, as shown in Figure 2. Generally you’ll need to crouch slightly.

Now count the number of grid intersection points within the “V” that are covered by either a tree, a leaf, or a high branch. The number will be between 0 and 17.

Next you will collect 5 depths and measure the size of 5 pieces of substrate as you move across the stream. These measurement points will be at the left bank, 25% of stream width, midstream, 75% of stream width, and at the right bank. At the 3rd measurement point, you will collect 4 canopy cover measurements, facing upstream, left, downstream, and right. 1st measure the depth at the bank (in centimeters) using the PVC depth stick (to the nearest cm). Read the depth from the side of the depth stick to avoid being misled by the “bow wave” created in front of the stick in strong currents. Select a piece of substrate randomly as follows. With your toe near the bank, reach down, with your head averted and your index finger outstretched, until your finger touches the substratum. Aim for directly in front of your big toe. Pick up the first piece your finger encounters. It is important not to bias your selection by shifting your finger to pick up something “easier” (i.e. larger). This takes some practice. Next, using the gravelometer, find the largest hole that the rock will NOT fit through, and record this number. Non-numeric categories include sand, muck and bedrock. Isolated pieces of sand should be recorded as “< 2 mm” rather than as sand. The sand designation should only be used for a patch of sandy bottom. Repeat this process (depth and substrate measurement) at 25%, 50%, 75% of the stream width, and at the opposite bank. At the 50% (midstream) point, record canopy cover as described above, while facing

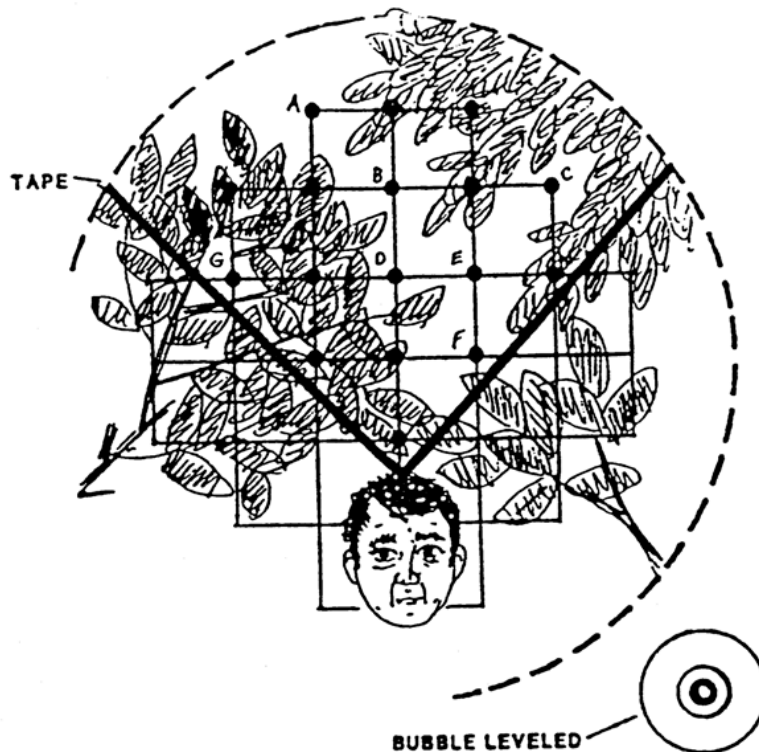


Figure 2. Marking and using a convex spherical densitometer. From Mulvey *et al.* 1992. Note proper positioning with the bubble leveled and face reflected at the apex of the "V"., giving sin this example, 10 of the 17 intersections show canopy cover, giving a densitometer reading of 10.

upstream, left, downstream and then right. Occasionally, one of these stations will be a midchannel bar or emergent boulder. If so, record a depth of "0 cm" and measure a piece of substrate from the bar.

Thalweg Profile

Thalweg refers to the flow path of the deepest water in a stream channel. The thalweg profile is a longitudinal survey of maximum depth and several other selected characteristics at 100 or 150 equally spaced points along the centerline of the stream between the two ends of the stream reach. Data from the thalweg profile allows calculation of indices of residual pool volume, stream size, channel complexity, and the relative proportions of habitat types such as riffles and pools. In this habitat assessment procedure, one proceeds upstream in the middle of the channel, rather than along the thalweg itself (though each thalweg depth measurement is taken at the deepest point at each incremental position).

1. Determine the interval between measurement stations based on the wetted width used to determine the length of the sampling reach. For widths < 2.5 m, establish stations every 1 m. For widths between 2.5 and 3.5 m, establish stations every 1.5 m. For widths > 3.5 m, establish stations at increments equal to 0.01 times the sampling reach length.

NOTE: If a side channel is present, and contains between 16 and 49% of the total flow, establish secondary cross-section transects as necessary. Collect all channel and riparian cross-section measurements from the side channel.

2. Measure the wetted width if you are at station “5” (if the stream width defining the reach length is > 2.5 m), or station “7” (if the stream width defining the reach length is < 2.5 m). Wetted width is measured across and over mid-channel bars and boulders. Record the width to the nearest 0.1 m. For dry and intermittent streams, where no water is in the channel, record zeros for wetted width.

3. At station 5 or 7 (see above) measure the substrate particle size of 5 pieces of substrate, at the left bank and at positions 25%, 50%, 75%, and 100% of the distance across the wetted width of the stream. This procedure is identical to the substrate size evaluation procedure described for regular channel cross-sections, except that no depth measurements are recorded.

4. At each thalweg profile station, use the calibrated PVC depth rod to locate the deepest point (the “thalweg”), which may not always be located at mid-channel. Measure the thalweg depth to the nearest cm.

At stations where the thalweg is too deep to measure directly, stand in shallower water and extend the surveyor’s rod or calibrated rod or pole at an angle to reach the thalweg. Determine the rod angle by resting the clinometer on the upper surface of the rod and reading the angle on the external scale of the clinometer. Leave the depth reading for the station blank and record the water level on the rod and the rod angle in the comments section of the field data form. For even deeper depths, it is possible to use the same procedure with a taut string as the measuring device. Tie a weight to one end of a length of string or fishing line, and then toss the weight into the deepest channel location. Draw the string up tight and measure the length of the line that is under water. Measure the string angle with the clinometer exactly as done for the surveyor’s rod. If a direct measurement cannot be obtained, make **the best estimate you can** of the thalweg depth and record “estimate” in the comments section.

5. Determine the habitat unit type (listed below) for the station.

6. Record the presence or absence of quiescent off-channel aquatic habitats, including sloughs, alcoves and backwater pools. If a backwater pool dominates the channel, record “PB” as the dominant habitat unit class. If the backwater is a pool that does not dominate the main channel, or if it is an off-channel alcove or slough, include this in the “Notes” to indicate the presence of a backwater, but classify the main channel habitat unit type according to characteristics of the main channel.

7. Proceed upstream to the next station, and repeat Steps 4 through 6.

8. Repeat Steps 4 through 7 until you reach the next transect.

Channel Unit Habitat Classes^a

Class (Code) Descriptions

Pool: Still water, low velocity, smooth, glassy surface, usually deep compared to other parts of the channel:

Plunge Pool (PP) Pool at base of plunging cascade or falls.

Trench Pool (PT) Pool-like trench in the center of the stream

Lateral Scour Pool (PL) Pool scoured along a bank.

Backwater Pool (PB) Pool separated from main flow off the side of the channel.

Dam Pool (PD) Pool formed by impoundment above dam or constriction.

Pool (P) Pool (unspecified type).

Glide: Water moving slowly, with a smooth, unbroken surface. Low turbulence.

Riffle: Water moving, with small ripples, waves and eddies -- waves not breaking, surface tension not broken. Sound: "babbling", "gurgling".

Rapid: Water movement rapid and turbulent, surface with intermittent whitewater with breaking waves. Sound: continuous rushing, but not as loud as cascade.

Cascade: Water movement rapid and very turbulent over steep channel bottom. Most of the water surface is broken in short, irregular plunges, mostly whitewater. Sound: roaring.

Falls: Free falling water over a vertical or near vertical drop into plunge, water turbulent and white over high falls. Sound: from splash to roar.

Dry Channel: No water in the channel

^aNote that in order for a channel habitat unit to be distinguished, it must be at least as wide or long as the channel is wide.

Discharge measurement

See SOP 10: Discharge Measurement. The discharge measurement should be performed after other procedures are complete.

Channel gradient

Slope is typically measured by two people, one holding a surveyor's rod and the second sighting through a surveyor's level or clinometer. Be sure that the person is standing (or holding the marked pole) at the water's edge holding the rod at the surface of the water. The intent is to get a measure of the *water surface* slope, which may not necessarily be the same as the bottom slope. Because of ease of use, portability, and cost, hand-held clinometers are often used to determine slope. However, the field crews will also have access to more sophisticated instrumentation (e.g., a surveyor's or transit level), and some field personnel are experienced in the use of these instruments. Be sure to record the method used.

The surveyor's level is leveled according to the manufacturer's recommendations which is generally to adjust the three screw leveling feet until the bubble is centered. Level is checked in

all planes to be measured. If the level does not “self level” in all measured planes the user should check the instruction manual for suggested options. Elevation readings are made at each transect and the difference between each elevation reading is recorded as the change in elevation. NOTE: Multiple transect elevations can often be made for each setup of the level, but every time the transit is moved requires re-measuring the last transect elevation from the last setup. You cannot use elevations from previous setups because the relative height of the transit has changed.

Use the 100-m tape to measure linear distance along the centerline of the stream between the transit level (or clinometers) and the surveyor’s rod. Record this distance along with the measured elevation difference (or the observed gradient as %). Generally, multiple gradient measurements will need to be made.

Panoramic photos

See SOP 9: Spherical Panoramic Photography

Photodocumentation

The final items that are generally completed at each site are the site notes and site photos. Site photos should be taken in addition to any spherical panoramas. At a minimum, photographs should be taken looking upstream and downstream from the bottom of the reach (approximate site coordinates). However, if time permits, many more photographs can be taken to document conditions at the reach. For these supplemental photos, the GPS coordinates should be recorded for each photograph (either by hand in the field notebook, or by designating a Photopoint in the Trimble Data Dictionary, which is the preferred method. Be sure to record any unusual observations (e.g., evidence of a recent flood, unusual plants).

Site Notes

Site Notes provide critical ancillary and descriptive data that are important for establishing the context within which to analyze the other types of data that are collected. There are two types of Site Notes in this protocol. Menu-based site notes are recorded in the Trimble Data Dictionary, as discussed below. Descriptive site notes are recorded in the field notebook, or on the back side of the datasheets if the Trimble Data Dictionary is not being used.

AirTemp

The default value is “cool”. This is a qualitative way to assess the working conditions in which the crew is operating, which may help explain anomalous data (for example if it is very cold, an uncomfortable crew may be rushing to complete data collection)

SkyConditions

Also used to assess working conditions, and may be useful in explaining other aspects of the data (for example heavy rain may be changing instream conditions data collection.

Wind

Also used to assess working conditions and may be useful in explaining other aspects of data collection (for example in high winds, habitat data may be difficult to collect accurately).

WeatherComment

Overall impression of weather, any unusual conditions not covered in the three previous Site Notes.

ForestHealth

The default value is “good”. This is a qualitative way to monitor the observable effects of spruce bark beetle and other pests on the condition of riparian and upland forests.

ForestHealth Comment

Add additional information (e.g., apparent cause of any decline in forest health).

ChannelType

Here you will want to determine the degree, extent, and type of channel constraint based on envisioning the stream at bankfull flow. Classify the stream reach channel pattern as predominantly a single channel, an anastomosing channel, or a braided channel.

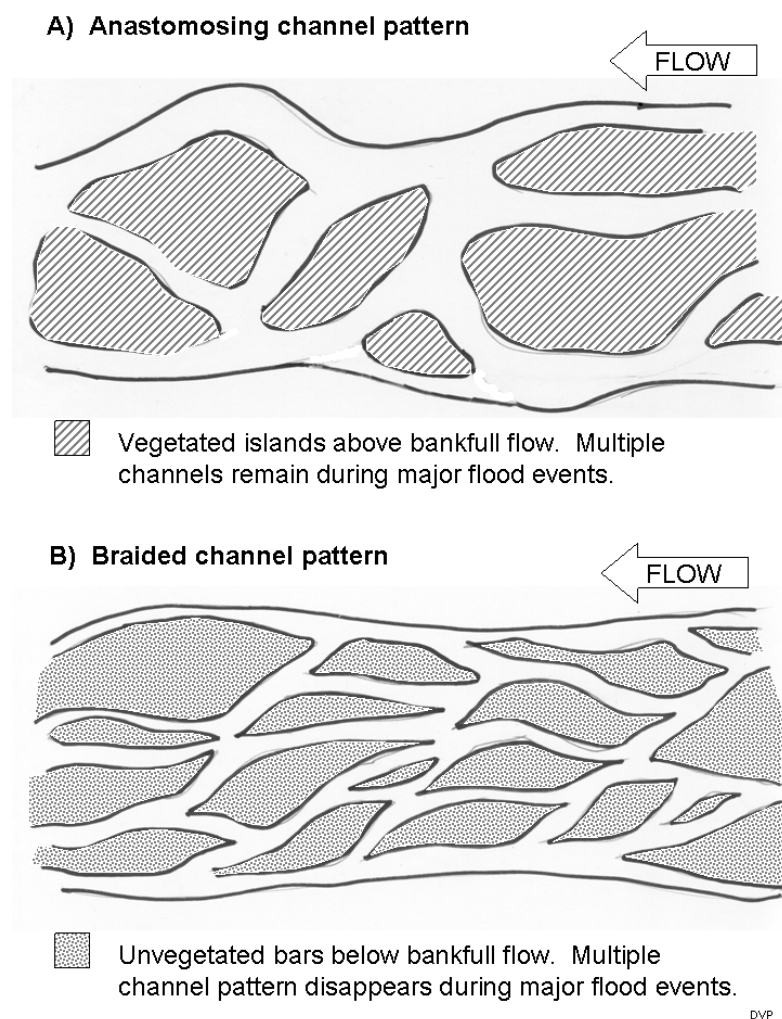


Figure 3. Types of multiple channel patterns.

- **Single** channels may have occasional in-channel bars or islands with side channels, but feature a predominant single channel, or a dominant main channel with a subordinate side channel.
- **Anastomosing** channels have relatively long major and minor channels branching and rejoining in a complex network separated by vegetated islands, with no obvious dominant channel.
- **Braided** channels also have multiple branching and rejoining channels, separated by unvegetated bars. Subchannels are generally small, short, and numerous, often with no obvious dominant channel.

Figure 3 shows what the two types of multiple channels look like.

ChannelConstraint

Next you will want to determine whether the channel is constrained within a narrow valley (“V_Shaped_Valley” in the menu), constrained by local features within a broad valley (“Incised_Broad_Valley” in the menu), unconstrained and free to move about within a broad floodplain (“Broad_Valley_Uncons” in the menu), or free to move about, but within a relatively narrow valley floor (“Narrow_Valley_Unconst” in the menu). For constrained streams, you will want to examine the stream to ascertain the bank and valley features that constrain the stream (e.g., bedrock, hillslopes, terraces) and enter those under *ChannelType_Comment*.

ChannelType Comment

Use this comment to list constraining features and to describe the overall nature of the stream reach (e.g., plane bed, pool-riffle, step-pool). Include any other information that you think might be useful in classifying the stream by physical type.

DominantSubstrate

This is a qualitative estimate of the median substrate size. It should be recorded whether or not the quantitative substrate measurements are made.

Substrate Comment

Here you should provide any additional information regarding substrate characteristics that you think would be useful (e.g., “most substrate is angular” or “dominated by granite boulders”)

Reach_Represent?

Is the sampling reach representative of the larger stream segment in which it is embedded?

Reach Comment

How confident are you of your determination? If the reach is not representative, why not, and how does it differ from the larger stream segment?

Stage

Based on the visual evidence and your knowledge of the stream, select the best description of the current flow. The default value is “Baseflow”, which refers to a seasonal minimum flow that is approximately the same from year to year. The categories are qualitative.

Stage Comment

How confident are you about your determination of stage? Include any other information you think may be relevant.

Recent High Flow

Is there evidence of a recent high flow event (*i.e.* at least bankfull flow). The default value is “No”.

High Flow Comment

Describe the evidence, how recent the flow event appears to be, and your level of confidence in these determinations.

Water Color

Is the water colored or not? The default value is “Colorless”. Turbidity does not qualify as “color”. You want to determine the level of coloration that would be present in filtered water (examining the filtered water samples may help in this determination).

Describe Water Color

Provide more information about any coloration that you see (*e.g.*, “dark brown, apparently high DOC”).

Water Clarity

How much suspended sediment is in the water? The default value is “Clear”.

Turbidity Comment

Include any other information you think may be useful here. For example, is the turbidity of glacial origin? Has there been a recent storm that might account for the turbidity?

Qualitative Site Notes

These should be recorded in the field notebook. Be as exhaustive as possible. Record any relevant or interesting observations, including evidence of human influence, animal encounters, etc.

References

- Andrews, E.D. and J.M. Nankervis. 1995. Effective discharge and the design of channel maintenance flows for gravel-bed rivers. Pages 151-164 *in*: Costa, J.E.; A.J. Miller; K.W. Potter, and P.R. Wilcock, editors. Natural and anthropogenic influences in fluvial geomorphology: the Wolman volume. Geophysical Monograph 89. American Geophysical Union, Washington, DC.
- Buffington, J.M., D.R. Montgomery, and H.M. Greenberg. 2004. Basin-scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness in mountain catchments. *Canadian Journal of Fisheries and Aquatic Sciences* 61:2085-2096.
- Emmett, W.W. and M.P. Wolman. 2001. Effective discharge and gravel-bed rivers. *Earth Surface Processes and Landforms* 26:1369-1380.

- Henderson, F.M. 1963. Some properties of the unit hydrograph. *Journal of Geophysical Research* 68:4785-4793.
- Leopold, L.B. 1994. *A view of the river*. Harvard University Press. Cambridge, Massachusetts.
- Leopold, L.B., M.G. Wolman and J.P. Miller. 1964. *Fluvial processes in geomorphology*. W.H. Freeman, San Francisco, California.
- Mulvey, M., L. Caton and R. Hafele. 1992. Oregon nonpoint source monitoring protocols: stream bioassessment field manual for macroinvertebrate and habitat assessment. Oregon Department of Environmental Quality, Laboratory Biomonitoring Section. Portland, Oregon.
- Parker, G. 1978. Self formed straight rivers with equilibrium banks and mobile bed. Part 2. The gravel river. *Journal of Fluid Mechanics* 89:127-146.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.
- U.S. Environmental Protection Agency (USEPA). 2007. *National Rivers and Streams Assessment: Field Operations Manual*. EPA-841-B-07-009. U.S. Environmental Protection Agency, Washington, D.C.
- U.S. Environmental Protection Agency (USEPA). 2013a. *National Rivers and Streams Assessment 2013-2014: Field Operations Manual – Wadeable*. EPA-841-B-12-009b. U.S. Environmental Protection Agency, Office of Water, Washington, DC.
- Williams, J. R. 1978. A sediment graph model based on an instantaneous unit sediment graph, *Water Resources Research*. 14:659-664.
- Wolman, M.G. and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *Journal of Geology* 68:54-74.
- Wolman, M.G. and L.B. Leopold. 1957. River flood plains: some observations on the formation. *US Geological Survey Professional Paper* 282-C.

SOP 9: Spherical Panoramic Photography

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) explains the procedures for generating spherical panoramic photographs, which are an important tool for documenting site conditions and detecting change in those conditions, and are also an effective public outreach tool. The SOP contains instructions for identifying the No Parallax Point for a given camera-lens combination, setting up and adjusting the Nodal Ninja 5 panoramic head, lists settings for camera-lens combinations used by the Central Alaska Network, details procedures for taking panoramic photographs in the fields, and gives step-by-step instructions for stitching the photographs and creating a spherical panorama using PTGui software. An early version of this SOP was generated by Bill Brody, Greta Burkart and Tyler Logan in 2008.

Equipment

The brand names listed are those currently in use by the Central Alaska Network. Other brands or types of equipment will also work for generating spherical panoramas; however, the procedural details may vary from those described in this SOP.

- Camera and lens (Nikon D40x with Nikon 16mm 2.8 D lens)
- Panoramic head (Nodal Ninja 5)
- Tripod (Manfrotto 190 MF4)
- Trimble GPS field computer with current CAKN Streams Data Dictionary loaded
- Panoramic stitching software (PTGui)



Figure 4. Nikon D40x with Nikkor 16mm 2.8D fisheye lens mounted on a Nodal Ninja panoramic head.

Finding the No Parallax Point and adjusting the panoramic head

Detailed instructions on proper assembly and adjustment of the Nodal Ninja 5 panoramic head (NN5) can be found in the user's manual, available at the following URL: (http://www.nodalninja.com/Manuals/NN5_USER_MANUAL.pdf). Once the NN5 has been assembled, the next step is to locate the No Parallax Point (NPP) for the particular camera-lens combination that you will be using. This should be done in office, prior to leaving for the field. Parallax is the apparent shifting of a foreground object relative to a background object when viewed at different angles or perspectives. In panoramic photography, if parallax is present foreground objects will tend to shift relative to the background in successive photographs as the camera is rotated. Seamless stitching of adjacent photos is then almost impossible, and the resulting panorama will have alignment errors. Parallax effects can be eliminated by ensuring that the camera is rotated around the entrance pupil of the lens. The entrance pupil is the vertex of the camera's angle of view (where converging light rays cross) and occurs as a floating point inside the lens at the location where the image is visible when looking into the front of the lens. It is therefore the center of perspective, meaning that rotation about this point does not lead to parallax effects.

The adjustment involves mounting the camera and lens on the adjustable VR pan head and observing the relationships of foreground and background subjects through the viewfinder as the camera is panned. If differences in the relationship between foreground and background subjects are observed while panning, pivot the camera backward or forward. Repeat the previous steps until you can no longer see a difference in the relative distances between background and foreground objects as you rotate the camera. This is No Parallax Point -- note the location and mark the location on the adjustable head to avoid need for repeating this process in the field.

A comprehensive and detailed set of instructions for finding the NPP can be found at this URL: (<http://www.johnhpanos.com/epcalib.htm>).

Table 8. Settings for the Nodal Ninja 5 panoramic head for currently-used CAKN camera-lens combinations. For the Nikon D40x, the bottom rail setting is 47 mm for all lens combinations.

Lens	Focal length	Top rail setting (mm)
Nikkor 16mm 2.8D Fisheye	16mm	82
Nikkor 18-70mm DX	18mm	92.5
Nikkor 18-70mm DX	24mm	83.5
Nikkor 18-70mm DX	35mm	76.5
Nikkor 18-70mm DX	50mm	66

Finding the No Parallax Point is not difficult, especially in the case of most single lens reflex cameras, for which the entrance pupil can be readily seen as a bright spot or disc when you point the viewfinder (i.e. the *back* of the camera) at a bright light and simply look into the lens. Stop down the lens to f/16, say, and hold down the depth of field preview button on the camera.



Figure 5. The correct positions for a Nikon D40x and 16 mm lens on the Nodal Ninja 3 Mk II.

Adjusting for zero parallax step-by-step:

- Position two cords hanging from a rod so that one is 1 foot and the other 3 feet way from the lens and arranged so that the two appear as one.
- Alternately position a three-foot piece of conduit so the near end is about one foot from the lens and the open end appears centered.
- Rotate the camera on the head as far to the right as you can and still see the front cord (end of the conduit).
- Now rotate as far to the left as you can and still see the front cord.

- If the camera is rotating about the zero parallax point, the back cord (end of the conduit) should be obscured (centered) regardless of the camera angle.
- If not, adjust the camera pivot forward (or backward) and repeat the test until it succeeds.
- Carefully note the location and mark the location on the adjustable head to avoid the need for repeating this process in the field.

With the 3D vision provided by your two eyes, it is easy to judge the approximate position of the bright spot: just move a finger along the lens barrel to a point where it seems to be the same distance away. If you have difficulty seeing a bright spot or disc, just point the back of the camera up at the sky and look into the front of the lens. (With a fisheye lens, it isn't really necessary to stop down the aperture as the spot will be quite small even with the aperture wide open).

This leads to a novel method of adjusting the camera position on a panorama head - simply watch the entrance pupil as you rotate the camera and check for sideways movement of the spot. It works well for short focus lenses such as fisheyes.



But first, you need to set the position of the camera on the horizontal arm of the head so that the entrance pupil is laterally aligned with the rotation axis. To do this, you can rotate the camera to point vertically down. Then, the axis point of the head (such as the central adjustment screw on the Nodal Ninja 3 head) should be centered in the image frame. You may not be able to focus sufficiently closely with some lenses to make this adjustment, but you could temporarily switch to a different lens. Alternatively, with the head levelled, you can make a visual check of the entrance pupil spot using a plumb line held in front of the lens. The spot and centre of the adjustment screw should be vertically aligned, as shown here. (The thread was taped to the top of the lens simply to take the photograph. You can just hold the thread in a steady hand).

An indication that the lateral position is not quite right is a broken, sawtooth edge to the head at the nadir in a stitched panorama (an unpatched nadir, of course). The example on the right is a typical example:

The top of the head looks somewhat like a circular saw. In this case, the "teeth" are set for cutting with a clockwise rotation of the saw. This indicates that the entrance pupil is offset to the left of the pano head axis, as viewed from the back of the camera, so the camera needs to be shifted a little to the right. If the saw is set for cutting with a counter-clockwise rotation, then the camera needs to be shifted to the left.



Next, you will need to devise some sort of sighting device to provide a fixed reference point when checking for movement of the bright spot of the entrance pupil. This shows a simple sight that can be made in a couple of minutes with a needle and a strip of cardboard:



You can also use an empty ball point pen barrel set up in front of the lens so that the bright spot appears centered in the hole at the end when you peer through it. If the spot moves to the left when you rotate the camera clockwise, then the entrance pupil is in front of the rotation axis

and you need to move the camera back a little. If it moves to the right, then you want to move the camera forwards. If the spot remains stationary, the entrance pupil is at the no-parallax point. This shows what you see when the camera is too far back on the top rail:



Nudge the camera position forwards and backwards until there's no difference in entrance pupil position when the camera is rotated from one normal shooting position to the next, e.g. at yaw -30 and +30 degrees if you take 6 shots at 60 degree increments to cover 360 degrees. A quick way to adjust the camera is to first centre the entrance pupil in the sight for the yaw=0 position. Then rotate the camera to the yaw=30 position and slide the camera along the top rail to bring the entrance pupil back into alignment with the sight. Check the yaw=-30 position and you're done:

The important thing is that the entrance pupil is in the same position at each angle of yaw, e.g. +30 and -30. Any shift of the entrance pupil between the two angles is not important, particularly in the case of fisheye lenses, as explained in the note at the end.



Adjusting the panoramic head to the appropriate pan angle for the lens you plan on using.

- Set the detent on the head (Fig. 2) to 45 degrees when using a 16mm lens because it will require approximately eight photos with approximately thirty percent overlap to obtain 180 degree coverage. For 35mm, the detent ring should be change to 20 degrees, so 18 shots are taken. Check to ensure that the correct ~30 degree overlap is present between images.



Figure 6. The detent rings on the Nodal Ninja 5 (NN5).

Check Batteries

pack at least one extra set of batteries for every ten panoramas.

Workflow in the field

- Identify the site using the Trimble GPS.
- Set up tripod and panoramic head. Level the tripod using the bubble level on the head, not the tripod. Attach the camera to the adjustable head at the predetermined position.
 - The tripod should be set as high as possible to reduce its footprint in the final image.
 - Extend all tripod legs all the way
 - Do not expand the legs past their first stop (narrow angle)
 - Extend the telescoping neck of the tripod
 - Shorten the legs as necessary to level the panoramic head
- Check to make sure the camera is properly placed to adjust for zero parallax (see “Prior to field work”).
- Using the camera’s manual for assistance, change the camera settings to the following:
 - Set the camera to manual
 - Set the camera’s white balance and exposure while pointing the camera directly at the ground or 90 +/- 30 degrees away from the sun including as much land in the view finder as possible. If the camera bases exposure and white balance off of a bright sky or a reflective surface such as water the photos will be underexposed.
 - Select an f-stop one lower than the highest f-stop available on the camera. For example if the highest f-stop is F22, set the camera to F16.
 - Under Menu select ISO 100 or 200.
- Record all environmental and camera settings in the Trimble.
- Check the lens and to be sure it is free of dust and smears. If needed, clean with the proper cleaning brush, cloth and spray.
- Row 1 is the first set of photos taken. For a 16mm lens they will be at -30° tilt*. Record your starting location in degrees rotation about the vertical axis. Note that the degrees rotation recorded for the first photo taken in Row 1 will be the same (approximately) for all following rows.
- Now you are ready to begin taking photos for Row 1. Take photos while panning horizontally in a clock-wise direction allowing approximately 30% overlap between photos. NOTE: Always pan in a clock-wise direction. After taking eight photos, you should be at or near the starting position.
- To find the starting point of Row 2, pivot the camera upward to a +30° tilt. The first photo taken in Row 2 should be taken at the same rotation about the vertical axis as the first shot
- Shoot eight shots around again.

*Different lenses will not only require a different numbers of shots around (see previous section), but also different tilt angles to ensure the correct overlap. For a 35mm lens, rows should be taken at -60, -30, 0, 30, and 60 degrees, with 18 shots around. This creates a tremendously large file.

You have now created enough images to create an almost complete spherical panorama, with only a small circle containing the footprint of the tripod and a corresponding gap directly overhead absent.

Post processing upon return

- Download the images from the camera.
 - Each panoramic series (16 images) should be placed into its' own folder.
 - Designate each folder with the site name, date, and picture location.
 - *i.e.*, Office Slough 05-06-08 Overview
- Process Panorama in PTGui.
 - Open PTGui.
 - Load the 16 images into software (Project Assistant tab, Load images).
 - In the Panorama Settings tab (advanced) set the Projection to Equirectangular and the Field of view to 360° x 180°.
 - In the image parameters tab (advanced), enter yaw and pitch and roll information for each image.
 - The roll for all images will be either 90 or -90, depending on the orientation of your camera. The images should be upright.
 - The first eight images should have a pitch of -30, and the last eight a pitch of +30, corresponding to the settings of the pano. head.
 - The 1st and 9th images (0 and 8) will have a yaw of 0.
 - The 2nd and 10th image will have a yaw of 45, again corresponding to the rotation of the pano. head.
 - Continue to assign locations to all of the remaining images, proceeding from 0,45,90,135,180,-135,-90,-45.
 - Click 'align images' and move misplaced/aligned images into their approximate proper locations (if you entered the positions correctly, you should have a very well aligned panorama already)
 - Click 'optimize'.
 - The optimizer will return results including maximum and average control point distances, and an overall fit. This fit needs to be 'good' or better.
 - Add, delete, and manipulate control points until optimization produces a good fit (see tutorials links below).
 - Preview your panorama to make sure no major seams or misalignments are present.
 - Save your project in the same folder as the original images.
 - Save your panorama as a still image. (See Fig. 3)
 - Navigate to the Create Panorama Tab.
 - Make sure 'Link width and height' is checked.
 - Click 'Set optimum size' and select maximum.
 - Change 'File format' to TIFF (.tif) with 'Settings' of 8-bits, no compression, no alpha.
 - 'Layers' should be set to 'Blended panorama only'
 - In the advanced field, uncheck 'use fast transform'
 - Save the file to the same folder as the original images, with the same name as the folder.
 - Click 'Create Panorama'
 - Wait. (This *will* take awhile)
 - Save your panorama as an interactive sphere. (See Fig. 4)
 - Navigate to the Create Panorama Tab.
 - Make sure 'Link width and height' is checked.

- o Click 'Set optimum size' and select maximum.
- o Change 'File format' to QuickTime VR (.mov) with 'Settings' as default *except* for 'Quality' which should be 100%.
- o 'Layers' should be set to 'Blended panorama only'
- o Save the file to the same folder as the original images, with the same name as the folder.
- o Click 'Create Panorama'
- o Wait. (This *will* take awhile)
- Repeat processing for all panoramic images from the field.
- If you are processing multiple images, it may be useful to send the images to the batch stitcher instead of doing them one at a time.
 - o This is accomplished by clicking 'Send to batch stitcher' instead of 'create panorama'
 - o The files will be saved in the appropriate folders after they have been stitched. This streamlines the stitching process while using a minimum of system resources.

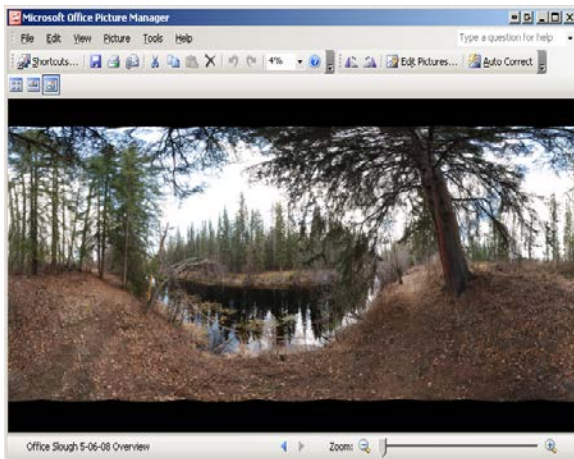


Figure 7. Office Slough as a .tif still image.

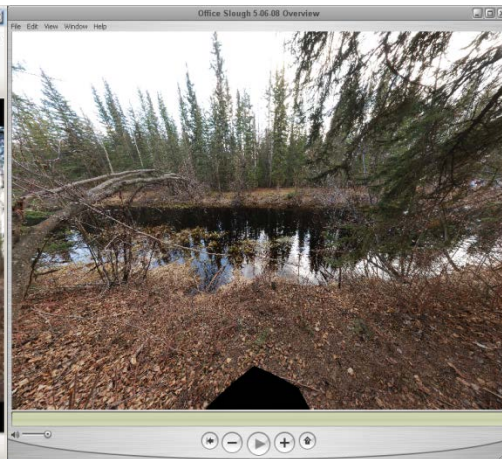


Figure 8. Office Slough as a .mov interactive panorama showing the tripod footprint

Good tutorials for panoramas and PTGui

<http://www.ptgui.com/examples/>

<http://www.johnhpanos.com/pttute.htm>

http://www.dffe.at/pano360/360-5_2e.html

References

Bailey, Bill. 2008. Camera Settings for Nodal Ninja. *Online at* http://www.nodalninja.com/nodal_ninja_3_camera_settings.html. Accessed on 05/06/2008.

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

Additional comments on protocol

HK 10/27/08 The panorama will not export properly if the file is too large. If more than 16 images are used, or if the camera used produces very large image files, it does not work to set the optimum size to maximum. Instead, enter the desired size (a width of 15000 pixels works well; if the link width and height option is checked it will automatically set the height to be proportional to the width when a new width is entered).

HK 10/27/08 Another small thing to remember is to center your panorama before exporting the still image. For some sites it doesn't matter, but if you have a panorama of a water body, it helps to have the water body centered in the middle of the panorama rather than split into 2 parts. This can be done in the panorama editor, which is accessed by clicking the "Align panorama..." button in step 2 under the Project Assistant tab. The image can be re-centered by dragging the image to the left or right in the window.

SOP 10: Discharge Measurement

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

Introduction

Stream discharge is equal to the product of the mean current velocity and vertical cross sectional area of flowing water. Discharge measurements are critical for assessing trends in streamwater acidity and other characteristics that are very sensitive to streamflow differences. Discharge should be measured at a suitable location within the sample reach that is as close as possible to the location where chemical samples are collected (typically the reach bottom), so that these data correspond. Discharge is usually determined after all other data collection is complete.

No single method for measuring discharge is applicable to all types of stream channels. The preferred procedure for obtaining discharge data is based on "velocity-area" methods (*e.g.*, Rantz *et al.* 1982; Linsley *et al.* 1982). For streams that are too small or too shallow to use the equipment required for the velocity-area procedure, two alternative procedures are presented. One procedure is based on timing the movement of a neutrally buoyant object (*e.g.*, an orange or a small rubber ball) through a measured length of the channel, after measuring one or more cross-sectional depth profiles within that length. The second procedure is based on timing the filling of a volume of water in a calibrated bucket. This second procedure is not expected to be useful in the Central Alaska Netowkr, and is included only for completeness. The procedures and activities presented here are essentially identical to those developed for the EMAP Wadeable Streams Assessment (Kaufmann, 1998), and currently used in the EPA National Rivers and Streams Assessment (USEPA 2007, 2013a).

Velocity-Area Procedure

Because velocity and depth typically vary greatly across a stream, accuracy in field measurements is achieved by measuring the mean velocity and flow cross-sectional area of many increments across a channel (Figure 1). Each increment gives a subtotal of the stream discharge, and the whole is calculated as the sum of these parts. Discharge measurements are made **at only one carefully chosen channel cross section within the sampling reach**. It is important to choose a channel cross section that is as much like a canal as possible. A glide area with a "U" shaped channel cross section that is free of obstructions provides the best conditions for

measuring discharge by the velocity-area method. You may remove rocks and other obstructions to improve the cross-section before any measurements are made, although major disturbance of the stream bed should be avoided. However, because removing obstacles from one part of a cross-section affects adjacent water velocities, you must not change the cross-section once you commence collecting the set of velocity and depth measurements.

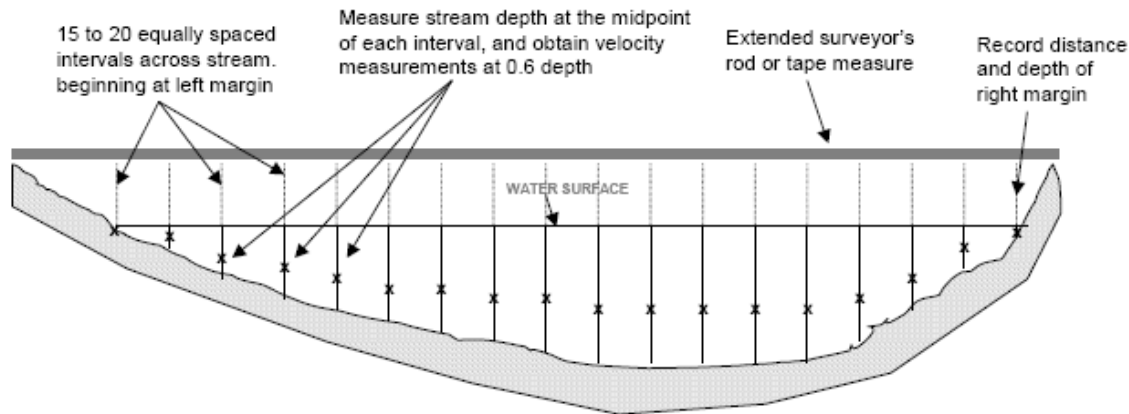


Figure 9. Layout of channel cross-section for obtaining discharge data by the velocity-area procedure.

Required Gear

30-m and 100-m tapes
 Top-setting wading rod
 Marsh-McBirney Flo-Mate current meter (or equivalent)
 2 short pieces of rebar (if needed)
 Small sledge (if needed)

Velocity-area procedure for determining stream discharge.

Locate a cross-section of the stream channel for discharge determination that has most of the following qualities (based on Rantz *et al.* 1982):

- Segment of stream above and below cross-section is straight
- Depths mostly greater than 15 centimeters, and velocities mostly greater than 0.15 meters/second. Do not measure discharge in a pool.
- "U" shaped, with a uniform streambed free of large boulders, woody debris or brush, and dense aquatic vegetation.
- Flow is relatively uniform, with no eddies, backwaters, or excessive turbulence.

Stretch either the 30 or 100 meter tape across the stream perpendicular to its flow, with the “zero” end of tape on the left bank, as viewed when looking upstream. Anchor the tape at both ends by tying it around a tree or bush or other appropriate object. Short pieces of rebar stuck into the ground also work well. Make sure the tape is tightly suspended across the stream. Ideally, it will be approximately one foot above water level, although this is not critical.

Measure the wetted width of the stream. Divide the total wetted stream width into equal-sized intervals. The goal is to have approximately 20 such intervals, but generally no fewer than 15 and no more than 25. To determine interval width, divide the width by 20 and round up or down to a convenient number, adding or subtracting from the total of 20 intervals as needed. Intervals should not be less than 10 cm wide, even if this results in fewer than 15 intervals. The first interval is located at the left margin of the stream (left when looking upstream), and the last interval is located at the right margin of the stream. Write down the increments on the data sheet or in the field notebook, including both the actual interval, and the “observed” interval as read on the measuring tape. For example, imagine that the left edge of the wetted width occurs at 4.35 meters as read on the tape, and the right edge of the wetted width occurs at 12.4 meters as read on the tape. The total wetted width is 8.05 meters and the interval width would be 0.4 meters ($8.05/20$, rounded down). Readings would be taken at 0, 0.4, 0.8, 1.2, 1.6, etc meters, which would be read on the tape as 4.35, 4.75, 5.15, 5.55, etc, on the tape. The first and last measurements will be taken at the left and right bank of the stream, respectively. For either or both of these measurements, the depth and velocity may be “0”.

Attach the Flo-Mate velocity meter probe to the top-setting wading rod, and tighten the locking screw (see Figure 2). Turn on the meter (hit “ON/C”). The display will cycle through the display segment test and will then show a velocity. Make sure the display show velocity in m/sec (unless you are using an English-unit wading rod – then you want to record in ft/sec). To change the units, press the “ON/C” and “OFF” buttons simultaneously. There are 4 settings available – FT/S, M/S, F/S and M/S. The first two settings will activate the beeper, while the last two will silence the beeper. Generally speaking, the beeper should be activated. To cycle between settings, keep pressing the ON/C and OFF keys. Next, make sure the signal dampening method is set to use fixed –point averaging (“FPA”). There are two dampening methods available, FPA and time-constant filtering (“rC”). To cycle between them, press the up and down arrows simultaneously. The averaging period for FPA should be set to 40 seconds. To check and/or change the FPA averaging period, press either the up or down arrow.

Stand downstream of the rod or tape and to the side of the first interval point. Place the wading rod against the measuring tape at the appropriate interval point, on the downstream side. Holding the wading rod vertically, use the depth gauge rod (see Figure 2) to measure the depth of the stream and record it on the datasheet or in the field notebook. The depth gauge rod has three sets of markings. Triple hash marks correspond to 50-cm increments, the double hash marks to 10-cm increments, and the single hash marks to 2-cm increments (on an English-unit rod, these correspond to 1-ft, 0.5-ft and 0.1-ft increments). If the depth is less than 0.75 meters (2.5 feet), you will take one velocity measurement at 0.6 of the total depth. If the depth is greater than 0.75 meters, you will take two velocity measurements, at 0.2 and 0.8 of the depth. The top-setting wading rod can be used to set these depths easily. To set the rod at 0.6 of the depth, press the release button (grey rubber, see Figure 2) and slide the sliding rod so that the number on the sliding rod that corresponds to the “10” digit of the depth aligns with the number on the scale at

the top of the depth gauge rod that corresponds to the “1” digit of the depth. For example, if the depth is 35 cm (0.35 m), then you would align the “3” on the sliding rod with the “5” on the depth gauge rod. This sets the depth of the current meter at $0.6 \times 35 = 21$ cm (as measured from the water surface). Figure 2 illustrates this, in

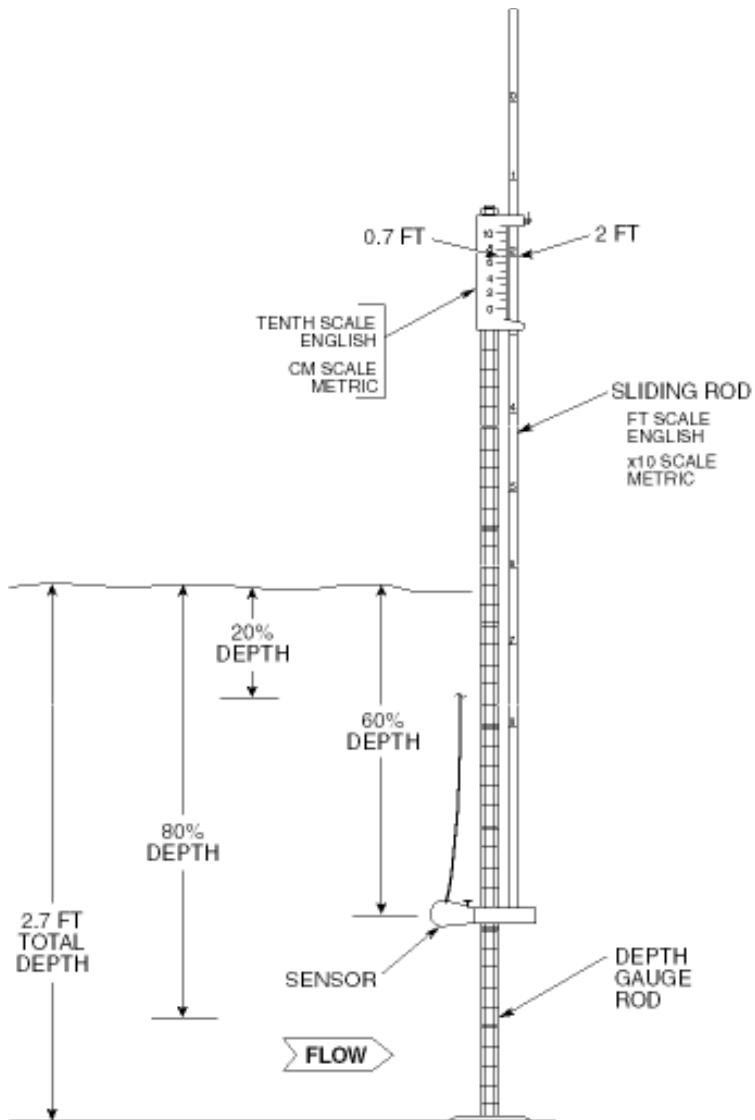


Figure 10. Top-setting wading rod. This example shows an English-unit wading rod. The release button is visible on the right side, just above the “2 FT” label.

English units. Setting the current meter to read at 0.2 and 0.8 of the depth is similar. To set the wading rod at 0.2 of the depth (in this example that would be $0.2 \times 35 = 7$ cm depth as measured from the water surface), multiply the measured depth by 2, and set the wading rod for 0.6 of this new depth. For example, if the measured depth is 35 cm, then $2 \times$ the depth would be 70 cm. Setting the wading rod to 0.6 $\times$ 70 (by aligning the “7” on the sliding rod with the “0” on the depth gauge rod) adjusts the depth of current meter to $70 - 0.6 \times 70 = 28$ cm as measured from

the bottom, which corresponds to 7 cm depth as measured from the water surface. Similarly, to set the wading rod to 0.8 of the depth, divide the measured depth by 2 and set the rod for this new depth (in this example, $35/2 = 17.5$ cm).

Once the depth of the current meter is properly adjusted, stand downstream and to one side of wading rod to avoid disrupting the stream flow. Face the current meter sensor upstream at a right angle to the measuring tape, even if local flow eddies hit at oblique angles to the cross-section.

Press the “ON/C” button to clear the display and start a measurement. A bar across the bottom of the display will show how much time has elapsed in the fixed-point averaging. When the bar reaches 40 seconds, the unit will beep, indicating that the measurement is complete. Record the displayed value. Note that as soon as one measurement is complete, another FPA interval begins.

Move to the next interval point and repeat these steps. Continue until depth and velocity measurements have been recorded for all intervals.

Neutrally-Buoyant Object Procedure

In very small, shallow streams, where the standard velocity-area cannot be applied (or in other situations where a good measurement cannot be obtained), the neutrally buoyant object method may be the only way to obtain an estimate of discharge. The required pieces of information are the mean flow velocity in the channel and the cross-sectional area of the flow. The mean velocity is estimated by measuring the time it takes for a neutrally buoyant object to flow through a measured length of the channel. The channel cross-sectional area is determined from a series of depth measurements along one or more channel cross-sections. Since the discharge is the product of mean velocity and channel cross-sectional area, this method is conceptually very similar to the standard velocity-area method. Examples of suitable objects include oranges, small sponge rubber balls, or small sticks. The object must float, but very low in the water. It should also be small enough that it does not “run aground” or drag bottom and be easily visible (which is why oranges are often used).

Choose a stream segment that is roughly uniform in cross-section, that is deep enough so the object can float freely, and that is long enough to require 10 to 30 seconds for an object to float through it. Determine and record the length of the segment, measuring down the center of the channel.

Select one to three cross-sections to represent the channel dimensions within the segment, depending on the variability of width and/or depth. If the channel width and/or depth change substantially within the segment, measure widths and depths at three cross-sections, one near the upstream end of the segment, a second near the middle of the segment, and a third near the downstream end of the segment. If there is little change in channel width and/or depth, obtain depths from a single “typical” cross-section within the segment.

At each cross section, measure and record the wetted width using a surveyor’s rod or tape measure. Measure the stream depth using a wading rod or meter stick at points approximately equal to the following proportions of the total width: 0.1, 0.3, 0.5, 0.7, and 0.9.

Using a stopwatch, measure and record the time required for the object to pass through the measured segment that includes all of the selected cross-sections. Repeat the time measurement at least two more times.

Timed Filling Procedure

In channels too "small" for the velocity-area method, discharge can sometimes be determined directly by measuring the time it takes to fill a container of known volume. "Small" is defined as a channel so shallow that the current velocity probe cannot be placed in the water, or where the channel is broken up and irregular due to rocks and debris, and a suitable cross-section for using the velocity area procedure is not available. This can be an extremely precise and accurate method, but requires a natural or constructed spillway of free-falling water.

Choose a cross-section of the stream that contains one or more natural spillways or plunges that collectively include the entire stream flow. A temporary spillway can also be constructed using a portable V-notch weir, plastic sheeting, or other materials that are available onsite. Choose a location within the sampling reach that is narrow and easy to block when using a portable weir. Position the weir in the channel so that the entire flow of the stream is completely rerouted through its notch. Impound the flow with the weir, making sure that water is not flowing beneath or around the side of the weir. Use mud or stones and plastic sheeting to get a good waterproof seal. The notch must be high enough to create a small spillway as water flows over its sharp crest.

Position a calibrated bucket or other container beneath the spillway to capture the entire flow. Use a stopwatch to determine the time required to collect a known volume of water. Record the volume collected (in liters) and the time required (in seconds). Repeat this step a total of 5 times for each spillway that occurs in the cross section. If there is more than one spillway in a cross-section, you must use the timed-filling approach on all of them.

References

- Kaufmann, P.R. 1998. Stream discharge. Pages 67-76 in J.M. Lazorchak, D.J. Klemm, and D.V. Peck, editors. Environmental monitoring and assessment program-surface waters: field operations and methods for measuring the ecological condition of wadeable streams. EPA/620/R-94/004F. U.S. Environmental Protection Agency, Washington, D.C.
- Peck, D.V., J.M. Lazorchak, and D.J. Klemm, editors. Unpublished draft. Environmental monitoring and assessment program -surface waters: western pilot study field operations manual for wadeable streams. EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.
- Linsley, R.K., M.A. Kohler, and J.L.H. Paulhus. 1982. Hydrology for engineers. McGraw-Hill Book Co. New York.

Rantz, S.E. *et al.* 1982. Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge. U.S. Geological Survey Water-Supply Paper 2175.

USEPA. 2007. National Rivers and Streams Assessment: Field Operations Manual. EPA-841-B-07-009. U.S. Environmental Protection Agency, Washington, DC.

SOP 11: Decontamination

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

This SOP contains procedures for the decontamination of equipment and gear used in sampling aquatic habitats. The following procedures were directly adapted from the Great Lakes Network Standard Operating Procedure 5: Decontamination of Equipment to Remove Exotic Species (Elias 2005), Upper Columbia Basin Network Standard Operating Procedure 8: Decontamination of Equipment for Aquatic Invasive Species (Starkey *et al.* 2009), Sierra Nevada Network Standard Operating Procedure 7: Equipment Disinfection (Schweizer 2007) and Standard Operating Procedure 10: Field Equipment Decontamination of Aquatic Invasive Species from the Southwest Alaska Network Freshwater Flow Systems monitoring protocol.

Introduction

Aquatic invasive species (AIS) are a serious ecological and socio-economic threat to freshwater systems throughout North America. AIS have the potential to out-compete native flora and fauna, alter habitat conditions, and cause billions of dollars in infrastructure repairs and mitigation. The introduction and subsequent spread of zebra mussels (*Dreissena polymorpha*) in the Great Lakes Region is a classic example. The U.S. General Accounting Office (2001) reports that from 1989 to 1995 that \$70 million was spent on control of zebra mussels by municipalities and industry in the Great Lakes region. New Zealand mudsnails (*Potamopyrgus antipodarum*), silver carp (*Hypophthalmichthys molitrix*), and Eurasian watermilfoil (*Myriophyllum spicatum*) are just a few other notable examples in a long list of species whose introduction and spread throughout U.S. waters have resulted in ecological and economic impacts. However, relatively few AIS have been introduced to the waters of Alaska. Reasons for Alaska's fortunate status include geographic isolation, strict plant and animal transportation laws, relatively low human population, and northern climate (Fay 2002).

To date, we are unaware of any AIS populations established within CAKN lakes and rivers. Pursuant to its mission, the National Park Service has a responsibility to take a proactive role in maintaining the ecological integrity that characterizes CAKN aquatic ecosystems and to prevent the introduction and spread of AIS within network waters. This SOP identifies the most likely

AIS threats to Alaska lakes and streams and provides general decontamination procedures for field crews to minimize the risk of accidental transport of all species, native and AIS, between water bodies during water quality, hydrology, and fisheries monitoring activities. This SOP does not address terrestrial or marine invasive species that may be encountered along upland or coastal areas.

Existing and Potential Aquatic Invasive Species Threats to Alaska

Aquatic invasive species that have not yet been found within the CAKN but that are considered high priority threats within the state of Alaska are listed in Table 1. These lists are not meant to be all inclusive and information on species introductions is limited and anecdotal due to the lack of an AIS monitoring program (Fay 2002).

Table 9. Aquatic invasive species considered high priority threats to freshwaters and riparian areas of Alaska (Fay 2002, McClory and Gotthardt 2008).

Scientific Name	Common Name
<u>Plants</u>	
<i>Polygonum cuspidatum</i>	Japanese knotweed*
<i>Phalaris arundinacea</i>	Reed canary grass*
<i>Hydrilla verticillata</i>	Hydrilla
<i>Landoltia punctata</i>	Dotted duckweed
<i>Lythrum salicaria</i>	Purple loosestrife*
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil*
<i>Spartina alterniflora</i>	Salt marsh cordgrass
<i>Spartina densiflora</i>	Dense-flowered cordgrass
<i>Utricularia inflata</i>	Swollen bladderwort
<i>Elodea canadensis/nuttali</i>	Waterweed*
<u>Animals</u>	
<i>Salmo salar</i>	Atlantic salmon*
<i>Perca flavescens</i>	Yellow perch*
<i>Rana aurora</i>	Red-legged frog*
<i>Pseudacris regilla</i>	Pacific chorus frog
<u>Invertebrates</u>	
<i>Potamopyrgus antipodarum</i>	New Zealand mudsnail
<i>Eriocheir sinensis</i>	Chinese mitten crab
<i>Dreissena polymorpha</i>	Zebra mussels
<i>Pacifastacus leniusculus</i>	Signal crayfish*
<i>Bythotrephes cederstroemi</i>	Spiny water flea
<u>Viruses</u>	
<i>Myxobolus cerebralis</i>	Whirling disease*

* present or previously documented in Alaska

Procedures

The following procedures must be followed before entering any waterbody for sampling purposes. Additionally, these procedures must be followed when sampling is complete on one waterbody but before sampling begins on a different waterbody. As stated previously, we are unaware of any established AIS populations within CAKN waters. However, without an active AIS monitoring program in place, we will take a proactive approach and treat all equipment when moving between any waterbody.

Procedure at non-remote locations when tap water is available

1. Remove and rinse mud, plant material, mussels, and other visible organic material boat/raft, paddles/oars, boots, and from all sampling equipment.
2. Soak all nets, waders, and boots in a 2% Sparquat 256 solution for 10 minutes or spray a 10% Sparquat 256 solution on equipment and let stand for 5 minutes. Sparquat is preferred over bleach since it is less harsh on nets and wader material.
3. Thoroughly rinse disinfectant solution off sampling equipment.
4. Let equipment dry for 10 days. If it is not possible to let equipment dry, proceed to steps 5 – 8.
5. Use a hose with spray nozzle and scrub brush to rinse and scrub all equipment, paddles/oars, boots, waders, etc. Perform this task on vegetated land away from impervious surfaces and slopes where rinse water may run directly into the nearby lake or river.
6. Use a bottle or toilet brush to clean the inside of PVC housing units for continuous multiparameter water quality sondes.
7. Pay particular attention to ropes, cracks, and crevices in equipment, and rinse well.
8. Visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.

Procedure at remote locations when tap water is not available

This procedure uses dry, granular chlorine bleach as a disinfectant instead of Sparquat 256. Dry chlorine bleach is readily available at pool / spa supply stores and is easy to pre-measure and transport to remote field sites rather than a liquid disinfectant (Schweizer 2007). One cup of 56% dry chlorine bleach mixed with 2 gallons of water will yield a 2% bleach solution used to disinfect equipment.

1. Remove and rinse mud, plant material, mussels, and other visible organic material boat/canoe, paddles/oars, boots, and from all sampling equipment.
2. Run hand up and down ropes attached to all equipment and anchor to dislodge mud, plant material, and organisms.
3. Pay particular attention to cracks and crevices in equipment when rinsing.
4. Visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.
5. Let equipment dry for 10 days. If it is not possible to let equipment dry, proceed to steps 6 – 11.
6. Measure 1 cup of dry chlorine bleach into a collapsible bucket with 2 gallons of water.
7. Allow equipment to soak in bleach solution for a minimum of 2 minutes.
8. Rinse equipment with water from the new survey site. Do NOT rinse equipment with water from old survey site as you will only re-contaminate the equipment.

9. For large equipment that can not be soaked in the bucket, fill a spray bottle with 2% bleach solution and spray all surfaces. Allow equipment to air dry, then rinse with water from new survey site.
10. Dispose of bleach solution at least 100 meters from any surface waters.
11. Visually inspect all gear to verify that all equipment and gear has been cleaned and rinsed.

Procedures to follow regardless of remoteness

1. When possible, avoid using boats and other equipment on different waters. The CAKN will work towards obtaining a set of field equipment for each park but water quality meters, filtration equipment, *etc.* will always be used in different watersheds within each park.
2. If AIS becomes established in CAKN waters, that particular waterbody should be sampled last, to the extent possible, during the field season.
3. To the extent possible, sampling should start at the most upstream sites within a watershed and proceed downstream.

Note: procedures listed in this SOP may need to be modified in the event AIS are detected within CAKN waters.

References

- Elias, J. 2005. Standard Operating Procedure #5, Decontamination of equipment to remove aquatic exotic species. *in* Magdalene S., D.R. Engstrom, and J. Elias. 2007. Large rivers water quality monitoring protocol, version 1.0. National Park Service, Great Lakes Network, Ashland, Wisconsin.
- Fay, V. 2002. Alaska aquatic nuisance species management plan. Alaska Department of Fish and Game, Juneau, Alaska.
- McClory, J., and T. Gotthardt. 2008. Non-native and invasive animals of Alaska: a comprehensive list and select species status reports. Final Report, Alaska Natural Heritage Program, Anchorage, Alaska.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher. 2002. Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.
- Schweizer, D. 2007. Standard Operating Procedure #7: Equipment disinfection. *in* Heard, A.M., L.A. Harrod Starcevich, J.O. Sickman, D.W. Schweizer, and M.G. Rose. 2007. Sierra Nevada Network lake monitoring protocol, version 1.0. National Park Service, Sierra Nevada Network, Three Rivers, California.
- Starkey, E. N., L.K. Garrett, T.J. Rodhouse, G.H. Dicus, and R.K. Steinhorst. 2009.

Standard Operating Procedure #8, Decontamination of equipment for aquatic invasive species. In Starkey, E.N., L.K. Garrett, T.J. Rodhouse, G.H. Dicus, and R.K. Steinhorst. 2009. Integrated water quality monitoring protocol standard operation procedures, Upper Columbia Basin Network. Natural Resource Report NPS/PWR/UCBN/NRR—2009/00xx. National Park Service, Fort Collins, Colorado.

U.S. General Accounting Office. 2001. Invasive Species: Obstacles hinder federal rapid response to growing threat. Report GAO-01-724. Washington DC.

SOP 12: Water Chemistry Laboratory Procedures

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

This Standard Operating Procedure (SOP) contains information on water chemistry sample submission procedures as well as information on detailed procedures for the laboratory analysis of solutes in water samples and QA/QC procedures. Currently, the Cooperative Chemical Analytical Laboratory (CCAL), a water chemistry analysis laboratory operated jointly by the U.S. Forest Service and Oregon State University that specializes in the detection of low-level solutes from ambient environmental water samples, performs all water chemistry analyses for the CAKN. The CCAL website (ccal.oregonstate.edu) contains detailed information regarding methods, detection levels, QA/QC procedures, order forms, sample submission procedures and analysis costs. As of 2017, the laboratory director is Kathy Motter. She can be reached at 541-737-5120.

Selecting Analytes

Currently, the CAKN Stream Monitoring program submits samples for 2 distinct sets of analyses each year. Judgment or Other sites that are being sampled for the first time, as well as Long Term (GRTS) sites (see SOP2 for definitions) that are being sampled either for the first time, or as part of the regular panel rotation schedule (*i.e.*, once every 10 years), should have a full suite of analyses performed. For sentinel sites, or Judgment/Other sites that are sampled annually, or relatively often (*i.e.*, more often than once every 10 years), samples from repeat visits should have a reduced suite of analyses performed. These suites of analyses are listed in Table 10. The rationale for this approach is to reduce costs. If sufficient funding is available in a given year, then all samples collected should be designated for the full suite of analyses.

Shipping Samples

Before submitting samples for analysis, both a Sample Submission Form (<http://ccal.oregonstate.edu/sample-submission-form>) and a Sample Submission Worksheet (downloaded from the Sample Submission Form web page) should be completed and submitted. On both forms, the "Project" should be entered as

Table 10. List of analytes for CAKN water chemistry samples.

Analyte	Sample type	CAKN designation (if different)	Analytic suite
pH	Unfiltered		Full only
Alkalinity	Unfiltered		Full and Reduced
Specific conductivity	Unfiltered		Full only
Organic carbon	Filtered	Dissolved organic carbon	Full and Reduced
Ammonia nitrogen	Filtered		Full only
Nitrate + nitrite nitrogen	Filtered	Nitrate nitrogen	Full and Reduced
Orthophosphorous	Filtered	Phosphate phosphorous	Full only
Total nitrogen	Both	Total nitrogen (unfiltered)	Full and Reduced
		Total dissolved nitrogen (filtered)	Full and Reduced
Total phosphorous	Both	Total phosphorous (unfiltered)	Full and Reduced
		Total dissolved phosphorous (filtered)	Full and Reduced
Sulfate	Filtered		Full and Reduced
Chloride	Filtered		Full only
Sodium	Filtered		Full only
Potassium	Filtered		Full only
Calcium	Filtered		Full only
Magnesium	Filtered		Full only
Silicon	Filtered		Optional

“CAKN Stream Monitoring”. On the Sample Submission Worksheet, enter an estimate under “Sample Delivery Date”. Typically this will be 2 days from the ship date when shipping via Federal Express. The Sample Submission Worksheet should otherwise be filled out as follows. Under “Sample Name or ID”, list the Site Name. Under “Barcode”, list the Site Code. Under “Date Collected”, list the Sampling Date. Under “Sample Type”, enter “Stream”. Under “Cold or Frozen”, use the dropdown menu to select “Both”. Individual analytes should be selected according to Table 10. For some analytes, there is a dropdown menu where the sample type (filtered, unfiltered or both) needs to be selected. For Organic Carbon, Sodium, Potassium, Calcium and Magnesium, select “filtered”. For Total Nitrogen and Total Phosphorous, select “both”. For all other analytes, enter an “X” in the appropriate cell.

Include a hard copy of the Sample Submission Worksheet with the samples themselves. The samples should be shipped in a cooler. Use separate coolers for frozen and unfrozen samples. Be sure to use sufficient packing material in the cooler to cushion the samples, especially the frozen samples, as they are more delicate. Coolers should be securely taped shut with packing tape and/or duct tape. Pack the samples for shipping in the morning of the day they are to be shipped. Samples should be delivered to the Federal Express office at 6059 Old Airport Way at the Fairbanks Airport before noon. Request Next Day delivery. Samples should be shipped to:

CCAL
OSU College of Forestry
056/048 Peavy Hall
Corvallis, OR 97331
Contact phone: 541-737-5120

Laboratory SOPs and Quality Assurance Plan

CCAL SOPs for all methods used in the analysis of solutes in CAKN water chemistry samples are available at ccal.oregonstate.edu/sops. The SOPs are extremely detailed, are many pages long and are updated regularly. Accordingly, they are not explicitly included here. The CCAL Quality Assurance Plan (QAP) is available at ccal.oregonstate.edu/qaqc.

References

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002

SOP 13: Diatom Laboratory Procedures

Revision History Log

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This Standard Operating Procedure describe laboratory procedures and QA/QC for the processing and identification of diatom samples. Currently Ecoanalysts, Inc. is contracted to provide these services for the CAKN. This SOP is adapted directly from Ecoanalysts, Inc.'s SOPs and QAPP. More information regarding EcoAnalysts, Inc. diatom taxonomy services is available at their website www.ecoanalysts.com. The contact person for diatom taxonomy services is the Project Coordinator. As of 2017, the Project Coordinator is Shanda McGraw (208-882-2588 extension 30, smcgraw@ecoanalysts.com).

Shipping Samples

Diatom samples should be shipped via Federal Express in a sturdy box or cooler with adequate packing material. Use parafilm or tape to secure the top of each sample tube so it doesn't come loose during shipping. Since the samples are stored at ambient temperatures, they can be shipped either Next Day or 2nd Day. You may either arrange for a pickup of the package at the NPS office on Geist Road, or drop them off at the 6059 Old Airport Way Federal Express office. Prior to shipping, you should contact the Project Coordinator so EcoAnalysts is aware that samples are coming. You will need to send an electronic copy of a sample list/chain-of-custody form to the Project Coordinator, as well as including a hard copy with the samples. The sample list should contain the following information about each sample – Site Name, Site Code, Sampling Date, Sample Volume, Total Area Sampled (generally 120 cm²), and Sample Proportion of Total Area Sampled. This proportion can be calculated from the total area sampled, the sample volume, and the composite sample volume that is recorded in the field as follows. Sample Proportion of Total Area Sampled = Total Area Sampled * (Sample Volume/Composite Sample Volume). This will allow Ecoanalysts to calculate areal densities for each species identified. Be sure to request that they provide this service in advance. As of 2017, samples should be shipped to the following address. However it is a good idea to doublecheck that with the Project Coordinator.

EcoAnalysts, Inc.
1420 S. Blaine St., Suite 14
Moscow, Idaho 83843
Contact phone 209-882-2588

Summary of Methods - EcoAnalysts, Inc. Phytoplankton/Periphyton *Determination of Proportion of Sample*

The methods described in this laboratory manual are the standard methods used in the processing of plankton samples for a qualitative assessment of plant/animal/detritus composition and can be catered upon request to fit the requirements of specific study designs or a detailed scope of work. Unless otherwise specified, all equipment is calibrated and maintained according to the manufacturer's guidelines. Taxonomic references and other processing references are available upon request.

Sample Receiving and Chain of Custody Tracking

Immediately upon receipt of samples, all containers are inspected for damage or leakage. Sample labels are checked against chain of custody forms and/or packing slips and any discrepancies are noted. Receipt and chain of custody logs are reported throughout the project according to timelines and methods requested by the client.

Samples are logged into the EcoAnalysts, Inc. custom Laboratory Information Management System, LIMS, database and assigned a unique sample tracking number.

Sample Preparation

Before a sample is processed, the taxonomist or lab technician confirms the following information with the packing slip or chain of custody form: sample identification number, pertinent location and replicate information, sample date, habitat type, area sampled, and sample volume, if available.

The taxonomist mixes each sample for proper distribution of the communities. Proper distribution is achieved by a manual 270 degree inversion of sample bottles for at least one minute.

Subsamples are removed from each sample bottle. Volumes are measured using a 25mL graduated cylinder, and placed into Utermohl settling chambers for microscopy. The amount of each individual subsample is 20mL for all sample bottles.

Utermohl chambers are allowed to settle overnight untouched. Assessment of the communities is performed 24 hours after settling on an inverted microscope with total magnification capabilities of 1060x.

Community Determination

Each sample is assessed using ten random fields of view. Magnification of each field of view is 630x, with a diameter of 315 microns and a total area of 0.08mm².

The taxonomists identify, measure, and enumerate three categories, phytoplankton, and detritus, in each field.

Unicellular, colonial, and filamentous algae/diatoms are taken into account for phytoplankton community assessment.

Unicellular and colonial zooplankton are taken into account for zooplankton community assessment.

Plant matter, sand particles, wood chunks, and other non-phytoplankton/zooplankton particles are enumerated for representation of detritus in the samples.

Relative abundances and size of individuals in each category are calculated into percentages of sample they represent.

Based on final percentages of three categories, community make-up is determined for each individual sample in the form of a ratio between the three different categories.

A digital photo reference collection is also collected and may be provided to the client upon request.

Data Compilation and Delivery

The purpose of this step is to compile the analysis data for each sample.

Throughout the project and sample analysis, data entry is double checked for accuracy. Using our networked computer systems, the appropriate data are combined for each sample to obtain the sorting statistics and comprehensive taxa lists and counts.

A narrative report of each sample assessment and a narrative final assessment of the samples is written.

Data are delivered in an electronic format specified by the client and emailed to the technical contact(s). Hard copies and/or copies on compact disc can be mailed to the client upon request. The delivery schedule will be agreed upon by the client and EcoAnalysts, Inc. in advance, specifying the sample lots, dates, and components. EcoAnalysts, Inc. retains all raw data files used and derived in our projects.

Sample Components Retention and Return

Processed sample components may include Coolers, Sorted and Unsorted residues preserved in ethanol in jars and all identified organisms preserved in ethanol and/or slide mounted.

The standard retention period for these components at EcoAnalysts, Inc. is at least 30 days after the data delivery date. We will store the sample components longer upon client request. After the retention period is over, the sample components specified for return by the client are returned with the chain of custody forms and according to the Department of Transportation (DOT) and International Air Transportation Association (IATA) rules and regulations for offering hazardous materials for shipment. Any components not requested to be returned to the client become the property of EcoAnalysts, Inc.

Personnel Safety and Hazardous Materials Handling and Shipping

All personnel are trained to adhere to safety rules and regulations when working with lab and office equipment, materials, and sample preservatives. Sample material is to be disposed of according to local rules and regulations.

All hazardous materials shipping is done according to DOT and IATA rules and regulations. When importing or exporting biological samples, all United States Fish and Wildlife Service (USFWS) and customs rules and regulations are followed.

Quality Assurance (QA) of Taxonomic Identifications

This series of steps represents a proven method to help ensure the accuracy of our taxonomy.

- High quality digital images are taken of all dominant soft-bodied taxa encountered in the project. This is one of the best voucher systems for soft algae specimens as there is no consensus or proven and effective techniques for permanent mounts. These images include taxa names, photographer/taxonomist name, date, and project ID number.
- An independent phycologist will evaluate the photographic reference collection.
- Diatom slides are archived in slide boxes with the project name.
- A minimum of 10% of all diatom slides will be re-identified by an independent phycologist to ensure taxonomic accuracy.
- Taxonomists meet via phone conference to discuss any discrepancies. In some cases it is necessary to re-examine the digital images and/or specimens to resolve discrepancies.
- The final data are adjusted according to the recommendations of both taxonomists.

QA Methods

- Soft-bodied algae and diatom proportional counts will be subject to the following criteria:
 - o The common algae identified by both taxonomists should match.
 - o Diatom taxa accounting for more than 10% relative abundance should be identified similarly by both taxonomists (synonyms are acceptable).
 - o The percent community similarity index calculated from the two diatom counts will meet established criteria.
- If any of these criteria are not met, the sample will be re-analyzed and any discrepancies will be resolved.
- A quality control report describing results and corrective steps taken, if necessary, will be provided concurrently with data delivery.

Vouchering

- Each microscope slide will be labeled with all information necessary for the identification of the sample, including water body name, site identification number, and sampling date.
- Samples will be placed into slide boxes in an orderly fashion and shipped to you upon completion of the project.
- Two copies of the digital photo reference collection are downloaded to CD.

Data Management and Reporting

- Data are entered into a custom-built taxonomy counting program which creates an electronic file for each project.
- Since the counting program automatically tallies the number of cells for each taxon, no handwritten bench sheets are required – this entirely eliminates the potential for transcription error. Printed electronic bench sheets are available upon request.
- Sample identifier information is entered, followed by the taxa and counts and notes.
- After all samples in the project are identified, the data are formatted in the output specified by the client.
- Any remaining sample materials are retained until final disposition is determined by the client, thereby always being available for additional QC.

References

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002

SOP 14: Macroinvertebrate Laboratory Procedures

Revision History Log

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This SOP contains detailed instructions for laboratory sorting and taxonomic identification of macroinvertebrate samples, along with a Quality Assurance plan. These procedures are taken directly from Standard Operating Procedures and QAPP provided by Cole Ecological, Inc., the laboratory that is currently under contract to provide macroinvertebrate identification services to the Central Alaska Network. The first section of the SOP contains instructions for shipping macroinvertebrate samples to Cole Ecological. Following that are the Cole Ecological SOP and QAP for sample processing and sorting, followed by the SOP and QAP for macroinvertebrate taxonomy.

Shipping samples

Macroinvertebrate samples should be shipped as soon as possible following the completion of the field season. Before shipping samples, contact Mike Cole at Cole Ecological (413-774-5515, mikebcole@comcast.net) to alert him that samples will be coming and to verify the shipping destination. You should also request an electronic copy of the chain of custody form, which should be filled out with sample information and emailed to Mike at the time of shipping. Normally, samples are shipped to the Massachusetts office:

Cole Ecological, Inc.
15 Bank Row, Suite B
Greenfield, MA 01301
Phone contact: (413) 774-5515

Shipping macroinvertebrate samples is complicated by the fact that the samples are preserved in 70-80% ethanol, which qualifies them as Hazardous Material (hazmat). Currently there are no qualified hazmat shippers in the Fairbanks NPS office, although there have been discussions about getting someone qualified. If a qualified hazmat shipper is available, then samples can be shipped via Federal Express. To become qualified to ship hazmat by air with Federal Express generally requires a 3-5 day in-person training. More information is available at this website: <http://www.fedex.com/us/service-guide/ship-dg-hazmat/dangerous-goods/index.html>.

General hazmat training for shipping via ground transportation is available at a variety of online sources (e.g. <http://www.lion.com/hazmat-training>). Training must be renewed

every 3 years. Samples can then be shipped conveniently from Fairbanks using either Carlile Transportation Systems (<http://www.carlile.biz/>) or Lynden Transport (<http://www.lynden.com/ltia/>). Note that currently the National Park Service does not offer training and does not specify the level of training required to ship hazmat via ground transportation. This may change at any time.

Samples should be packed and labeled according to Department of Transportation regulations ([CFR packaging requirements](#)). All of the required materials can be obtained from Arctic Fire and Safety at 702 30th Ave. in Fairbanks. Following are instructions for packing and labeling macroinvertebrate samples preserved in 70-80% ethanol. All sample bottles must be secured so the lids cannot accidentally come loose and leak. The lids can be secured by wrapping them with parafilm, packing tape or duct tape. The sample bottles must be packed inside secondary containment. Large heavy-duty plastic bags are sufficient for this. The bottles should be placed in the bag with sufficient absorbent material (*e.g.*, vermiculite) to absorb all of the liquid in the bottles. After securely sealing the bag (*e.g.*, tie it shut with a knot, then tape securely with packing tape), place the bag in a 4G fiberboard box. 4G boxes meet or exceed all of the Department of Transportation and UN Recommendations for hazmat shipping. Use packing peanuts or other packaging material to completely fill the interior of the shipping box. Close and seal the box very securely with packing tape. Be sure to include a Cole Ecological chain of custody form inside the box!

Samples preserved in 70-80% ethanol are classified as follows:

Hazard Class 3, Flammable Liquid

Proper shipping name: Ethanol solutions

Packing Group III

UN designation: UN1170

All of this information should be clearly marked on all sides of the box, along with the shipping address and an emergency contact phone number. You should contact the shipping company to verify that your package meets their requirements. You will also be required to fill out a Bill of Lading at the shipping company prior to shipping.

Macroinvertebrate Sample Processing Procedures

Sample Inventory and Log In

When samples arrive at the lab the following steps should be taken:

1. Check the sample lot against the Chain of Custody form or sample list provided by the client. If a sample list hasn't been provided, call the client and request a sheet. Whenever possible, we should request an electronic and paper copies of the client's sample list to facilitate CE sample number assignment and sample log in. No further steps should be taken until a list has been provided by the client.
2. Place the samples in order to match the client list. Check the number of samples and sample labels against the inventory list provided by the client. No processing will begin until we are sure that we have all of the samples and that coding on the

list is consistent with labeling in the sample bottles. Any discrepancies between the COC form or list provided and the CE inventory **MUST BE RESOLVED** before any processing is initiated. Immediately notify the project manager and then call the client to resolve any discrepancies.

3. Fill out both electronic and paper CE sample logs (see Attachment A: Sample Log). Any electronic list received from the client can be used to facilitate entry of sample codes into the CE electronic log (template named **2013_sample_log_template.xlsx**). This log should be renamed and stored in the project folder on the server for easy access by all users and the project manager at all times. The following information will be entered into the log at this time:
 - **CE sample ID** – This number includes the CE project number as a prefix followed by the sample number which is assigned in the same order in which the samples are logged in (e.g. 05-467-001, 05-467-002, etc.). If the client's samples follow a numeric sequence, the CE sample numbers should be aligned with that sequence. For example, if a client sends samples numbered 004, 016, and 033, we would label those samples 01, 02, and 03, respectively. **Use a sharpie to also write the CE sample ID on the outside of the bottle.**
 - **Client sample name, code, and collection date** – Record any information the client has used to identify the sample themselves. Please include the collection date.
 - **Number of bottles** – If a sample is stored in more than one bottle, use the SAME SAMPLE NUMBER and record the number of bottles on the log-in form so the sorter knows how many bottles to look for when taking the sample off of the shelf. Be sure to also write “(1 of 2)” or “(1 of 3)” etc. on the bottle as an additional measure of assurance that all bottles will be included in the sample processing.
 - **Duplicate Samples** - When duplicate samples are included, they should receive DIFFERENT SAMPLE NUMBERS, with the notation “(DUP 1)” or “(DUP 2)” etc. following the sample number. Also be sure to record “Y” in the “Duplicate?” column if the sample is a duplicate. Both the original sample and the duplicate should receive the “Y” to allow easy cross referencing in the sample log.
4. Check samples for Proper Preservation. Each sample should also be opened at this time and checked for proper preservation. Sample bottles should not be more than 2/3 full of collected material and should be in alcohol that smells strong. A foul smell or otherwise weak or lack-of-alcohol smell indicates that the alcohol is likely too diluted and that it should be replaced. Also be aware that if samples with a lot of fine material are not inverted after being filled with alcohol,

organisms may decompose in the water trapped in the fine material. Be sure to invert samples gently before opening them to ensure you will be able to ascertain whether the entire sample has been adequately preserved. If the alcohol must be replaced, carefully decant the alcohol off of the sample, by pouring through a 500- μ m sieve (or smaller) over the sink and refill with 80% ethyl alcohol.

Project Specifications Sheets

Once samples are checked in and ready to be sorted, consult the project manager and the *Project Specifications Sheet* (Attachment B) before commencing. The project specifications sheet provides project-specific sorting information and is located in the project folder in the CE server. Each project specs sheet should be posted in the lab at the commencement of sample processing for the project.

With samples logged in, the project specifications sheet consulted, and any project-specific processing requirements discussed with the project manager, sample processing may be commenced.

Sample Preparation for Sorting

Samples from the field are often laden with fine materials that cloud the sample and very coarse materials that add a lot of volume to the amount of material to be examined. Sample washing is intended to rid the sample of these materials at the extreme ends of the size spectrum without losing any macroinvertebrates. Importantly, some samples require a thorough washing while others require none. Most require some; only experience will help you determine in advance how much washing will likely be needed. Sample washing will only be performed by the laboratory manager or by technicians with at least one year of sample sorting experience.

If the sample contains a lot of silt and sand (can be seen through the bottle once it's settled), much of this can be washed out through a 500- μ m sieve:

1. Pour the sample contents through a 500- μ m sieve.
2. Catch the alcohol in a container below the sieve to save for later use.
3. Run tap water through the sieve and sample contents for about 1 minute.
4. Dump the sample into a dish pan.
5. Fill the dish pan halfway with water; allow the water to stir up the contents of the sample.
6. Swirl the dish pan GENTLY and pour again into the sieve, this time allowing the water to run into the sink, while catching the sample in the sieve.
7. Repeat this process until the water from the sample is clear

At this point, the sample may have large material that can be hand picked from the contents.

1. Pour the sample again into the dishpan and allow to fill halfway with water.
2. Hand pick leaves, sticks, etc from the sample and discard in a debris pail.
3. Closely examine and wash, if necessary, items that have inverts adhered to them. The items should be washed in a 500- μ m sieve in the sink to catch any organisms

that are washed off of the materials.

The sample should now be ready for sorting and subsampling.

Sample Sorting Procedures

CE's standard sorting procedures follow a modified EPA RBP subsampling protocol. Owing to the number of clients requesting 500-organism subsamples, CE's standard sorting and subsampling procedures consist of subsampling 525-550 organisms from Caton gridded trays under 7X magnification. CE's standard procedures are described below. CE utilizes other sorting and subsampling procedures, as necessitated by projects or as requested by clients. The most common deviations include lower subsampling counts (ranging from 100 to 300 organisms) and modifications to subsampling procedures to conform to a particular set of protocols normally used by a client.

CE Standard Sorting Procedures (500-Count Subsamples)

CE's standard subsampling procedure requires that all samples are subsampled to remove 525-550 organisms or the entire sample is sorted, whichever occurs first. Standard subsampling is performed using a 30-square Caton gridded tray. As sample volume necessitates, additional trays should be used to avoid overfilling gridded trays.

1. Pour the washed sample into a gridded tray and then float the sample on the tray to evenly distribute the sample contents across the tray. Pull the tray from the water bath to set the sample directly on the wire screen.
2. Randomly select one square and place in a Petri dish. Use the posted random numbers tables to select squares. Add 70% alcohol (new, or from the original sample, depending on the color and clarity of the alcohol from the original sample) to the sample. Usually, about half full is enough to facilitate sorting.
3. Place the Petri dish under a dissecting microscope. 7X power is the standard magnification for sorting. As a rule, if the entire depth of the material is not in focus, then there is too much material on the Petri dish. In this case, carefully place half of the sample on another Petri dish and sort after the first half is sorted. This is important in ensuring that the sample can be well searched and that organisms aren't being missed because they are out of focus or because too much material is impeding visibility.
4. Place an unfolded paper clip across the center of the Petri dish to provide reference points while the sample is being searched. Beginning on one side at one end of the clip, begin systematically working through the material towards the other end of the dish until the other end of the paper clip is reached. Repeat this procedure on the other side of the clip. This systematic approach ensures that the entire sample is searched and searched with equal effort.
5. Once the entire Petri dish has been searched, scan the dish for another several minutes to ensure that organisms were not missed. Be watchful for small

organisms, including nematodes, microcrustaceans, and midge larvae that are more easily overlooked.

6. Once finished, the sorted contents should be placed in a graduated container to estimate volume sorted and to save the sorted fraction for later quality-control inspection.
7. Continue sorting additional squares until 525-550 organisms are counted. Use a tally counter to keep an accurate track of your count. Inaccurate counts are easily recognizable to the project taxonomist and will require additional sample processing if target counts are not achieved.

You must accurately count and record the number of squares searched, as this information will be used to calculate macroinvertebrate densities. Sorting can be stopped at the next **quarter-square** after achieving a count of 525-550 organisms. In other words, there is no need to continue searching the rest of an entire square of 200 more invertebrates if you've just started the square and removed 20 to achieve a count of 525. Continue searching until you have searched a quarter of the Petri dish and record the number of squares searched to the nearest quarter.

Large/Rare Organism Search

Once the 525-550 organism subsample is complete, the remaining unsorted squares are searched with the naked eye for large and/or rare invertebrates. These are invertebrates that are larger than ~1 cm and are represented by only a few specimens in the sample (i.e., they weren't encountered while you were sampling the squares under the scope). Use the following procedure to perform the search, and place these specimens in a separate vial with a large/rare search label included:

1. Refloat the sample with water in the gridded tray.
2. Gently redistribute the remaining material across the tray screen.
3. Search the sample with forceps and place a few of each large/rare organisms into the vial.

NOTE: Some projects may require that this search be performed before subsampling occurs or not at all. Please consult with the project manager and project specifications sheet before each project to know if/when to perform this search.

Original EPA RBP Sorting Procedures

The following procedures are described in EPA's RBP manual (Barbour *et al.* 1999). These protocols are included for reference only. It should be noted that clients often modify these protocols for their own biomonitoring programs. Modifications can include changes to target count numbers (e.g. 100 organisms in MA) and changes to subsampling methodology. CE can also accommodate client requests to subsample without magnification or under magnified illuminators rather than under a stereomicroscope.

To perform sample sorting as described by Barbour *et al.* (1999), after washing the sample as described in the previous section the following steps are performed:

1. Pour the washed sample into a **gridded tray** and then float the sample on the tray to evenly distribute the sample contents across the tray. Pull the tray from the water bath to set the sample directly on the wire screen.
2. Randomly select 4 grids from the gridded tray and remove and place the contents of those four squares into a second gridded tray. Sort and count all organisms in the 2nd tray. If fewer than 200 $\pm 20\%$ organisms are removed, continue removing grids from the first tray and sorting in the second tray until the target count is achieved.
3. If, after 4 grids from the first tray are sorted, the count exceeds 240 organisms, place the 240+ macroinvertebrates from the original 4-grid subsample into a gridded tray for a second level of subsampling. Randomly select grids from this second tray until the target number of 200 $\pm 20\%$ organisms is achieved. Record the total number of grids sorted for each subsampling level in the project sample log.
4. **Large/Rare Organism Search** - A thorough large/rare search is not standard protocol for EPA RBP sorting and subsampling. However, some clients may request that such a search be performed. As such, be aware that large/rare searches may be added or removed from protocols on a project-by-project basis when using RBP and similar protocols.

DESIRED REMOVAL RATE: 95% (i.e. only 1 out of every 20 invertebrates can be missed, preferably fewer). QUALITY CONTROL INSPECTIONS WILL BE PERFORMED BY THE PROJECT MANAGER OR LAB MANAGER TO ENSURE THIS REMOVAL RATE IS BEING ACHIEVED.

Sample Sorting Rules

The objective of sample processing is to remove a representative subsample of benthic macroinvertebrates (living on the bottom of the river/stream) from the sample. Samples will primarily contain benthic macroinvertebrates, but will also contain:

- Macroinvertebrates that live in the water column (daphnia and backswimmers, for example) or the water's surface (Collembola and water striders, for example)
- Terrestrial invertebrates (spiders, commonly)
- Airborne adult stages of aquatic invertebrates

Some of these invertebrates are *sorted, but not counted*; others are *rejected* altogether. As a rule, if you're not sure about a particular type of organism, sort it, but don't count it, and place it in a separate vial.

IMPORTANT: SOME PROJECTS MAY HAVE SORTING RULES THAT DIFFER FROM THE DEFAULT RULES LISTED BELOW. ALWAYS CONSULT THE SORTING RULES TAB OF THE PROJECT SPECIFICATIONS SHEET TO ENSURE PROJECT-SPECIFIC SORTING RULES ARE FOLLOWED, AS SORTING RULES VARY FROM STATE TO STATE.

CE's default rules are as follows:

REJECT: Do not sort or count these organisms – i.e. leave them in the sorted residue.

Terrestrial insects and invertebrates: Aphids, leaf hoppers, spiders, and thrips are among the more common terrestrial insects encountered.

Larval Molt Skins: Look for the split down the ecdysial line on the mid-dorsum of the specimen. Skin casts are usually transparent/translucent and do not have any internal materials.

Invertebrates that are covered by thin white fungus and that were obviously dead prior to sample collection and preservation.

Eggs of invertebrates or vertebrates (Oligochaeta worm egg cases, where the worm is readily visible inside the case, are not counted either)

Miscellaneous body parts: Legs, antennae, gills, tips of abdomens, etc. Counts are based on heads.

Small fragments of Oligochaeta: Worm counts are based on tips, when worms are fragmented (more often than not). Please sort only large pieces, and tips (anterior and posterior ends), count each tip as one half. Ignore smaller sections that do not have an end on them.

SORT, BUT DON'T COUNT: Put these specimens in a separate vial for a taxonomist to see. If large numbers of any of these are encountered, put a number of them (6-12) in a vial and make a note estimating the total number you encountered. Also note that these sorting rules may vary among projects.

Cladocera: Associated with water column, not the benthos.

Collembola: Terrestrial or semiaquatic

Empty caddisfly cases

Empty mollusk shells

Water surface associated taxa: e.g., water striders, whirligig beetles (Gyrinidae)

Water column taxa: e.g., Corixidae, phantom midges, notonectids

Arial adults of benthic insect larvae: mayfly, caddisfly, stonefly, dipteran adults, etc. Look for lacy wings. If the wings are covered by hard elytra (as with the Coleoptera adults) then sort and count.

Vertebrates: Fish and amphibians (including tadpoles) should be saved, but not counted.

Headless specimens should be sorted, but not counted.

Use of Sorting Vials

Sorted invertebrates should be placed into 1-dram, snap-cap vials. Use separate snap-cap vials for each distinct group of organisms (as listed below). Sometimes, larger containers (such as plastic scintillation vials) will be needed for mollusks and other larger organisms. Generally, 6-7 vials are used per sample. Benthic samples from rivers and streams are generally sorted into the following groups:

- Mayflies, stoneflies, caddisflies, dipterans, oligochaetes, other.

Depending on the relative abundance of the groups, the sorter may “lump” or “split” these groups to facilitate identification work. For example, if few EPTs occur in a sample, but many beetles and mollusks occur in that sample, then EPTs could be lumped, while the beetles and mollusks are split. Furthermore, when larger mollusks occur in a sample, always keep them separate from all other specimens to avoid having the smaller specimens become “trapped” inside the apertures of the larger mollusks. Importantly, please place a small strip label with the COMPLETE CE sample number inside of each vial.

Sample Processing Products

Unsorted Fraction

The unsorted fraction is returned to the original sample bottle and refilled with the alcohol that had been removed from this sample and set aside. Use a spatula to return the unsorted material to the bottle. An **UNSORTED FRACTION LABEL** should be filled out and placed INSIDE the sample jar with the remaining fraction.

Vigorously wash the gridded tray thoroughly between samples to ensure that no cross-contamination of samples occurs. Use a scrub brush to scrub the gridded tray screen and edges at the sink while running water over these areas concurrently.

Sorted Residue

The sorted residue is also saved, unless otherwise specified by the project specifications sheet. Save this material in the graduated blue-capped cups. Record the approximate volume of material (in ml) sorted in the sample log, and be sure to include a **SORTED RESIDUE LABEL** in the cup with the material. Some of the alcohol from the original sample should be used to preserve this material, as well. This material is saved to perform a later quality control inspection of sorting efficacy.

Sorted Subsample Vials

The vials containing the sorted subsample of invertebrates should be bound with a rubber band (include the LG/RARE vial, as well, as affix a **SORTED SAMPLE LABEL** to the sample vials). The sorted sample label (sample below) should include the following information:

- CE sample ID (e.g. 04-467-045)
- Client-assigned site name and/or number information
- Number of organisms sorted
- Subsample type (e.g. 30-cell GT, 15-cell GT, etc)
- Fraction(s) of sample sorted (if multiple levels of subsampling, 1st fraction represents first level, 2nd fraction represents second level, etc.)
- Sorter initials
- Sample field collection date
- Sort date

CE Sample ID: _____
Client Site ID: _____
sorted: _____ Sub Type: _____
Fraction(s): _____
Sorter Initials: _____
Coll Date: _____
Sort Date: _____

To recap, **these products are expected from each sample**, unless otherwise instructed on the project specifications sheet:

- Vials with sorted invertebrates (include both an CE label and client's original internal sample label)
- Vial with large/rare organisms (include label)
- Unsorted fraction (label inside and out)
- Sorted residues (may sometimes discard, check with lab manager)
- Completed information in sample log

Sorted Sample Log Entry

The sample log has three sections for each sample processed:

- 1) Sample log-in information,
- 2) Sample sort data, and
- 3) Quality control information.

Once a sample has been sorted, the “sample sort” section of the log will be filled out. Information required includes:

- Subsampler type used

- Sorted fraction (if multiple levels of subsampling required, *record fraction at each level*)
- Sort time (this should equal the amount of time you're going to report on your time sheet for the sample)
- Number of organisms sorted
- Residue volume
- Matrix type
- Sort date
- Sorter initials

We use **both a paper and an electronic log**. The electronic log should be turned on when the lab is in use and should be filled out at the same time and with the same information recorded on the paper log. Electronic logs will be kept for each project. A template for the electronic log, named “**2010_sample_log_template.xls**” can be found on the server. Sample logs for projects should be renamed with the project number and stored in the project file for easy access by all users and the project manager.

PLEASE PAY CAREFUL ATTENTION TO PROPER LABELING AND RECORDING, AS FAILURE TO DO SO CAN SERIOUSLY COMPROMISE DATA SETS

Macroinvertebrate Sample Sorting Quality Assurance/Quality Control Procedures

Sorting Efficacy

As a rule, SORTED RESIDUES of 10% of the sample lot will be rechecked by the project manager or laboratory manager to determine whether the sorting efficacy **data quality objective (DQO) of a 95% organism removal rate** has been achieved. With a 525-550 organism subsample, this translates to a maximum of 26-27 organisms remaining in the sorted fraction. Obviously, these allowable omissions are even lower with lower subsampling counts. With large amounts of detritus and inorganic material, sorting can become very slow and tedious; **be patient and thorough and do not get hasty**. Also, check yourself. After you've completed a sample, re-check the residue to ensure that you're sorting thoroughly. If any of the randomly selected samples are not adequately sorted, as ascertained by the QC inspections, then additional samples will be checked at the discretion of the project manager. In such cases, if the QC inspection determined that any sample failed before the entire sorted fraction was examined, then the entire sorted residue will be re-sorted by the person who originally sorted the sample, with the assistance and oversight of the lab manager. These organisms will become part of the original sample, but will be retained in a separate vial as a record of the failed inspection. Inspection rates on a staff member will be increased to a minimum of 20% (one in every five samples) following a failed QC inspection of sorting efficacy. Mike Cole and the lab manager may determine that higher inspection rates are necessary in some circumstances. If more than one additional sample fails during the higher inspection-rate period (a minimum of 10 samples), then termination of lab sorting duties for this person will be considered, and all samples sorted by this person following the initial 95% DQO failure will be re-inspected.

Results of all quality control inspections for sorting efficacy will also be recorded in the sample log (both paper and electronic). Any failed samples should be immediately reported to the project manager to ensure that appropriate and timely corrective actions are taken. Clients often require that such failures be immediately reported to them. It is therefore required that the project manager be immediately informed of such results.

The project manager or lab manager will perform all quality control inspections of sorted residues to ascertain the removal rate of the each selected sample. Samples will be randomly selected from the sample lot. Either 10% of the sample lot or an inspection rate specified by the client, whichever is higher, will be inspected for each project.

Target Count Checks

This section establishes a data quality objective for sort counts of all benthic samples being processed in CE's Oregon and Massachusetts macroinvertebrate labs and describes a process for tracking and rectifying sample-count data quality. The approach utilizes the lab manager's availability to track and report on data quality almost in real time, as opposed to relying on count data coming from taxonomists weeks or even months later.

The protocol is designed to increase the ability to detect failing samples when DQOs are not being met through an incremental increase in inspection rates. Likewise, the protocol incrementally decreases inspection rates when DQOs are being met. Inspection rates will vary between 5% and 20%, and will occasionally reach 25%, as described below.

QC Protocol: At the start of each lab season, one in every five samples (20%) sorted by each technician is recounted by the lab manager and tallied in the NEW QC section of the sample log.

Data Quality Objective: Sample counts must fall between 475 and 575 to pass the sample count quality inspection. Samples must maintain a passing rate of 95% (per staff member).

Target counts (those reported by the technician on the sample label) will be between 525 and 550.

For each staff member, if at any point their target count DQO passing rate falls below 95%, then the inspection rate is increased to 25% and the lab manager works with Lead Taxonomist Michael Cole to determine the likely cause for the failed counts. This inspection rate for staff members having difficulty with accurate counts will be maintained until their counts meet the DQO of 475-575 at a 95% rate, at which time the inspection rate will be decreased to 10% as noted below. If any staff member continues to fail DQOs at a rate exceeding 5%, despite efforts to improve their counts and higher inspection rates, then termination of the duties in the lab will have to be considered by the lab manager, Mike, and Todd.

For each lab staff member, if their sort count DQO of 95% is maintained beyond the first 20 samples inspected, then the inspection rate is decreased to 10% (one in ten samples). If the DQO continues to be met following the inspection of 10% of the next 20 samples processed (i.e., only 1 or none of the 20 inspected samples fails), then the inspection rate is further decreased to 5% for the remainder of the lab season. If the 95% passing rate is not maintained at the 10% inspection-rate level, then the inspection rate will be increased to 20% for those staff members not meeting DQOs at the 95% rate.

Inspection Rates:

Lab technician begins sorting for the season: **20%** (1 in 5 samples)

If 19 or 20 of 20 samples meet DQO of 475 to 575, then rate is **decreased to 10%** (One in ten samples)

If fewer than 95% of checked samples meet DQO, then the rate is **increased to 25%**

(One in four samples).

If, at the 10% sample inspection rate, 95% of samples continue to pass, then the inspection rate is further **decreased to 5%** (One in 20 samples).

Irrespective of the current inspection rate (5, 10, or 20%), if the passing rates falls below 95%, then the rate is **increased to 25%**.

Miscellaneous Notes and Guidelines

Sorting too quickly will lead to errors and omissions. First and foremost, work methodically and thoroughly. You will be asked to be efficient, but NEVER AT THE EXPENSE OF COMPROMISING THE DATA. If you ever feel that your sampling is compromised by time constraints please inform the project manager. Please do all that you can to avoid such errors, as they will be detected and corrective actions taken.

Macroinvertebrate Identification Procedures

Sample Preparation and Microscope Use

Processed samples that are ready for identification have been sorted by phylum, class, or order into separate vials. These vials are bound together with a rubber band and an external label complete with sorted sample information has been affixed (please refer to the CE sample processing protocols for details). Each individual vial will also contain an internal label with the unique CE sample number.

To start, the sample bench sheet header fields are filled in with all information from the label accompanying the sample before beginning sample identification work. Contents of one of the vials are then placed into a Petri dish or removed with a pipette. Identifications are normally performed under a stereoscope with zoom magnification capabilities ranging from 10 to 100X. Normally, the sample is left in the alcohol in which it was placed during sample sorting.

Identification of some organisms, particularly Chironomidae (when identifying to genus), Oligochaeta, and early instars of some insects, requires examination under higher magnification to see microscopic diagnostic characters (mouthparts, chaetal and setal patterns etc.). Such observations will require the use of the compound microscope. Slides can be prepared for temporary use by mounting specimens in alcohol or can be permanently mounted in CMC-10 for inclusion in the project voucher collection (discussed later). Please refer to Epler's Chironomidae of South Carolina (in the lab) for a detailed description of specimen preparation and slide mounting for most applications. **NOTE THAT SOME CLIENTS REQUIRE ALL CHIRONOMIDAE AND OLIGOCHAETA TO BE PERMANENTLY MOUNTED. THIS INFORMATION WILL BE PROVIDED ON THE PROJECT SPECIFICATIONS SHEET.**

Use of Bench Sheets

Data collected as macroinvertebrates are being identified are recorded on paper bench sheets (example provided at the back of this document). Standard CE Macroinvertebrate Identification bench sheets contain five columns for sample information: 1) Taxon (name assigned), 2) life stage, 3) sample count, 4) comments column, and 5) voucher specimen number. Comments should follow the format of **standardized USGS notes** (see Tables 1-3) and are often used to explain why the desired taxonomic level is not achieved or to convey additional information about that taxon in the sample. It also important to note in this column whether specimens left at higher taxonomic levels were unique to the sample by recording **NOT UNIQUE** or **UNIQUE** in the comments column.

All specimens from any large/rare vials accompanying the sample are recorded as such on the identification bench sheet. The shorthand notation "**LG/RR**" is used on the bench sheet to identify these specimens.

Taxonomic Effort: Level of Taxonomic Resolution

Because CE processes samples from across the country, we have no single set of rules regarding standard taxonomic effort (STE). Regional STEs, such as those for the Pacific Northwest (managed by PNAMP) and those for the southwest (managed by SAFIT) are applied within the appropriate geographic area. In other regions, target taxonomic levels may vary among states, or even among projects within a state, depending on project objectives. For routine bioassessment and biomonitoring purposes, CE's taxonomic effort will follow that

requested by the client; typically, most projects will default to the appropriate state or regional STE.

As a general rule, aquatic insects are identified to genus or species as much as condition and maturity allow. Most larval insect identification keys are for use with mature larvae, while benthic samples contain larvae at various stages of maturity. Earlier instar larvae and damaged specimens can preclude making determinations to the desired level of resolution because the necessary characters have been damaged or have not yet developed. In such cases, higher-level determinations are warranted. Supporting notes should be included in the comments column to convey additional information about such determinations.

Because CE processes samples for a variety of clients with needs for differing levels of taxonomic resolution, no single list of STE is maintained. Instead, the desired level of resolution is determined on a project-by-project basis and is based on the client's needs and the level of resolution achieved during past work performed for the client to maintain consistency in the data among years (unless otherwise requested by the client). Examples of taxonomic groups for which level of taxonomic resolution varies considerably among projects or clients include Oligochaeta and Chironomidae; some projects require leaving Chironomidae and Oligochaeta at family and class, respectively, while others require identifying these groups to genus or species.

Before any sorting or identification work begins on a given project, a project specifications sheet is produced that details processing and taxonomic specifications for the project. This document is made available to the client for review prior to commencing with sampling processing work. Furthermore, when CE assumes a contract and project that have previously been worked on by another contractor, we will request taxa lists derived from previous data sets to help ensure consistency in taxonomic effort between firms and across years.

Table 11. Standardized notes used to justify benthic macroinvertebrate identifications where the prescribed taxonomic level is not achieved

Note	Description
imm.	Y Means "immature" and includes all synonyms thereof Y Identification to prescribed level not supported because the organism(s) is/are too immature Y May be applied to larvae or pupae
dam.	Y Means "damaged" and includes all synonyms thereof Y Identification to prescribed level not supported because the organism(s) is/are damaged
mount	Y Means "poor mount" and includes all synonyms thereof Y Identification to targeted level not supported because slide mounted organism(s) is/are poorly oriented on slide
indet.	Y Means "indeterminate" and includes all synonyms thereof Y Identification to targeted level not supported for recently molted organisms, mayfly subimagos, mature and intact organisms because of undocumented variation or indistinct characters, required case is missing/damaged, or required habitat/ecological information is missing/unavailable Y Unlikely that taxon is new to science
gender	Y Includes males and females Y Identification to targeted level not supported because of gender
retained	Y Denotes unmounted/unidentified organisms retained in separate vial

CE primarily uses the Integrated Taxonomic Information System (ITIS) for naming conventions of identified macroinvertebrates (<http://www.itis.usda.gov/>); however, we recognize that this source of information is neither entirely up-to-date nor complete. Both PNAMP's and SAFIT's standard taxonomic effort lists now includes taxa from the Pacific Northwest (Oregon and Washington), and as such, we now use the most recent version of the PNAMP list for freshwater macroinvertebrate taxa list as the primary source for naming conventions of western taxa (<http://www.safit.org/ste.html>). Naming conventions and STEs in eastern states generally follow those of the various state agencies.

Table 12. Notes of taxonomic interest that convey additional information about benthic macroinvertebrate identifications

Note	Description
new state record	Y Refers to a potential new state record for a taxon based on known distributional information in the published literature or other reliable source
new U.S. record	Y Refers to a potential new United States record for a taxon based on known distributional information in the published literature or other reliable source
new species ?	Y Represents a potentially undescribed species that cannot be linked to any closely related species Y Used with Genus-level identification only
no. lost	Y Refers to the number of organisms accidentally lost in handling Y The number of organisms lost is indicated before "lost" Example: Y 2 lost, ? lost, all lost
artifact	Y Identification of a bryozoan fragment (missing zooids) or empty mollusk shell Only Y used in qualitatively processed samples, when taxon is not represented by a complete organism
Ref.	Y Denotes an organism(s) placed in a reference collection

Table 13. Standardized conditional or provisional taxonomic designations applied to benthic macroinvertebrate identifications

Designation	Description
sp.	- Y Species place holder for identifications to Genus-level only - Y Denotes both singular and plural forms of species Example: - Y <i>Hydropsyche</i> sp.
sp. nr.	- Y Means “species near” - Y Refers to a potentially undescribed species nearest to the species/authority following the designation - Y Example: <i>Hydropsyche</i> sp. nr. <i>simulans</i> Ross
cf.	- Y Means “confer” - Y Refers to a species that closely matches the species/authority following the designation but differs morphologically in some minor ways or the description in the literature is too vague or incomplete to be certain - Y Example: <i>Hydropsyche</i> cf. <i>simulans</i> Ross
/ “slash”	- Y Used to denote two or more taxa that are unresolvable or where only two species are known in a monophyletic group - Y Placed between the taxa in question - Y Taxa are ordered alphabetically - Y If Species, authorities are included - Y Example: <i>Hydropsyche</i> <i>rossi</i> Flint, Voshell, and Parker/<i>simulans</i> Ross
sp. 1 or sp. A genus A	- Y Refers to provisional taxa reported in the literature where their specific identity remains unknown; also known as “operational taxonomic units” or “OTUs” - Y Provisional designation is reported exactly as it appears in the literature Provisional designation is followed parenthetically by the author(s) and year of the publication - Example: <i>Oecetis</i> sp. A (Floyd, 1995) - Y
group	- Y Denotes a group of more than two closely related species that cannot be separated or organisms that can be reliably placed in a species group where determination to species is unsupported - Y If only two species in the group, then use “/” or slash designation Is - Y formally recognized in the literature - Y Example: <i>Hydropsyche scalaris</i> group
complex	- Y Denotes a species for which there may be considerable variation suggesting two or more cryptic species - Y Is formally recognized in the literature - Y Example: <i>Oecetis inconspicua</i> complex
n. sp.	- Y Means “new species” - Y Represents a species new to science that has been verified by a recognized authority or one that appears in the literature as such - Y If the designation appears in the literature, the designation must be followed parenthetically by the authors and year of the publication - Y Example: <i>Hydroptila</i> n. sp. (Moulton and Stewart, 1997)
Other conditional or provisional designations	- Y Reported exactly as they appear in the reference from which they were obtained - Y The designation is followed parenthetically by the author(s) and year of the publication - Y Example: <i>Stilocladius?</i> sp. (Epler, 1995)

Taxonomic Resources

CE maintains an extensive library of taxonomic literature to support the identification of aquatic macroinvertebrates in the laboratory. This library is continuously updated with new materials as they are published or otherwise made available. These materials are maintained in the laboratory for easy access and are well organized. Shorter journal articles are maintained in three-ring binders arranged by taxonomic group, while more lengthy materials such as unbound monographs are spiral bound.

Special Circumstances: Difficult Taxa

On occasion, even mature specimens will not seemingly fit neatly through a dichotomous key. In such cases, a **Difficult Taxon Worksheet** will be used to assist with the identification (an example is provided at the back of this document). This worksheet documents the steps taken through a dichotomous key and the taxonomist assigns a certainty rating (1 = most certain, 5 = least certain) to the decision made at each couplet. When a determination is made, the taxonomist then assigns an overall certainty rating to the determination. This allows the taxonomist to better understand how their determination was made and with what confidence. The worksheet will also allow a quality assurance taxonomist to verify the determination AND isolate precisely where errors were made if they occurred. This will ultimately help better train the taxonomist, *as specific weaknesses in taxonomy can be identified, discussed, and resolved*. All such specimens that are taken through this process should be added to the project voucher collection (discussed in the next section).

Any such taxa that cannot be identified with a certainty rating of 1 (most certain) should be assigned a voucher specimen number (see below for voucher collection SOPs) and also placed in the project voucher collection. The specimen(s) in question should be named “Unk.” followed by the lowest taxonomic name that can be assigned to the organism with certainty. For example, an unknown dipteran larva might be assigned voucher number 1500 (the next in the master collection sequence) and be named “Unk. Diptera 1500”. This name should then be used whenever these specimens are encountered until a definitive identification is made.

Any such specimens, or descriptions and illustrations thereof, will be sent out to regional or national experts for verification.

Voucher Collection Assembly

Every CE project will have a voucher collection assembled. This collection should be assembled as new taxa are encountered and should include every taxon encountered, even those that are very common and/or easy to identify, and *regardless of whether that taxon already occurs in the CE master reference collection*. Importantly, every morphologically unique specimen should be catalogued. For example, if morphologically distinct *Isoperla* species are encountered, even if they are not being identified to species, they should both be catalogued as *Isoperla* sp. taxa (sp. 1 and sp. 2). Every new voucher specimen should be entered into the CE Voucher database. Please enter the specimen into the database when the specimen is physically placed into the collection; this eliminates the possibility that it won’t get entered.

Voucher specimens should be placed in borosilicate glass vials with polyvinyl caps to minimize alcohol loss through evaporation. 70%-75% denatured ethanol should be used for

preservation of archived specimens. Vials should be large enough to permit at least four parts of alcohol to one part of specimen material. A “voucher specimen” label should be placed into the vial with the specimen that includes the voucher number, CE project and sample number, location (state and county), water body, date collected, taxonomic determination and taxonomist’s name or initials. All labels should be printed only on acid-free paper and written in pencil. The assigned voucher number should also be written on the top of the vial cap with a permanent marker for easy location as needed in the future.

If a voucher specimen was identified using diagnostic characters under a compound slide microscope, those body parts should be permanently mounted on a slide scope and included in the voucher collection in addition to the whole organism in a separate vial. The slide scope should receive the same voucher number as the vial, and a note should be made in the database that X slides are also included.

Use of Existing CE Master Reference Collection

The existing CE master reference collection is used, in part, to help confirm the identity of specimens. Reference collection information is contained in the Excel data file entitled “Master Reference Collection”. Reference specimens that have been verified by an external expert taxonomist should be used for confirmative purposes. Verified specimens are noted as such in the data file, followed by the initials of the expert who verified by specimen(s). A list of experts’ names corresponding to the initials used occurs in the worksheet labeled “coding” within the data file.

Quality Assurance/Quality Control Procedures for Taxonomic and Enumeration Data

A second taxonomist will perform quality checks of taxonomic data. The QC taxonomist will re-inspect a fraction of the sample lot (typically 10% of the sample lot, unless otherwise specified by the client). The inspection includes both a review of the accuracy of taxonomic determinations and enumeration of specimens. Inspected samples must achieve the data quality objective of 95% similarity between project and QC taxonomist, as determined by the Bray-Curtis Similarity Index. The results of these inspections are recorded on CE’s **Taxonomic Data Quality Control Inspection Worksheet** (or any alternative documentation form provided by the client), an example of which is provided at the back of this document. Additional QC metrics routinely calculated by CE include Percent Taxonomic Disagreement (PTD) and Percent Difference in Enumeration (PDE). PTD must not exceed 15%, while PDE must not exceed 5% (per USEPA national aquatic resource assessment DQOs). The QC taxonomist will also review the entire voucher collection assembled for the project to verify determinations made by the project taxonomist.

Broadly speaking, the following types of errors can be made by a taxonomist:

- **Miscounting** (e.g., counted 22, when 24 *Plauditus* sp. were in sample)
- **Accidental omission of taxa** (e.g., 1 single *Plauditus* was not counted)
- **Misidentification** (e.g., 2 *Plauditus* were misidentified as *Acentrella*),

- **Identification to a taxonomic level that is higher or lower than could be achieved based on organism condition and maturity** (*e.g.*, 4 *Plauditus* were retained at Baetidae level, but condition and maturity should have allowed identification to genus).

It is important to recognize that the first two types of errors (miscounts and accidental omissions) are typically isolated occurrences, whereby the occurrence of one such error does not require re-checking other records of the same taxon in the data set. In contrast, the latter two types of errors (misidentification and identification to improper level of resolution) are potentially systemic errors, which will require re-examination of other records of the taxa in question.

Once the quality control re-identifications have been performed by the QC taxonomist, the results are tabulated and discrepancies (irrespective of whether the samples passed or failed) will be reviewed together by the two taxonomists, who will also re-examine the specimens together to determine why the discrepancy occurred and to determine what corrective action should be taken. Among samples that achieve the 95% BC Index DQO, differences in counts are not reviewed, but taxa omissions, differences in levels of resolution, and differences in taxonomic identifications are reviewed and changes are made to the sample data in question. In cases of misidentifications, other samples will also be inspected to ensure any systemic errors are rectified.

If any of the samples fail the 95% BC Index DQO, all errors will be reviewed by both taxonomists, including miscounts. Only the data resulting from the quality inspection, including counts, will be used for those samples that are QC inspected. Additional samples (normally another 10% of the sample lot) will be inspected for all types of errors identified in the 10% sample-lot inspection. Samples will continue to be inspected until the 95% similarity DQO is consistently achieved (threshold to be determined through a consult with the client at this point) or until all samples have been re-identified.

If consensus on a particular determination cannot be reached, the specimen(s) in question will be sent out for validation by an expert source outside of CE. If taxonomic agreement (as determined by the Bray-Curtis measure of similarity) is less than 95% in any inspected sample, additional samples will be inspected until 95% agreement is again consistently achieved.

All bench sheets are reviewed for completeness before beginning data entry. When any required information is missing (life stage, count, etc.), the specimens in the sample are re-examined and the data sheets are completed or corrected. Additionally, any identifications not attaining the desired resolution and not accompanied by supporting comments will be re-examined and comments completed. Once electronic data are entered, they are then checked by the manager for errors and omissions. Paper bench sheets will be compared to electronic data. If any errors or omissions are found, the entire data set will be examined by the project manager. Corrective actions will then be taken until the electronic data file is complete and free of transcription errors.

References

- Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Rapid Bioassessment Protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish, second edition. EPA841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002

SOP 15: Data Management

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

This SOP summarizes data management of the shallow lake monitoring protocol for the Central Alaska and Arctic Networks. Here we document the two-tiered Microsoft SQL Server/Access database used to house project data, provide instructions for data entry, import, validation and management, and outline the administration of the database. This SOP has been developed following strategies and guidance for data handling and quality assurance/quality control in the CAKN Data Management Plan. It is adapted directly from SOP 24: Data Management in Larsen *et al.* (2011).

Stream Monitoring Database

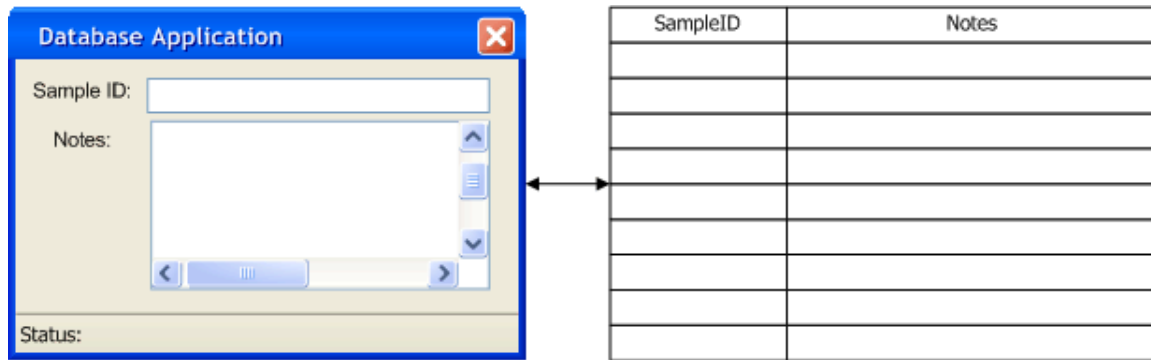
Most of the data associated with this project are housed in a single database. This database has a two-tier architecture, in which the application's presentation (forms, queries and reports) is in Microsoft Access, while the underlying data model and business logic is contained in a Microsoft SQL Server database. The Access file is commonly referred to as the "front end", while the SQL server database is commonly referred to as the "back end".

The SQL Server is located in the server room at the Fairbanks Administrative Center office building. SQL Server databases exist as files (.mdf and .ldf) in a directory, and the process of attaching a database to a SQL Server essentially shows the SQL Server where the database files reside. The details of the SQL database used for this project are listed below:

Server Name: INPYUGAMS08\SQLEXPRESS

Database: AK_Streams

Security: Integrated



Front End. The presentation layer
(Microsoft Access)

Back End Database (Microsoft SQL
Server Express)

The Microsoft Access front-end file is named Streams-X.X.adp, with the X.X being the numeric indicating the version. This front-end file is stored on the CAKN network drive: J:\Monitoring\Streams\Database. In order to use this two-tiered database, the two layers must be connected.

SQL Server Database Structure

The database is fairly large and complex, with many tables and relationships. The database model is regularly mapped, and can be viewed either as a diagram showing a visual representation of the tables and their relationships, or as a text data model, listing each table with all of its properties and fields. Select the appropriate link below to view either the diagram or the full text data model report.

[Data Model – Diagram](#)

[Data Model – Full Text](#)

Preparing Tablet PC for use in the Field

The AK_Streams database can be loaded onto a Tablet PC, allowing data to be entered directly into the database in the field and reducing the need for paper forms. With the introduction of the SQL database with an Access front end, the procedures for loading the database onto the Tablet PC became more complex than simply copying an .mbd file to the hard drive. The SQL Server database must be loaded onto the Tablet PC, along with the Access front end, and then a connection must be established between the two.

Field Data Backups

A number of different methods are used for collection of field data, including several different electronic formats. Most of the field data are collected using a Trimble GPS unit, a Garmin eTrex unit, or the YSI MDS 650 field computer. It is very important to back up this electronic data regularly while in the field.

1. Use the SQL Server Backer-Upper to back up Tablet data to a thumb drive

2. Download YSI files to field PC and clear data from the MDS 650 unit. Clear the site list in the 650 and add the sites for the following sampling day.
3. Download Trimble files to field PC, leave the originals on the Trimble unit
4. Download Garmin eTrex using MapSource, saving as a .gdb file with the unit number and date as the file name
5. Download photos from Camera if necessary or desired.
6. Save a copy of data backups to a thumb drive. The most important data to include on the thumb drive is the YSI files, as the data is not saved anywhere other than on the computer. The Trimble and Garmin units retain their data, so are of a lower priority for thumb drive backup. The rule of thumb is to have all data in at least 2 places at the end of the field day:
 - a. Tablet: on Tablet and thumb drive
 - b. YSI files: on field PC and thumb drive
 - c. Trimble: on Trimble and PC
 - d. Garmin: on Garmin and PC
 - e. Camera: on memory card and/or thumb drive and/or field PC as appropriate

Backing up data upon return from Field

1. Move the following backup files from the field PC to J:\Monitoring\Streams\Field_Data\YYYY
 - a. Tablet: to TabletBackups folder
 - b. YSI files: to YSIProfiles folder
 - c. Garmin: to GarminTrackLogs folder (if more than one park is being visited during the season, it may be helpful to add a subfolder with the park name in order to keep the files more organized).
2. Download Trimble files directly from the unit to J:\Monitoring\Streams\TrimbleData\YYYY
3. Download cameras directly (or move the photos already downloaded to the field PC) to J:\Monitoring\Streams\Photos\YYYY
4. Do not retain duplicate copies of the data on the field PC. Delete (or clearly mark for deletion) the folders once the data has been transferred to the J drive, in order to reduce potential for confusion about which file is the most recent.

Lab Sample Tracking

Because many of the samples collected in this program require extensive laboratory processing before the data are available, it is essential that the samples be inventoried and tracked. When the data are received back from the laboratories, the project manager must notify the data

manager who will then import the data into the database (see the Import and Validation of Laboratory Data section).

To assist the labs in analysis and minimize errors in sample identification, an inventory of the samples shipped to the lab for analysis should be generated and forwarded to the lab. These lists can all be generated from the database.

Spatial Data

Data with a spatial component are collected using Trimble GPS units, and must be properly transferred, post-processed, and archived to ensure a high quality dataset. Some of the information collected with Trimble GPS units is imported into the Streams database, while most is maintained in a geodatabase and file management system external to the database. Refer to SOP 7: Using the GPS for more information about the collection, organization, and processing of spatial data using Trimble GPS units and software.

Trimble Data Management

All data collected using the Trimbles are stored in the following location, filed appropriately by year and then by Park: J:\Monitoring\Streams\TrimbleData

There is a project created through Pathfinder Office for each park for each year that data are collected. Creating these projects in Pathfinder Office, and using the appropriate project when processing any Trimble data ensures that all the data will be organized in a standard arrangement of folders, and that the raw data will always be preserved in the event that data sets need to be re-processed. Any time Trimble data are transferred from the unit, post-processed, or exported for use in ArcGIS, these processes should be performed within the appropriate project to ensure that the dataset is entire and uncorrupted.

Because the Trimble software is frequently updated, and the procedures for processing data tend to change regularly, the most recent protocols developed for GPS: Trimble Pathfinder Systems (Course No. 1730-56) should be used. Contact the GIS program in the Alaska Regional Office of the National Park Service for course information and materials.

Data Entry and Validation of Field Data

Data Sources

Most of the data are entered in electronic format directly in the field. Paper datasheets are carried in the field as backup, in case of equipment malfunction, but the only paper forms filled out regularly in the field are supplemental field notes. At the end of the field season, the following tasks should be completed in order to ensure that all of the data are imported into the proper location and/or archived for long-term storage.

Enter any data collected on paper datasheets into the database. As soon as possible upon returning from the field, go through all of the field notebooks and any paper datasheets used, and make sure that all of the information is entered into the database. This can either be done on the Tablet PC before concatenation, or after concatenation on a desktop computer. Mark each datasheet with initials and date to indicate that the data was entered.

Mark corrections on data sheets with red pen. Any corrected errors, or changes that are entered differently into the database than they appear on the paper data sheet, should be circled

and corrected using a red fine-point Sharpie marker. Notes, in red ink, should be written on the margins or in the comments section whenever necessary to document the reason for the corrections.

Archive the original data sheets. Organize the original field data sheets by lake and store in the designated fireproof safe or cabinet used by the Stream Monitoring program.

Prepare database for concatenation. Ensure that all site names and sample dates are correct in the database before the concatenation process. Check in particular for improper cases and extra spaces in site names. Check each entry in the Streams table and the Events table to make sure that all of the fields have been filled out as completely as possible, and correct any typos or unusual spellings that result from field entry into the Tablet PC.

Transfer, Post-process, and Import Trimble files. Transfer the data files from the Trimble GPS unit, post-process the files, import the data into the database, and archive the spatial data as outlined in the Trimble Data Management section of this document. In addition, some of the Trimble files have notes fields that may contain data that needs to be added to various fields within the database, including Secchi depths, notes from the Depths files, and the measured pond depths for each Water Chemistry sample location.

Import YSI profile data. The data collected using a YSI Sonde are stored on the YSI MDS 650 field computer and transferred to a field computer at the end of every day during a long field excursion. These files must be imported into the Streams database.

Because there are so many different instruments and tools used to collect data, often each requiring specific protocols for downloading, processing, and importing or archiving data, a checklist has been developed to keep track of all of the steps necessary for managing the data for this project. Print a copy of the Data Processing Checklist for each park where data are collected in any given year, and use it to track the completion of each step in data management.

Import and Validation of Laboratory Data

Several different samples are sent out for laboratory analysis, and it may take several months to a year to receive the results. Once the results have been received, they must be imported into the database. These tasks should also be logged on the Data Processing Checklist.

Water Chemistry Data. The water samples collected and filtered for water chemistry analysis are sent to the Cooperative Chemical Analytical Laboratory (CCAL) for analysis. The data are returned with the results in spreadsheets, and the comments in textfile format. The tabular data are imported in the database by creating a SQL Insert Into query, while the comments in the textfiles must be manually entered.

Diatom Data. The invertebrate and diatom data are the most complicated datasets sent out for analysis. A small database is sent to the lab to be populated with the data, then returned for integration into the Streams database.

Invertebrate Data. The invertebrate and diatom data are the most complicated datasets sent out for analysis. A small database is sent to the lab to be populated with the data, then returned for integration into the Streams database.

Database Concatenation

The Stream Monitoring data management system consists of a Microsoft Access front-end application that is connected to a Microsoft SQL Server Express back-end database. The back end database is designed to be split into multiple (child) copies running on field computers and the copies reintegrated with the master (parent) database. At the end of the field season, any data entry performed on any field computers needs to be integrated into the main SQL Server database back-end housed at the NPS Fairbanks Administrative Center.

Communication with Project Leader

Once all of the data have been entered and checked, and all of the data from external sources have been imported into the database, inform the Project Leader that data entry for the current year is complete. Check the Data Processing Checklist to make sure that all tasks have been documented as being complete.

Data Administration

The data management procedures that are common to all monitoring protocols implemented by the CAKN monitoring program are outlined in the CAKN Data Management Plan (<http://science.nature.nps.gov/im/units/cakn/datamgmt.cfm>).

Data Maintenance. Any editing of archived data is accomplished jointly by the Project Leader and Data Manager. Every change is to be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions. To be in compliance with the National Park Service Inventory and Monitoring Program's Natural Resource Database Template, there must be a table in the database to track any of these edits. This table is currently under development; more details will be added as they become available. All data collected using this protocol are subject to the following two caveats:

1. Only make changes that improve or update the data while maintaining data integrity.
2. Once archived, document any changes made to the data set.

Computer File Organization. Files for this project are maintained on the CAKN network drive (the "J" drive) at the Fairbanks Administrative Center office in the folder: J:\Monitoring\Streams

Access Front End Version Control. Prior to any major changes in the Streams.adp front end, a copy of the .adp file is created, and assigned a sequential version number. This file is then edited, while the previous file is stored in the Database folder under the appropriate year with the appropriate version number to allow for tracking of changes over time. The most recent copy of the database front end is always stored in the root Database folder with the filename Streams-X.X.adp, where the X.X indicates the version. *Only* the most recent version should be kept in the root Database folder, to avoid confusion.

SQL Database Backups. It is important to understand that the Access front end (.adp) file does not actually contain any data, but serves as a conduit to access the data tables of the SQL Server database. In order to view the data in the Access file, it must be connected to the SQL Server database. When editing data or tables in Microsoft Access, the changes are actually taking place

in the SQL Server database, and any version of Streams.adp that is attached to that same SQL Server database will reflect these changes. As such, making a backup of the Access file does NOT back up the actual data. To save the data and tables in the database at any given time, the backup must take place in SQL Server. Changes to the appearance of the front end are saved in Access, as described above.

The SQL Server database is backed up every Monday. This involves the entire database being written to a separate file on the same server. In addition, the server is backed up regularly by IT staff at the Fairbanks Administrative Center. This replicates the data on the server and stores it on an off-site server (FAPLIC). Contact one of the IT staff to access archived versions of the database. Note that both the .mdf and .ldf files will need to be obtained to reconstruct the database.

At the end of each season, when all data has been entered, imported and checked, the database should be backed up and saved in the database backup folder. Both the .mdf and .ldf files must be included. (J:\Monitoring\Streams\Database\Database Backups)

Database Metadata. All of the fields in all of the tables in the Access front end have descriptions of the field. Any new fields that are added must have a description added that clearly explains what type of data is to be entered in that field, and any pertinent information required for future users of the database to understand the data presented. In addition, all tables and views should have a description entered in the Object Properties window, which can be viewed and edited by right clicking the name of the table or view in the Access table of contents pane. The descriptions entered in the Object Properties window are also added to the record of the table/view in SQL Server, and can be viewed by right-clicking the table/view and selecting Properties. The information can be found under Extended Properties, in the MS_Description field.

STORET Database

The primary mechanisms that will be employed to enter water quality data into the EPA's STORET database are a series of input screens (forms/templates), developed as part of the Natural Resource Database Templates (<http://www.nature.nps.gov/im/apps/template>), and the STORET Interface Module (SIM Ver. 2). The input screens (called NPSTORET), developed by the NPS WRD, will allow Vital Signs Monitoring Networks to enter data about their projects, stations, metadata, and results.

References

- Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, R. McGinnis, H. Kristenson. 2011. Shallow lake limnology monitoring protocol: Central Alaska Network (CAKN) and Arctic Network (ARCN), Version 2.0. Natural Resource Report NPS/AKRO/NRR—2011/347. National Park Service, Fort Collins, Colorado.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002

SOP 16: Field Season Demobilization

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. "Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number" (Peitz *et al.*, 2002).

This SOP describes procedures that all field observers for shallow lake monitoring should complete following the field season. These tasks help bring the field season to a close by tying up loose ends, making sure data and equipment are properly stored and maintained. Effectively accomplishing these tasks can dramatically reduce efforts to initiate sampling in the following spring and reduce the likelihood of an aborted field excursion to lack of preparation. This SO is adapted directly from SOP 26: After the Field Season in Larsen *et al.* (2011).

Procedures

Equipment and Reference Materials

Properly clean, maintain, or replace, all equipment prior to storage in the appropriate park resources storage area.

Log missing or broken equipment in the equipment log, as appropriate. Store all calibration standards with MSDS sheets in the laboratory.

Prepare Sondes for long-term storage (see SOP 7: Multiparameter Sonde Calibration and Maintenance for detailed instructions).

Prepare the Trimble GPS for long-term storage (See SOP 6: Using GPS for details).

Re-shelve all reference materials in the appropriate location in the project manager's office.

File other reference materials and extra data sheets in the appropriate locations.

Data

1. Review all data sheets and check again for completeness. Data sheets should have been checked for completeness in the field and again, once the sheets have been amassed following the end of each field trip (SOP 12: Field Trip Demobilization).
2. Identify any missing information and, if possible, fill in data from field notes or from the Trimble. If this is not possible, annotate the missing data with a brief explanation.

3. Be sure that all trip reports have been completed and turned in to the project manager.
4. Review trip reports and interview field crew members on suggested changes to procedures, what could be improved, etc.
5. Perform end-of-season electronic data management tasks. See SOP 16: Data Management for specific instructions and checklists for the following:
 - a. Trimble file management: transfer, post-processing, import and archiving.
 - b. Import of YSI water chemistry profiles into the database.
 - c. Adding notes and ancillary data collected using the Trimble GPS to the database.
 - d. Importing laboratory data from water chemistry into the database.
 - e. Importing laboratory data from invertebrate samples into the database.
6. Organize and process photographs from the field season.
 - a. Organize photos into folders by lake and update images and metadata in the Portfolio 8.5 catalog.
 - b. Use GPS-Photo Link to geotag aerial photos.
 - c. Stitch any panoramic images.
7. Obtain data for season from the nearest park weather station.

Samples

Refer to SOP 12: Field Trip Demobilization for details on storing, inventorying, and shipping samples. Ship macroinvertebrate samples to ABR, Inc. (or other contracted laboratory) for identification and analysis. Ship any remaining water samples to CCAL (or other contracted laboratory) for analysis. Ship diatom samples to EcoAnalysts, Inc. (or other contracted laboratory). Ensure that results from samples sent out for analysis are returned and complete.

Protocols

Revise protocol and SOPs to reflect changes in methods or conventions that were established during field season.

References

Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, R. McGinnis, H. Kristenson. 2011. Shallow lake limnology monitoring protocol: Central Alaska Network (CAKN) and Arctic Network (ARCN), Version 2.0. Natural Resource Report NPS/AKRO/NRR—2011/347. National Park Service, Fort Collins, Colorado.

Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.

SOP 17: Data Analysis and Reporting

Analysis and reporting

Overview

Refer to SOP 17: Data Analysis and Reporting for more specific information on the analyses that will be performed with the data collected for this project, along with the reporting methods that will be used to present the data. The summaries provided below provide a detailed introduction to the approaches we will apply. Most analyses will be conducted using the appropriate packages in Program R (R Core Team 2016), a free statistical software environment. Multivariate analyses such as classification and ordination will generally be conducted using the program PCOrd (McCune and Grace 2002, Peck 2010).

Annual reports will be prepared each year. Annual reports will describe the results of each year's field activities and data collection in detail and include basic statistical summaries and data visualization as described below. Where appropriate, annual reports will also include basic analyses of spatial pattern and trend as described below (*e.g.*, Simmons 2015). Annual reports will be published as part of the NRDS or NRTR report series. Annual reports will be made available on the CAKN website (<http://science.nature.nps.gov/im/units/cakn/reportpubs.cfm>) as well as being uploaded to the Integration of Resource Management Applications (IRMA) database. (<https://irma.nps.gov/App/Portal/Home>).

Synthesis reports will be prepared every 5-7 years, starting in 2018. The final sampling design for the program was implemented beginning in 2011, so the first synthesis report will be published 7 years after that. Synthesis reports will focus on detection of trends at both sentinel sites, and at the network scale, as described below. Synthesis reports will be published as part of the NRDS or NRTR series.

Periodically, more extensive or targeted analyses will be conducted with the assistance of the network biometrician. The results of these analyses will be published either as part of the NRTR series, or in peer-reviewed journal articles, or both, as appropriate. Other methods of reporting will include formal presentations at scientific conferences (*e.g.*, Simmons and Ostermiller 2012), as well as informal presentations to park and network staff and the general public.

Research Briefs will be published or updated when warranted. Currently, the CAKN stream monitoring program has 4 Research Briefs in circulation, covering hydrological monitoring, water quality, biological assessment of stream ecosystem condition, and climate change effects on stream ecosystems (Simmons 2012a, 2012b, 2011, 2010).

Reporting exceedances of State of Alaska water quality standards

Water chemistry data will be assessed each year to determine whether any collected values exceed the surface water quality standards defined by the Alaska Department of Environmental Conservation (ADEC). The most recent version of these standards was published in 2016 (ADEC 2016). Any exceedances will be reported to the Division of Water at ADEC. For reporting purposes, all waters in the network will be assessed under Designated Use Class C ("growth and propagation of fish, shellfish, other aquatic life, and wildlife"), as defined in 18 AAC 70.020. Water quality standards that are applicable to the data collected by the CAKN stream monitoring program are listed in Table 14. Note that exceedances for most pollutants

under these standards require either continuous data collection, or at least multiple data points, over a period of hours to days, and are therefore not compatible with data collection methods employed by the CAKN, which are typically restricted to one, or at most several, data collection events per year.

Table 14. State of Alaska surface water quality standards for selected attributes under Designated Use Class C. Only standards that apply to instantaneous values are listed. For many pollutants, standards are defined only for acute (e.g. 1-hour average) or chronic (e.g. 30-day average) concentrations, which are not measured by the CAKN monitoring program.

Attribute	Standard for waters used by anadromous and resident fish	Standard for waters not used by anadromous and resident fish	Notes
Dissolved Oxygen	➤ 7 mg/L	➤ 5 mg/L	May not exceed 17 mg/L
pH	Not < 6.5 or > 8.5	Same	May not vary more than 0.5 pH unit from natural conditions
Temperature	≤ 20°C; for migration routes and rearing areas ≤ 15°C; for spawning areas ≤ 13°C	≤ 20°C	Weekly average temp may not exceed site-specific requirements need to preserve normal species diversity or to prevent the appearance of nuisance organisms.
Alkalinity	➤ 20 mg/L as CaCO ₃	Same	Except where natural alkalinity is lower

Routine data summaries

Summary statistics for water chemistry, temperature, and biological data will be generated annually to provide basic information related to differences between sampling locations, parks, and any other groupings such as network stream classification scheme. In general, non-parametric statistical methods will be used to characterize the data collected by the CAKN program. Environmental data are characterized by three attributes that result in their typically following a non-normal distribution. These are a lower bound of zero, the presence of outliers on the positive side, and a resulting positive skewness. Accordingly, environmental data often violate a key assumption of parametric statistical methods. Median values rather than mean values will be used to summarize the central tendency of the data. In examining geographic and temporal patterns in water chemistry, temperature, and biological parameters like species richness and diversity, median values are more useful than mean values in that they represent typical values, and are resistant to the influence of outliers and skewed distributions (Helsel & Hirsch 2002). Maxima and minima will also be calculated and reported, as they can be more important ecologically than mean or median values.

Extreme values, or outliers, are common in environmental data such as water chemistry. Although such extreme values can be informative and important, they can also have a large influence on parametric summary statistics (Helsel and Hirsch 2002). Outliers can be a result of a measurement or recording error; however, they can also represent rare events or observations

from other populations. Outliers in monitoring data will be identified using graphical methods (box plots, normal probability plots) and examined to determine whether they can be attributed to measurement or recording error. If so, they will be discarded prior to further analyses. If they cannot be attributed to measurement or recording error, they will be retained for subsequent analyses. Because non-parametric analysis methods will be used, outliers will not have an undue effect on the results.

Variability is another important characteristic of environmental data. Because parametric summary statistics of variability or spread (sample variance, standard deviation) are strongly influenced by outliers, we will use the interquartile range (IQR) to summarize variability. The IQR (defined as the 75th percentile – the 25th percentile) measures the range of the central 50% of the data, and is not influenced at all by outliers (Helsel and Hirsch 2002).

For water chemistry parameters characterized by a substantial percentage of “non-detects” (typically values that are below the laboratory detection limit for that parameter, methods designed to handle these so-called censored data will be used to generate summary statistics. For streams in the CAKN, total dissolved phosphorous, phosphate-phosphorous, nitrate-nitrogen and ammonia nitrogen are the primary types of censored data that are collected. These methods are based on the use of percentiles or ranks for calculation of statistical summaries and for hypothesis testing (Helsel and Hirsch 2002).

Graphical methods will also be used to generate annual data summaries, and for exploratory data analysis to inform further study. For individual parameters, four types of graphical methods will be used. These are boxplots, quantile-quantile (Q-Q) plots, scatterplots, and cumulative distribution function (cdf) plots. All four methods provide important visual information regarding the distribution of the data, either among sampling locations, or across time at a single sampling location. For example, Q-Q plots can be used to determine whether differences between groups of data are additive or multiplicative.

Multivariate datasets, which include primarily macroinvertebrate and diatom community data, although water chemistry data can also be considered to be multivariate, will be visualized using ordination techniques. Primary among these will be NMDS, which has advantages over other multivariate ordination techniques in that it makes no assumptions about the properties of the underlying species distributions, and so is able to accurately identify gradients beneath non-normal distributions, which typically characterize ecological data (Wentworth and Ulney 2000). Principal Components Analysis (PCA) will be used in cases where an assumption of multivariate normality seems reasonable. Prior to any analysis, invertebrate and diatom taxa lists will be adjusted to ensure each reported taxon is unique by converting ambiguous taxa designations to Operational Taxonomic Units (OTU, Cuffney *et al.* 2007).

The results of these exploratory analyses will be used to direct more in-depth study. In particular, the network is still in the process of developing a robust stream classification scheme. Classification is a critical step in improving our understanding of spatial and temporal patterns across the network, as well as in improving our power to detect change. Different stream types/classes are likely to respond differently to global drivers. Accounting for variability across sites via classification will therefore increase our ability to detect changes in ecosystem attributes. A variety of classification methods, including cluster analysis (k-means, UPGMA,

Classification and Regression Trees [CART], and random forests) and ordination (NMDS, Principal Components Analysis) will be used to search for stream groupings based on landscape, chemical and/or biological attributes. The robustness of the groupings obtained by each method will be tested using various measures of classification validity, including bootstrapping, silhouette analysis, the Dunn index, and Classification Strength (Van Sickle 1997).

Biological assessment

Overview of RIVPACS modeling

Biological assessment of ecological condition across network streams will be accomplished through the application of empirical predictive models, commonly referred to as RIVPACS, or O/E models (*e.g.*, Clarke *et al.* 2006, Hawkins 2006). These models use natural environmental gradients to predict the species composition of invertebrate, diatom, or fish communities that would be expected to occur at a given sampling site in the absence of impairment. The ratio of the number of expected fauna that were actually observed to the number of expected fauna, or O/E, represents a measure of the degree to which the biological community at that site remains intact. Significant deviations from expected conditions constitute a measure of biological impairment, or in more general terms, of ecological change away from expected conditions. Given appropriately defined thresholds for change detection, O/E scores can be used to evaluate ecological condition and hence water quality either at individual sites of interest, or at regional or larger spatial scales. More generally, O/E scores can be used to detect any kind of change in ecological condition, including changes due to global drivers like climate warming.

The development of robust RIVPACS models is an iterative process, so only an overview of model construction is provided here, along with a brief description of the current RIVPACS model, based on invertebrate data collected from 2006-2011. We are currently in the process of updating the current CAKN model to include data collected through 2015, as well as data collected by other entities, including the U.S. Geological Survey and ADEC. Because RIVPACS models are designed to predict the expected community composition that would be observed in the absence of impairment, the models are built using data only from sites that are thought to be relatively free of human influence (Bailey *et al.* 2004). Although selection of these least-disturbed, or reference, sites can be challenging in many areas (Herlihy *et al.* 2008), it is relatively straightforward in a largely intact landscape like the CAKN. Log-transformed or presence-absence OTU-adjusted invertebrate and/or diatom data will be used to classify reference sites according to biological similarity in a cluster analysis. Discriminant function modeling, either best subsets linear discriminant modeling (Van Sickle *et al.* 2006) or random forests (Cutler *et al.* 2007), will then be used to identify sets of predictor variables that best discriminate among the biological groupings. All RIVPACS models the network has constructed to date have relied on random forest discriminant models. Although some predictor variables for RIVPACS modeling will be derived from field habitat and water chemistry data, the emphasis will be on extracting descriptive basin-level statistics for each site using GIS data. GIS-derived predictors have the distinct advantage that they are not subject to variation due to observer bias or field data collection methodology. Thus, the use of GIS-derived variables greatly increases the comparability of data collected at different times, by different observers, or by different monitoring programs.

Basins for each sampling reach will be defined as the upstream contributing area of each sampling location based on the geographic coordinates of the bottom of the reach. Basin

delineation can be conducted using a number of tools that operate in ArcGIS, including TauDEM (<http://hydrology.usu.edu/taudem/taudem5.0/>) and Arc Hydro (Maidment 2002). Currently, basin delineation for the CAKN monitoring program is conducted by GIS specialists at ABR, Inc., using customized ArcGIS scripts that allow delineations for multiple basins to be accomplished in batch mode. Corrected shapefiles corresponding to each delineated basin are then used in ArcGIS to extract a large number of descriptive statistics for each basin (Table 15). Climate statistics are derived from the spatially-explicit PRISM climate data models that are based on long-term averages (Daly *et al.* 2008). Other statistics are derived using DEMs, land cover and other data layers as needed.

To test the condition of new sites of interest (generally referred to as “test” sites), the discriminant model is used to calculate the posterior probability of membership in each biological class for each test site. The posterior probabilities, in combination with the frequencies of occurrence of each taxon across the biological classes, are then used to calculate the probability that each taxon will be captured at each of the test sites. The sum of these

Table 15. Examples of basin-level descriptive statistics derived for use in the development of RIVPACS models.

Climate statistics

Mean precipitation and temperature (annual)
Mean precipitation and temperature (by month)
Mean maximum precipitation and temperature (annual)
Mean maximum precipitation and temperature (by month)
Mean minimum precipitation and temperature (annual)
Mean minimum precipitation and temperature (by month)

Topography

Mean, minimum and maximum elevation
Basin area
Basin relief
Basin aspect
Channel gradient
Longest distance to source

Other basin descriptors

Percent glaciation
Percent lakes
Drainage density
Land cover type, percent by category
Percent permafrost, percent by type
Lithology, percent by category

probabilities for a given site across all taxa gives the expected number of native taxa that should be captured at that site (E). The ratio of the number of those expected taxa that are actually observed at the site (O) to E gives a measure of the degree to which the native fauna are intact. This ratio, O/E, is both site-specific and standardized, so it allows comparisons to be made among sites that have widely different native faunas.

To determine whether an observed value of O/E actually indicates a significant deviation from the expected, or reference condition, the model must be assessed for precision and bias. By definition, the O/E score for a reference site should be 1.0; that is, we should always observe what we expect at reference sites. However, due to model error, the O/E scores of reference sites instead form a distribution centered on 1.0, if the model is unbiased. Deviations away from a mean score of 1.0 indicate a degree of bias in model predictions. Bias can also be assessed visually by evaluating a plot of O versus E. The spread of the distribution of reference site O/E scores, generally quantified by the standard deviation, gives an estimate of model precision and allows us to set statistically valid thresholds for change detection. Given a sufficient number of reference sites, the model is constructed using one set of sites, and evaluated for precision using a second set of sites. For many programs, however, precision must be evaluated using the same set of reference sites that were used in model construction. This is the case for the CAKN stream monitoring program as well, until such time as sufficient reference data can be assembled.

CAKN RIVPACS Model

The CAKN has successfully developed two RIVPACS models in recent years, and is in the process of developing a third model. Here I describe the construction and performance of the current iteration of the model, completed in 2013. Invertebrate and environmental data from 68 reference streams in DENA and WRST were used to develop the current RIVPACS model. The data were collected from 2006-2011. For sites that had been sampled in more than one year, a single site visit was randomly selected. Invertebrate abundances were converted to presence-absence prior to model construction. 6 biological classes were identified using the unweighted pair-group method with arithmetic mean (UPGMA) clustering algorithm in PC-ORD, with between-sample similarity defined using the Sørensen index (McCune and Grace 2002). A random forest discriminant model to predict new sites into these biological classes was constructed using the randomforest library in R. 5000 trees were constructed, with 5 variables used at each split (see Cutler *et al.* 2007). The resulting model used 31 environmental predictors; Table 16 lists the 10 most important of these variables. The final discriminant model had an out-

Table 16. 10 most influential environmental predictive variables used in the CAKN RIVPACS random forest discriminant model. The Global Importance Value for a variable represents the mean decrease in the group prediction accuracy for the random forest discriminant model when that variable is omitted, averaged over all group predictions. All climate variables are derived from PRISM and represent mean values for the basin from 1971-2000. The complete discriminant model uses 31 predictors.

Variable	Interpretation	Category	Global Importance Value
Area.km	Watershed area	Stream size	5.79
Perimeter	Watershed perimeter length	Stream size	5.37
AnnMxTemp	Mean annual maximum air temp	Climate	5.3
JulMxTemp	Mean July maximum air temp	Climate	5.22
AnnMinTp	Mean annual minimum air temp	Climate	5.08
CVSlope	Variability of basin slope	Topography	4.85
MinElev	Elevation at sampling location	Topography/climate	4.82
EvergreenForest	%Evergreen forest in basin	Land cover	4.79
Pctlakes	%Basin area as lakes	Land cover/hydrology	4.57
pctwetlands	%Basin area as wetlands	Land cover/hydrology	4.54

of-bag estimate of error rate of 33.8%, with most misclassifications being into closely related groups. This discriminant model was combined with the frequency of occurrence of each taxon across all biological groups to create the final RIVPACS model.

To test the model for precision and bias, invertebrate and environmental data from the same 68 reference sites used to construct the model were used, as discussed above. The mean O/E score of the reference sites for this model is 1.07, which indicates a slight negative bias in predictions. Examination of a plot of O versus E (not shown) revealed that this negative bias is driven by modest underpredictions at sites with high E. In other words, at more diverse sites, the model predicts slightly fewer species than are actually observed. This is probably a reflection of the relatively small number of reference sites used in model construction, particularly given the large scale and ecological heterogeneity of the CAKN (J. Ostermiller, Utah Division of Water Quality, personal communication). Future iterations of the model that will include data from nearly 150 samples should alleviate this bias. There is a strong relationship between O and E ($r^2 = 0.86$), suggesting that variation in O is well predicted by E.

The precision of the model is reasonable, as reflected in the standard deviation of reference site O/E scores of 0.168. This is comparable to the precision of other large-scale RIVPACS models (Van Sickle *et al.* 2005, Hawkins 2006, Hargett 2012). Thresholds for the detection of change in ecological condition, or designation of a particular site as being in non-reference condition, for RIVPACS models are generally defined as the 10th and 90th percentiles of the reference site O/E distribution. These thresholds provide a balance between the risk of Type I and Type II errors appropriate to the implementation of an ecological monitoring program (Clarke *et al.* 1996, Ostermiller and Hawkins 2004). Using this definition, the thresholds for detecting change for the current CAKN RIVPACS model are an O/E score less than 0.84, representing a 16% loss of expected native taxa, or greater than 1.3, representing a 30% increase. In other words, over 10 years, this model is capable of detecting a net annual loss of less than 2% of native species diversity, or a net annual gain of 3%. Future iterations of the model that include more reference site data are expected to exhibit greater precision and therefore greater sensitivity to detect change.

One powerful advantage of this idea is that in principle, change can be detected at sites that are being sampled for the first time, because RIVPACS generates a site-specific expected community composition, and then merely quantifies any difference from those expected conditions. A site not in its expected condition can be inferred to have changed from that condition at some time in the past. Absent other proximal sources of anthropogenic stress, alterations in condition are likely due to the effects of climate change.

Trend detection

Water chemistry and temperature at sentinel sites

We will primarily use non-parametric methods to test for trend in measures of water chemistry and temperature at sentinel sites. Non-parametric methods are generally more appropriate for environmental data than parametric methods, due to the tendency of such data to be non-normally distributed (Helsel and Hirsch 2002). Accordingly, we will rely primarily on several robust non-parametric tests for trend, all of which are available as documented packages in R. In cases where seasonality is not thought to be a factor (for example, water chemistry parameters

calculated only from samples obtained during the summer index period (late June – late August), we will use Theil-Sen non-parametric regression (Helsel and Hirsch 2002) to test for trend over time using the *senth* package in R. To test for the effects of environmental covariates that may obscure trends in response variables of interest, we will use the *nptrend* package in R to first model the response variable against each covariate using a LOWESS smooth, followed by testing the LOWESS residuals for trend using Kendall's tau (Helsel and Hirsch 2002).

In some cases it may be desirable to use a step trend test to compare two time periods rather than testing for a continuous trend. For example, historical water chemistry data are available for a number of streams in the network (*e.g.* Edwards and Tranel 1998). Comparing values measured in past decades with those currently being collected by the stream monitoring program is best approached using a step trend test. Accordingly, for these types of analyses, we will use a 2-sample Wilcoxon test to test for differences between time periods.

In cases where seasonality is likely to confound detection of trends (*e.g.*, for continuous water temperature data), the Seasonal Kendall test will be used to test for trend using the *seaken* package in R. Whereas in Thiel-Sen regression, the computed slope is the median of pairwise slopes, in the Seasonal Kendall test, the slope is the median of all within-season pairwise slopes. As above, in cases where environmental covariates may also confound detection of trend, the *npseattrend* package in R will be used to first model the response variable against each covariate using a LOWESS smooth, and then the residuals will be tested for trend using the Seasonal Kendall test.

Power analysis for trend detection of water chemistry parameters at sentinel sites

To estimate the years of data that would be required to detect statistically significant changes in the values of water chemistry parameters (or of water temperature summary statistics) given the observed levels of interannual variability in data collected at sentinel sites since 2006, a power analysis was performed using the *powertrend* function in R. Because *powertrend* is a parametric power analysis package based on linear regression, it provides a very conservative estimate of power for the non-parametric tests the CAKN will rely on for trend detection. Non-parametric tests have substantially more power to detect differences or trend than parametric tests when data are non-normally distributed, as is generally the case for environmental data, and tend to have equivalent power for normally distributed data (Helsel and Hirsch 2002).

To assess how variability in measured values for various water chemistry and temperature parameters will affect the ability to detect change, I first conducted a power analysis using *powertrend* at 5 potential levels of variability, as represented by the coefficient of variation (CV, defined as the standard deviation divided by the mean). Here the CV ranged from 0.05, corresponding to a low level of variation between values measured at different sampling times, to 0.25, representing a moderate level of variation. Power to detect change was evaluated for two values of α . Because the emphasis in a long-term monitoring program should be on detecting change where it is actually occurring, or in other words on minimizing the chance of Type II errors, it is appropriate to set α above the traditional value of 0.05 (Rawhouser *et al.* 2012). Accordingly, power was evaluated for $\alpha = 0.10$ and $\alpha = 0.20$. Following Rawhouser *et al.* (2012), the rate of annual change to be detected was defined to be 3%, and the sampling frequency was set at once per year. The results are shown in Table 17. For $\alpha = 0.10$, anywhere from 6 to 19 years of data would be required to detect an annual change of 3%, depending on the

underlying variability of the parameter of interest. For $\alpha = 0.20$, the range is 6 to 17 years. In either case, the range of years of data required is well within the scope of the CAKN stream monitoring program, which has already collected as many as 10 years of data at some sentinel sites. Note that because power trend assumes that errors scale with the magnitude of the parameter value, more data are required to detect increases than to detect decreases.

To evaluate the actual variability of the parameters measured by the CAKN stream monitoring program, and hence the number of years of data that would be required to detect a 3% annual change in the value of those parameters, I looked at a representative set of water chemistry parameters from 12 sentinel streams where at least 5 years of data were available. Variability was again assessed using the coefficient of variation (CV). For sites that had been sampled in more than one season, only data from the index sampling period (late June – late August) were included in the analysis. Eight parameters were evaluated – pH, silicon concentration, total alkalinity, specific conductivity, sulfate-sulfur concentration, dissolved organic carbon

Table 17. Years of data required to achieve a given statistical power to detect a 3% annual change in the value of a parameter as a function of interannual variation (represented by the coefficient of variation [CV]). Power values above 80% are in italics.

CV	Years of data	Cumulative % change	Power to detect increase	Power to detect decrease
<u>$\alpha = 0.10$</u>				
0.05	6	18	76	<i>81</i>
	7	21	<i>90</i>	<i>91</i>
0.10	9	27	71	<i>80</i>
	10	30	<i>82</i>	<i>91</i>
0.15	12	36	72	<i>84</i>
	13	39	<i>80</i>	<i>91</i>
0.20	14	42	67	<i>82</i>
	16	48	<i>81</i>	<i>93</i>
0.25	16	48	64	<i>82</i>
	19	57	<i>82</i>	<i>97</i>
<u>$\alpha = 0.20$</u>				
0.05	6	18	<i>89</i>	<i>100</i>
0.10	8	24	74	<i>81</i>
	9	27	<i>85</i>	<i>90</i>
0.15	11	33	77	<i>86</i>
	12	36	<i>84</i>	<i>93</i>
0.20	13	39	75	<i>85</i>
	14	42	<i>80</i>	<i>90</i>
0.25	15	45	73	<i>86</i>
	17	51	<i>81</i>	<i>94</i>

concentration, total nitrogen concentration, and nitrate-nitrogen concentration. The results are shown in Table 18. Because the observed CV varied substantially among individual streams, the median CV value was used to estimate the years of data that would be required to detect a 3%

annual change, again with α set at either 0.10 or 0.20. For some parameters (pH, silicon), relatively few years are required, and the program already has sufficient data from some streams to detect change, whereas for others (DOC, total nitrogen, nitrate-nitrogen), more than a decade of data will be required. However, in general, it is clear that we will have the ability to detect this level of change within the next few years in most cases. Some individual streams exhibit a substantial variability, especially for nitrate-nitrogen, and change detection in these cases may require several decades of data.

Table 18. Median years required to detect a 3% annual change for representative water chemistry parameters, based on results from 12 CAKN streams with at least 5 years of data

Parameter	CV range	Median CV	Median years to detect 3% annual increase $\alpha=0.1$	Median years to detect 3% annual increase $\alpha=0.2$	Median years to detect 3% annual decrease $\alpha=0.1$	Median years to detect 3% annual decrease $\alpha=0.2$
pH	0.008 – 0.031	0.015	4	3	4	3
Silicon	0.021 – 0.142	0.049	7	6	6	6
Alkalinity	0.054 – 0.183	0.092	10	9	9	8
Specific conductivity	0.046 – 0.178	0.093	10	9	9	8
SO ₄	0.08 – 0.241	0.149	13	12	12	11
DOC	0.10 – 0.473	0.199	16	14	14	13
Total nitrogen	0.057 – 0.435	0.203	16	14	14	13
Nitrate nitrogen	0.069 – 0.734	0.251	19	17	16	15

Trend detection for water chemistry at the park or network scale

Generalized linear mixed models (Zuur *et al.* 2009) will be used to estimate status and long-term trends in water chemistry in streams across the network. These will be fit in a Bayesian framework using a model-based approach which can accommodate unbalanced sampling (*e.g.* different coverage extents in different years) and rotating panel designs (Gelman *et al.* 2004). Departures from the formal GRTS draw required due to access restrictions can also be accommodated under this approach. Additional sites that were selected based on ease of access can be included allowing the collection and use of much more data than would be possible under a strict design-based approach. Individual stream reaches will be treated as sampling units and trends at the reach and park levels will be estimated. Random effects at the level of the sampling unit will be used to explicitly address unbalanced sample sizes and revisit intervals for individual sample units. Spatially-explicit models (Cressie and Wikle 2011, Diggle and Ribeiro 2010) may be used to help to account for variation across the landscape and will help assess status and identify trends that may otherwise be obscured. Covariates such as ecoregion, ecological

subsection, lithology, elevation, landscape position, and basin area will also be included to help explain variation and reveal differences in status and trends across spatial scales (*e.g.*, watershed vs. park unit). When applicable, data from multiple parks will be used to increase precision and help identify change at the network level.

Trend detection for macroinvertebrate and diatom communities at sentinel sites

The CAKN will use a variety of methods to assess multivariate invertebrate and diatom community data collected annually at sentinel sites for change or trend in species composition. As discussed in the previous section, we will use the CAKN RIVPACS model to evaluate whether invertebrate samples collected at sentinel sites in years after the baseline period (2004-2011) have changed significantly from the expected composition, using the 10th and 90th percentiles of the reference site O/E score distribution as change detection thresholds.

Multivariate control charts are another approach that the CAKN will use for detecting change in invertebrate and diatom communities. Briefly, this approach examines whether the dissimilarity between the observed composition at time t and the multivariate centroid of previous observations (either a fixed baseline centroid, or a moving centroid including all observations up to time $t-1$) is statistically significant (Morrison 2008, Anderson and Thompson 2004). Multivariate control charts can be applied at any spatial scale, from an individual site to the entire network. Although this method is relatively new to ecologists, and has not yet been widely applied for ecological analyses, preliminary work shows that it is a robust approach for the analysis of change in lotic macroinvertebrate communities (A. Woodward, USGS, unpublished data).

Visualization of community data using non-metric multidimensional scaling (NMDS) will also be used to assess changes in community composition. As discussed above, NMDS has advantages over other multivariate ordination techniques in that it makes no assumptions about the properties of the underlying species distributions, and so is able to accurately identify gradients beneath non-normal distributions, which typically characterize ecological data (Wentworth and Ulney 2000). In addition, NMDS is able to handle data containing outliers, which occur frequently in ecological data, and can be important in identifying range shifts, but can cause problems for methods that assume multivariate normal distributions (Ruokolainen and Salo 2006). For these reasons, NMDS is widely used in analyses of community change (McCune and Grace 2002, Greenstein and Pandolfi 2008, Pucko *et al.* 2011).

Trend detection for ecological condition at the network scale

Finally, we will use RIVPACS modeling as an approach for the detection of changes in ecological condition at the network scale. We will establish a temporal baseline using macroinvertebrate and/or diatom data collected at a large set of reference sites collected over a limited period of time (2004-2011). These data have been collected by the CAKN, the U.S. Geological Survey, and Alaska DEC using field and laboratory methods that are the same or very similar. This will constitute the third iteration of the CAKN RIVPACS model, and is currently under development. Significant deviations from expectations in O/E scores at individual sites (defined as discussed above as being less than the 10th percentile or greater than the 90th percentile of the distribution of reference site O/E scores), or in average O/E score at the park or network scale can be interpreted as indicating a significant change in community composition. To assess whether ecological condition at the park or network scale (or any other grouping of

interest) has changed from baseline expectations, reference site data collected after the baseline period will be evaluated against the reference site data used to develop the RIVPACS model. The Mann-Whitney test, which is a non-parametric version of the t-test, or the Kruskal-Wallis test, which is a one-way ANOVA on ranks, will be used to test whether the typical site in the group under evaluation (*e.g.* all sites in DENA sampled from 2014-2016) is statistically different from the baseline reference site group (Helsel and Hirsch 2002). Because the majority of streams in the CAKN are not subject to traditional anthropogenic stressors, any such alterations will indicate the effects of climate change.

Trend detection for hydrologic regime

We will rely on the U.S. Geological Survey Alaska Science Center Water Resources office for analysis of and reporting on streamflow data from the existing gaging station on the Yukon River. The formal station ID for this gage is USGS 15356000 YUKON R AT EAGLE AK. Real-time stage and discharge data are available for this station at https://waterdata.usgs.gov/ak/nwis/uv?site_no=15356000. Historical data and flow statistics are published at https://waterdata.usgs.gov/nwis/inventory/?site_no=15356000&agency_cd=USGS. Under the current cooperative operating agreement for the Nabesna River gaging station, U.S. Fish and Wildlife Service Water Resources Branch staff are responsible for data management, analysis and reporting on streamflow data from the station. Standard methods of seasonally-adjusted time series analysis, specifically the seasonal Mann-Kendall test (Helsel and Hirsch 2002, Hirsch and Slack 1984), will be used to look for long term trends in flow data. Where appropriate, the partial Mann-Kendall test will be used to adjust for the effects of environmental covariates on trends in flow (Libiseller and Grimvall 2002).

References

- Alaska Department of Environmental Conservation (ADEC). 2016. Alaska water quality standards. Available at <http://dec.alaska.gov/commish/regulations/pdfs/18%20AAC%2070.pdf>. Accessed January 3, 2017.
- Anderson, M.J. and A.A. Thompson. 2004. Multivariate control charts for ecological and environmental monitoring. *Ecological Applications* 14:1921-1935.
- Bailey, R.C., R.H. Norris and T.B. Reynoldson. 2004. *Bioassessment of freshwater ecosystems: using the reference condition approach*. Kluwer Academic Publishers, New York.
- Clarke, R.T., J.F. Wright and M.T. Furse (2003). RIVPACS models for predicting the expected macroinvertebrate fauna and assessing the ecological quality of rivers. *Ecological Modeling* 160:219-233.
- Clarke, R.T., M.T. Furse, J.F. Wright, and D. Moss (1996). Derivation of a biological quality index for river sites: comparison of the observed with the expected fauna. *Journal of Applied Statistics* 23:311-332.
- Cressie, N. and C.K. Wikle. 2011. *Statistics for spatio-temporal data*. Wiley, Hoboken, New Jersey.

- Cuffney, T.F., M.D. Bilger and A.M. Haigler. 2007. Ambiguous taxa: effects on the characterization and interpretation of invertebrate assemblages. *Journal of the North American Benthological Society* 26:286-307.
- Cutler, D. R., T.C. Edwards, K. H. Beard, A. Cutler, K. T. Hess, J. Gibson, and J. J. Lawler. 2007. Random forests for classification in ecology. *Ecology* 88:2783–2792.
- Daly, C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis, and P.A. Pasteris. 2008. Physiographically-sensitive mapping of temperature and precipitation across the conterminous United States. *International Journal of Climatology* 28: 2031-2064.
- Diggle, P.J. and P.J. Ribeiro Jr. 2010. *Model-based geostatistics*. Springer, New York, New York.
- Edwards, P.J. and M.J. Tranel. 1998. Physical and chemical characterization of streams and rivers within Denali National Park and Preserve. Unpublished report. USDA, Forest Service, Northeastern Forest Experiment Station, Timber and Watershed Laboratory, Parsons, West Virginia.
- Gelman, A., J.B. Carlin, H.S. Stern and D.B. Rubin. 2004. *Bayesian data analysis*. Chapman and Hall/CRC, Boca Raton, Florida.
- Greenstein, B.J. and J.M. Pandolfi. 2008. Range shifts of coral reef taxa in coastal Western Australia. *Global Change Biology* 14:513-528.
- Hargett, E.G. 2012. Assessment of aquatic biological condition using WY RIVPACS with comparisons to the Wyoming Stream Integrity Index (WSII). Document #12-0151, Wyoming Department of Environmental Quality, Cheyenne, Wyoming.
- Hawkins C.P. (2006) Quantifying biological integrity by taxonomic completeness: its utility in regional and global assessments. *Ecological Applications* 16:1277-1294.
- Helsel, D.R. and R. M. Hirsch. 2002. Statistical methods in water resources. Chapter A3 in *Techniques of water-resources investigations Book 4*. U.S. Geological Survey. 522 pages.
- Herlihy, A.T., S.G. Paulsen, J. Van Sickle, J.L. Stoddard, C.P. Hawkins and L.L. Yuan. 2008. Striving for consistency in a national assessment: the challenges of applying a reference-condition approach at a continental scale. *Journal of the North American Benthological Society* 27:860-877.
- Hirsch, R.M. and J.R. Slack. 1984. A nonparametric trend test for seasonal data with serial dependence. *Water Resources Research* 20:727-732.
- Libiseller, C. and A. Grimvall. 2002. Performance of partial Mann-Kendall tests for trend detection in the presence of covariates. *Environmetrics* 13:71-84.
- Maidment, D.R. 2002. *Arc Hydro: GIS for water resources*. ESRI, Redlands, California.

- McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Glenden Beach, Oregon.
- Morrison, L.W. 2008. The use of control charts to interpret environmental monitoring data. *Natural Areas Journal* 28:66-73.
- Ostermiller, J.D. and C.P. Hawkins. 2004. Effects of sampling error on bioassessments of stream ecosystems: application to RIVPACS-type models. *Journal of the North American Benthological Society* 23:363-382
- Peck, J.E. 2010. Multivariate analysis for community ecologists: step-by-step using PC-ORD. MjM Software Design, Gleneden Beach, Oregon.
- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002. SOP 20: Revising the Protocol
- Pucko, C., B. Beckage, T. Perkins and W.S. Keeton. 2011. Species shifts in response to climate change: individual or shared responses? *Journal of the Torrey Botanical Society* 138:156-176.
- R Core Team. 2016. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
- Rawhouser, A.K., L.P. Grace, R.A. Lofgren, R.S. Glesne, J.R. Boetsch, C.A. Welch, B.A. Samora, P. Crain and R.E. Holmes. 2012. North Coast and Cascades Network water quality monitoring protocol. Natural Resource Report NPS/NCCN/NRR-2012/571. National Park Service, Fort Collins, Colorado.
- Royle, J.A. and R.M. Dorazio. 2008. Hierarchical modeling and inference in ecology: the analysis of data from populations, metapopulations and communities. Academic Press, San Diego.
- Ruokolainen, L. and K. Salo. 2006. Difference in performance of four ordination methods on a complex vegetation dataset. *Annales Botanici Fennici* 43:269-275.
- Simmons, T. and J.D. Ostermiller. 2012. Monitoring water quality in Alaskan National Parks: Development of RIVPACS empirical models for assessing ecological condition and detecting change in a heterogeneous landscape. 8th National Monitoring Conference, Portland Oregon, April 30-May 4, 2012.
- Simmons, T. 2015. Central Alaska Network Flowing Waters Monitoring Program 2011 Annual Report. Natural Resource Report NPS/CAKN/NRR—2015/965. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/DownloadFile/522694>. Accessed January 9, 2017.

- Simmons, T. 2012a. Cooperative monitoring of river flow on the Nabesna River. Streams & rivers resource brief. October 2012. Available at: <https://irma.nps.gov/DataStore/DownloadFile/458724>. Accessed January 9, 2017.
- Simmons, T. 2012b. Biological assessment of water quality. Streams & rivers resource brief. May 2012. Available at: <https://irma.nps.gov/DataStore/DownloadFile/456917>. Accessed January 9, 2017.
- Simmons, T. 2011. Monitoring water quality in streams and rivers. Streams & rivers resource brief. February 2011. Available at: Available at: <https://irma.nps.gov/DataStore/DownloadFile/470909>. Accessed January 9, 2017.
- Simmons, T. 2010. How will climate change affect rivers and streams in the Central Alaska Network? Rivers & streams climate change resource brief. October 2010. Available at: Available at: <https://irma.nps.gov/DataStore/DownloadFile/485236>. Accessed January 9, 2017.
- Van Sickle, J.V., D.D. Huff and C.P. Hawkins. 2006. Selecting discriminant function models for predicting the expected richness of aquatic macroinvertebrates. *Freshwater Biology* 51:359-372.
- Van Sickle, J., C.P. Hawkins, D.P. Larsen, and A.T. Herlihy. 2005. A null model for the expected macroinvertebrate assemblage in streams. *Journal of the North American Benthological Society* 24:178-191.
- Van Sickle, J. 1997. Using mean similarity dendrograms to evaluate classifications. *Journal of Agricultural, Biological and Environmental Statistics* 2:370-388.
- Wentworth, T.R. and C.J. Ulrey. 2000. Comparison of ordination methods for investigating vegetation/environment relationships. Pages 24-27 in P.S. White, L. Mucina, J. Leps and E. vander Maarel, editors, *Proceedings from the 41st International Association for Vegetation Science Symposium*. Opulus Press, Uppsala, Sweden.
- Zuur, A.F., E.N. Ieno, N.J. Walker, A.A. Saveliev and G.M. Smith. 2009. *Mixed effects models and extensions in ecology with R*. Springer, New York, New York.

SOP 18: Revising the Protocol

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

Only changes in this SOP will be logged. “Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Introduction

This Standard Operating Procedure (SOP) explains how to make changes to the Stream Monitoring Protocol Narrative and accompanying SOPs, and explains procedures for tracking these changes. CAKN or park staff editing the Protocol Narrative or any SOP need to follow this procedure to eliminate confusion in data collection and analysis methods. All CAKN aquatic resources staff should be familiar with this SOP in order to identify and use the most current methodologies. This SOP is adapted directly from the Bird Monitoring Protocol SOP #11 for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas (Peitz *et al.*, 2002). Their protocol can be accessed at <http://science.nature.nps.gov/im/monitor/protocols/birds.htm>

Procedures

In assembling the Stream Monitoring Protocol Narrative and accompanying SOPs, we have made every effort to incorporate the most sound methodologies for collecting and analyzing data. However, all protocols require editing as new and different sample collection, analysis, and data management information becomes available. Required edits should be made as soon as they are deemed necessary and appropriate reviews should be conducted.

All edits will be reviewed for grammatical and technical accuracy and overall clarity. Minor changes or additions to existing methods will be reviewed “in-house” by the CAKN aquatic ecologist and other appropriate network staff. However, if a complete change in methods is anticipated, then an outside review is required. Regional (Alaska Region) and National staff of the National Park Service familiar with the collection of stream monitoring data and data analysis will be utilized as reviewers. Also, local and state experts in stream monitoring and statistical methodologies outside of the Park Service will be utilized in the review process as needed.

Edits and protocol revisions will be documented in the Revision History Log that accompanies the Protocol Narrative and each SOP. Only changes in the Protocol Narrative or specific SOP that has been edited will be logged. “Version numbers increase incrementally by hundredths

(e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number” (Peitz *et al.*, 2002).

Notify the CAKN Data Manager of any changes to the Protocol Narrative or SOP.

Post new versions on the internet and forward copies to all individuals with a previous version of the Protocol Narrative or SOP.

When any significant changes in the sampling protocol occur such as changes in sample collection techniques or equipment, a change in analytical laboratory, or changes in staff, there should be an “overlap” of methods and personnel (Oakley *et al.*, 2003). This requires using both the old and new techniques on a given sample as well as having both the outgoing and new staff sample concurrently. While this approach is likely not feasible for the Long Lake weir, it should be the goal of the weir program to conform to these guidelines to the extent possible.

References

- Peitz, D.G., S. G. Fancy, L. P. Thomas, and B. Witcher (2002). *Bird monitoring protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas*. Prairie Cluster prototype monitoring program. Version 1.00, September 6, 2002.
- Oakley, K.L., L.P. Thomas, and S.G. Fancy (2003). Monitoring protocol guidelines. *Wildlife Society Bulletin* **31**: 1000-1003.

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