Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 1

Preparations for the Field Season and Equipment Needed

Version 1.00 (April 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes how to prepare for the field season, including a list of field equipment and tasks that are performed before each field trip.

1. Before the Field Season

The following tasks should be completed by the project manager or field crew leader well before the arrival of seasonal field crew members.

1. Post positions for seasonal employees or student interns 3-4 months prior to scheduled field work. Riparian monitoring requires four field crew members for vegetation sampling and geomorphology work. Hiring must be completed at least six weeks prior to the beginning of the field season to allow time for federal background check procedures.
2. Review the entire protocol. Understand the goals and procedures of the monitoring program before beginning other preparations. Discuss any proposed or recent changes to the sampling design or protocol with appropriate I&M personnel. If a change has been implemented since the last field season, make sure that all field forms, databases, and relevant SOPs have been updated.
3. Compile a list of sentinel and rapid sites that will be monitored. Discuss the season's objectives with appropriate I&M personnel to develop a field schedule.
4. Schedule field work. Use the guidelines below to develop a field schedule that meets the objectives for the field season and maintains some flexibility for unforeseen events.

   Seasonality of sampling
   Vegetation is sampled during the growing season, when the summer low flows have been reached, typically between late July and mid- September. Sampling visits should be scheduled to optimize phenology for the group of NCPN park units included in big river monitoring. Park units should be visited at approximately the same time each year to maximize repeatability.

   Field crew schedule

Crew members typically work 8 consecutive 10-hour days, followed by 6 days off, especially when working at distant park units or in the backcountry. Field work that does not require travel and camping has more flexibility. Driving to the launch site, rigging boats, and getting to the first campsite usually takes close to one full day. Similarly getting to the take out, de-rigging, and driving back to Moab takes another day. Therefore field hitches at DINO and CANY should plan for actual data collection to be implemented in 6 day stretches. There may be some additional time for hitches at BLCA and CURE where a raft is not required. Office work at the beginning and end of the field season is scheduled for 8 hour days Monday through Friday, and additional office days throughout the field season may be scheduled for trainings, field preparation, or data management.

5. Request research permits. Begin the process at least 10 weeks before the start of the field season to allow ample time for processing.
6. Request river permit for big river sections (DINO & CANY). Specific dates are usually required. Campsites, number of people, number of boats, etc. is usually required as well. Contact the river office of the specific park for requirements. We have a long term permit for BLCA and CURE.
7. Plan travel logistics. Notify appropriate park personnel of the dates the big river field crew will be in their park unit. Discuss housing availability and needs with appropriate parks, and acquire backcountry camping permits.
8. Organize and check all equipment. Equipment is usually tested and inventoried at the end of the field season. Review this list to make sure that you have adequate supplies and that all replacement equipment is ordered and will be available before the field season begins. Tables 1-4 list equipment needed for each SOP.
9. Review plant species lists for each park unit, and update them with new species detected in the previous field season. Print additional copies, if necessary, so that each 2-person team has a copy for the field. Review the species most likely to be encountered in each park and assemble relevant flora, keys, and field herbaria.

2. A few weeks before each field visit

The following tasks should be completed by the field crew leader in the weeks before a scheduled field visit.

1. Review existing maps for each park, and request additional maps from the GIS technician if necessary. Make sure that the locations of existing benchmarks are added to maps for surveying trips.
2. Pack and review relevant information for each sentinel and rapid sites to be monitored.

All visits

Access document – contains useful information for navigating to remotes areas of park units.

Trip reports - from the previous field season. At the end of each field trip, the crew leader writes a brief report describing general field conditions, access issues, logistical challenges, safety concerns, equipment problems, and suggestions for improving efficiency.

Monument photos – photos used to help relocate each headpin, total station instrument setup, or reference mark for surveying.

Vegetation sampling

Revisit data sheets – provides directions to the reach, coordinates of monuments, and any other specific information from the previous visit.

Reach species list - list of species detected during previous monitoring visits.

Surveying

Field notes – a copy of notes from the previous survey.

3. Print and copy the field data sheets, at least 1/4 of the data sheets should be on Rite-in-the-Rain© paper. Copies of each form are found at the end of the appropriate SOP. Data sheets for field measures are listed below with the minimum number needed to sample a reach.

Vegetation sampling

Sentinel site Quadrats/Transects
Rapid assessment sites
Photos
Point-intercept
Site assessment

Geomorphology sampling

4. Coordinate with the GIS technician to reserve GPS units and load UTM coordinates for the reaches to be sampled.
5. Load data from the previous total station survey on the datalogger.
6. Contact parks and provide detailed trip information. Contact the resource staff and chief ranger and provide dates the crew will be working in the park, names of field crew members, vehicle descriptions, and approximate locations of monitoring activity.
7. Check stream flows and weather forecasts. Stream flows can be referenced at usgs.waterdata.gov. Applicable gages include:

BLCA
09128000 Gunnison River below Gunnison Tunnel, CO for BLCA

CURE – Sum of these two sites
09119000 Tomichi Creek at Gunnison, CO
09114500 Gunnison River near Gunnison, CO

CANY
09180500 Colorado River near Cisco, UT
09315000 Green River near Green River, UT

DINO
09260050 Yampa River at Deerlodge Park, CO
09234500 Green River near Greendale, UT
09261000 Green River near Jensen, UT

3. Immediately before each field visit

The following tasks should be completed by the field crew leader immediately before each field visit.

1. File a backcountry safety plan. The day the crew leaves for a multi-day field trip, the crew leader should fax a backcountry safety plan to Glen Canyon dispatch. Crew leaders should review the NCPN Backcountry Safety Plan for specific procedures.
2. Check for satellite phone availability using the Globalstar Call Times Tool at http://calltimes.globalstarusa.com/.
3. Perform a vehicle safety inspection and replace any necessary fluids.
4. Check out cameras, GPS units, and satellite phones to crew members. Depending on the type of field trip, also check out lasers, total station, data logger, water level meter, peristaltic pump, PDA, field laptop, and/or cordless drill. **Make sure that the batteries are fully charged for all rechargeable equipment.**

Table 1. Equipment needed for all big river monitoring.

Item	Number needed	Description	Notes
General Equipment - *necessary for all SOPs*			
GPS with extra batteries	2	Trimble GeoXM or more accurate	main unit and backup
GPS car charger	1		
Digital camera	3		transect headpins and mid-channel, survey monuments and reference marks, wells and piezometers
Extra battery for digital camera	2		
Solar panel	1		recharging batteries in backcountry
Marine battery	1		charging electronic equipment
Multimeter	1		checking charge of batteries
Inverter	1	plugs into marine battery	charge electronic equipment
Permit	2 per vehicle		one on dashboard, one with crew
Maps	1 per 2 people		
Data sheets	variable		at least 25% on rite-in-the-rain paper
SOPs	1 per 2 people		
Clipboard	1 per 2 people	lightweight with interior storage	
Field notebook	variable	small, Rite-in-the-Rain©	field notes
Pencils	5 - 10		
Waders	1 per person	3 mm neoprene	optional during hot or cold weather
Safety Equipment - *necessary for all SOPs*			
First aid kit	1 per 2 people		content list in NCPN Backcountry Safety Plan
Satellite phone	1 per 2 people		
Satellite phone charger	1 per phone		
NCPN Backcountry Safety Plan	1 per 2 people		
NCPN Accident Report Logs	1 per 2 people		found in NCPN Backcountry Safety Plan
NCPN Medical Information Forms	1 per person		found in NCPN Backcountry Safety Plan
Throw bag	1		
Personal Equipment - *necessary for all SOPs, provided by observers*			
Insect repellent			

Item	Number needed	Description	Notes
Sunscreen			
Water bottles			
Sunhat or baseball hat			
Shoes for wading			
Vegetation.			
100-m Kevlar taglines	3	Kevlar string with meter markings	set up transects through dense vegetation
Rebar	min. 6	3/8" diameter cut into 18" lengths	secure taglines
Cam straps	4	6 footers	Tighten taglines
Stakes	4	Heavy duty	Tighten taglines
100-m transect tapes	3	fiberglass reel tapes	cross-section transects
Chaining pins	min. 6	striped metal pins	secure tapes
$1m^2$ quadrat frames	2	Pvc pipe	
Transect relocation photos	R - 2	reference photos taken during establishment	
Compass	2	with declination setting	set declination, take transect bearings
Rangefinder	E -1	short-range	measure riparian zone widths
Pin flags	min. 21	narrow steel pins with flag top	mark locations
Rebar	E -min. 18	3/8" diameter cut into 18" lengths	permanent and temporary markers
Sledgehammer	2		drive in rebar
Rebar caps	E - 14	1 1/2" pre-stamped with NCPN	label rebar and cover top for safety
Leather piece	E - 1	piece of old belt or glove	protects rebar cap when pounding
2-way radios	4		crew communication
Extra radio batteries	min. 12	AA alkaline	radios require 3 per unit
Reach species list	2	species previously recorded at reach	
Plant Identification and Unknown Plants, *Necessary for all visits.*			
Hand lenses	2		
2-gallon resealable plastic bags	min. 6	2- gallon or larger	collect plants
Masking tape	2		label plant collections
Permanent marker	2		label plant collections
Trowel	2	small garden tool	extract specimen roots
Plant press	1	field press with card, blotter, and paper	store plant collections for identification
Relevant floras and park species lists		various by park	

Photographs, *Necessary for all visits.*			
Chalkboard	2	5 x 7"	label photos
Chalk	2		
Rafting equipment, *Necessary for all visits.*			
Raft	1	14' Maravia	Including bowline and chicken line
Frame, including floor	1		Currently on long-term loan from CANY river office
Frame straps	4-6		Attaching frame to boat
Aluminum dry box	1		Currently on long-term loan from CANY river office
Cooler	1	80 qt	
Cooler board protector	1		
Table	1		Fits on frame over drop bag bay
Drop bag	1		
Beaver Tail	1		Cargo floor for stern
Oars	3		Includes one spare
Repair kit	1		Includes spare oarlock. Double-check equipment list in repair kit.
Hand pump	1		
Electric pump	1		Attaches to vehicle battery
Throw bag	1 big		
First aid kit	1		
PFD	One per person + one spare		Personal Floation Devices
Helmets	One per person		
Dry bags, small & lrg	One each per person		Small are day bags; large ones are for overnighters
Strap bag	Various straps		
Water jugs	3 or more		Heavy-duty 5 gallon. General formula is 1 gal/person/day.
Overnight Boating equipment, *Necessary for all overnight trips.*			
Stove	1		
Fuel	Enough for trip		Double-check stove fittings
Kitchen box	1		Double-check for necessary kitchen equipment, including bleach for dishes
Firepan	1		
Bucket for charcoal	1		Used for straining ashes
Strainer	1		Used for straining dishwater
Dishtubs	3		Washing dishes with 3 tub system

Groover	1		Necessary if on backcountry stretches
Sandstake	1		
Mallet	1		Pounding in sandstake
Rocket boxes	variable		
Roll-A-Table	1		
Tarp or rain shelter	1		
Duckie equipment,			
Duckie	1		NCPN 2-person inflatable kayak
Duckie seats	2		Back support; fits inside boat
Paddles	2		
Duckie repair kit	1		
Throw bag	1 small		

Table 3. Equipment needed for stream channel surveys by a three-person crew.

Item	Number needed	Description	Notes
Stream Channel Surveying - SOP #9, *Necessary for all visits unless noted with an I = initial survey or R = re-visit.*			
Total station with 2 batteries	1		make sure batteries are fully charged before leaving
Charger for total station	1		use when electricity is available
Marine battery and inverter and multimeter	1		For raft trips
Datalogger with Survey Pro software	1		make sure batteries are fully charged before leaving
Charger for datalogger	1		use when electricity is available
6-volt battery with transformer and cables	1		charging equipment in the backcountry
Tripod	1	with 5/8" screw-mount and adjustable legs	mounting total station
Backsight tripod and tribrach	1		mounting backsight
Prism	3	identical	for rods and backsight
Metric surveying rod	2	identical, telescoping to 5 m	
Rod level	2		Attached to rod
5-m rolling or 10-m engineer's tape measure	one per person		measure instrument and rod heights
2-way radios	one per person + extras		crew communication
Extra radio batteries	many	AA alkaline, 3 per radio	1.5 sets per radio per day

Item	Number needed	Description	Notes
Ear piece with microphone	1		for person running total station
Surveyor's tool belt	1		For person running total station
Rebar	I - min. 12, R - 4	3/8" diameter cut in 0.5 m lengths	permanent and temporary markers; secure taglines
Stamped aluminum rebar caps	I - 12	1 1/2" pre-stamped with NCPN	label rebar and cover top for safety
Stamp kit	1		Label rebar caps
Hammer/mallet	1		
Screwdriver, pliers, and wrench set	1		attach prisms, troubleshoot equipment
Pin flags	30	narrow steel pins with flag top	mark locations
Flagging	1 roll	brightly colored	mark locations
100-m Kevlar taglines (2)	2	Kevlar string with meter markings	set up transects through dense vegetation
GPS	1	Survey grade with horizontal accuracy < 0.1 m	
Field notes from previous survey			

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 2

Hiring and Training Observers

Version 1.00 (April 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP explains the qualifications needed for permanent and seasonal field personnel and procedures for training vegetation and geomorphology sampling technicians. Accurate, consistent data collection begins with the hiring process, followed by a rigorous training program. Technicians must also be prepared, both mentally and physically, for the extreme weather and difficult terrain of NCPN parks.

Hiring Field Technicians

Staffing requirements

Big river monitoring requires geomorphic and vegetation expertise. A permanent or term subject-to-furlough biological or physical science technician (GS-6/7) leads a crew responsible for vegetation and geomorphology sampling. Three seasonal crew members (NPS, volunteer, intern, or cooperator) comprise the riparian vegetation crew.

Qualifications and attributes

In addition to the technical skills, experience, and knowledge listed below, certain qualities are necessary for all NCPN field personnel. To maintain data quality, all staff should have the ability to successfully engage in repetitive, detail-oriented work. Technicians must be in excellent physical condition and able to thrive in difficult field conditions. Certification as a Wilderness First Responder (or Wilderness First Aid) and CPR is also an asset. Employees must expect to work away at parks for periods up to 8 consecutive days and, in many instances, to camp in backcountry situations.

Technical Skills, Experience, and Knowledge

The Riparian Crew Leader can be either a Biological or Physical Science Technician. Since it is unlikely that NCPN will be able to recruit a candidate with the technical expertise needed for both vegetation and geomorphology sampling, NCPN is committed to train the selected

candidate in the skill that they are lacking. The technical skills, experience, and knowledge required for all integrated riparian field positions is detailed below.

Lead Biological Science Technician (Crew Leader)

- Ability to identify common riparian genera and species.
- Ability to key plants to species using floras and technical keys.
- Experience leading a field crew to collect biological data in remote field settings.

Lead Physical Science Technician (Crew Leader)

- Experience using a total station and post processing total station data.
- Ability to identify bankfull and channel thalweg.
- Experience leading a field crew to collect physical data in remote field settings.

Seasonal Biological Science Technicians (or interns or volunteers)

The most essential element for the collection of quality data is well-trained, experienced field crews. Given the variability of plant community types across NCPN parks, it is necessary to hire highly skilled botanists with experience working throughout the region. The importance of hiring and training well-qualified observers cannot be overemphasized. In order to accurately detect trend across sampling periods, it is imperative that observers record vegetation and geomorphology data using the same methods and level of precision year after year. While not imperative, experience conducting quantitative vegetation sampling is a valuable skill in any employee. During the applicant review process, it will be important to give priority to those candidates with considerable experience conducting vegetation surveys and, secondly, to candidates with (1) experience conducting any type of field work that involves data collection, (2) extensive experience backpacking and hiking, and/or (3) an academic degree related to vegetation or ecology. Particular attention should be paid to the experience of the observer, his/her ability to learn new plants, physical abilities to withstand difficult field conditions, and overall attitude. NCPN will train biological science technicians in geomorphology survey techniques.

Training Seasonal Vegetation Observers

To promote accuracy and consistency in data collection among data collectors, training should be designed to calibrate data collectors so that they have comparable skills in identifying species and are recording data in a consistent format. For data collectors who are already competent at identifying plants by sight and taxonomic keying, the need for training in plant identification may be minimal. If the program is fortunate enough to hire all experienced personnel for a season, then the proposed training program will improve their skills. No data collector is exempt from the training program.

1. Prepare for the training program. The project manager or crew leader acts as the primary instructor; however, experts in various aspects of the protocol (such as First Aid/CPR) should be scheduled to assist in training as necessary. The instructor must prepare training materials, itineraries, and field gear before the training program begins.

2. Issue field gear before training begins. See SOP #1 for a list of field equipment. Provide a copy of this protocol to all trainees, along with a list of recommended personal field and camping

equipment, before training begins. Ensure that observers examine the list of necessary personal gear (see SOP #1) and that they have all the appropriate equipment by the time field work starts. It is highly recommended to check a weather forecast and ensure that all observers have appropriate clothing and equipment for the conditions. Make sure that trainees are informed and prepared for the training and survey events. Have the field technicians read the relevant riparian SOPs prior to field training.

3. Have all vegetation crew members participate in Riparian Vegetation Reach Establishment, Navigation and Safety training. Crew members from previous seasons normally do not need as much training in plant-identification skills as new crew members; however, all data collectors must attend the entire training course each year. In these cases, it will be important to specifically point out any changes to the protocol. Experienced crew members can assist with training less-experienced data collectors. Experienced crew members will also continue practicing plant identification skills, navigational abilities, and data collection methods. All procedures will be exercised to the full extent, including actual recording of observations on data sheets.

4. Focus on navigation and reach set-up. Training should be given in both general navigation techniques using traditional maps and compass, as well as handheld GPS units. All technicians should practice recording spatial data using a GPS unit.

6. Emphasize field safety procedures and issues. Discuss emergency safety procedures and important safety issues for the NCPN region, notably, rafting safety, heat exposure, flooding, and driving on rough roads. Training includes a one-day CPR/First Aid course and a review of the NCPN Backcountry Safety Plan. The crew leader or project manager will also review low impact and Leave-No-Trace camping procedures.

7. Review dominant plant species. Training will consist of field-based identification of plants likely to be observed during the field season, with emphasis on difficult-to-identify species. Additionally, field crews will be instructed on the use of available taxonomic keys and reference materials.

Suggested topics for training:

Program overview – introduction to NCPN goals and projects

Administrative responsibilities and policies – timesheets, travel, work hours, leave policies, and equipment care

Safety – NCPN Backcountry Safety Plan, Job Hazard Analysis, first aid kits, satellite phone use, specific safety concerns

Government vehicles – proper use and care, vehicle inspection, tire changing

Rafting safety – overview of hazards of working in big rivers, safety signals, etc.

Park etiquette – biological soil crust, visitor interactions, low impact practices

GPS – navigation, logging points, data dictionaries

Reach establishment – measuring active riparian zone width, identifying the channel thalweg, taking bearings using a compass, transect set up

Vegetation measures – Includes all methods in SOP #6. Pay particular attention to training observers in identifying the greenline, tagging trees, and measuring DBH.

Photos – taking good reference photos, appropriate camera orientations for monitoring photos, checking time and date settings

Plant identification – making plant collections, using available plant references, review of common species with particular attention to difficult groups including grasses, sedges, rushes and willows, plant walks in the field

Geomorphology surveys – proper extension of the rod and positioning of the prism, identifying geomorphic surface breaks

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 4

Establishing a Sentinel Site and Setting up Transects

Version 1.01 (October 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	10-1-2012	D. Perkins	Edits to instructions for establishing vegetation plots at CANY and DINO	Clarification	1.01

This SOP describes the methods for establishing a new monitoring sentinel site and setting up and relocating transects for vegetation monitoring and geomorphic surveying. A list of necessary equipment for these procedures can be found in SOP #1.

A minimum of a four-person team is needed to establish and set up the monitoring transects.

1. Sentinel Site Establishment

1.1 Sentinel Site Establishment - BLCA

Record directions to the feature
Write directions to the feature (beach-eddy, lateral bar, tip of debris fan, etc.) and include sufficient detail for someone who has never been there to relocate it. Begin with road travel from a designated location (such as the Red Rocks trailhead, East Portal hand cart) and the route used. Describe (and photograph) landmarks used to navigate to the reach. Note particular obstacles or hazards to be avoided at and en route to this particular site. Use specific language such as “southwest” and “downslope” rather than ambiguous terms such as “left” or “below.” You may also GPS the route (see SOP #3).

1.1.1 Establishing a monitoring feature and vegetation transects (BLCA – East Portal and Red Rocks)

Geomorphic features are classified using a lettering system from downstream to upstream (i.e. Feature A, B, C…A being the furthest downstream). Three to four one-bank stub transects are placed on each feature for vegetation sampling purposes (Figure 1). A stub transect is one where the transect ends in the water and does not span the entire river, referred to as “transect” from now on. Transects are numbered in sequential order, from downstream to upstream. Transects are spaced equally throughout the feature. For East Portal, all transects are on the river right side.

A. Establish three survey control points that are permanent and elevationally stable that will be visible from multiple instrument locations.

B. For each transect, establish a head pin and an additional orientation pin. A transect needs to be perpendicular to the channel.

   a. A headpin consists of a rebar with an inscribed tag or cap. Tags or caps can be prepared beforehand in the office or in camp. The labeling system is the following:
      - feature letter,
      - transect number,
      - RHP or LHP (right/left headpin),
      - Three digit number,
      - Example: "G2RHP203" is the right headpin #203 on the second transect on Feature G.

   b. An orientation pin is generally a 6" galvanized nail hammered into ground level with a flexible metal tag. The labeling system for orientation points is the following:
      - feature letter,
      - transect number,
      - P (for orientation point),
      - two digits (distance in meters away from the headpin),
      - three digits of the headpin number
      - Example: "G2P15203" is the orientation pin that is 15m away from the #203 headpin at the second transect on feature G).

C. Try to use as little metal as possible. Hammer the headpin rebar to within 5 cm of the ground surface. Attach the metal tag to the rebar using galvanized wire or gently hammer the cap onto the rebar, protecting the cap with a leather strip. If on bedrock, mark the location with chalk and place a headpin in line with the transect in the nearest possible stable location.

D. Record the distance and bearing (compass declination should be set; 10 degrees for BLCA) from the head pin to the orientation pin in a field notebook.

E. Survey the locations of the headpins, orientation pins and control points according to SOP #8. Document the locations with notes and sketch maps. GPS these locations with the highest precision possible.

F. Take reference photographs to document the location of the headpins and unmarked origin or end (if necessary), including the cliff line or other recognizable landmarks in the background. These are to assist future crew members in finding the headpins and are not used for monitoring purposes.
   a. Label a chalkboard with the park code, site, feature letter, transect number, R or L for right head pin or left head pin, direction looking (US=upstream, DS=downstream) and date (e.g., BLCA, EP, G2R-US, 14 Oct 2008).
   b. Prop the chalkboard by the rebar and pin flag.
   c. Take photos showing the rebar, chalkboard, and recognizable landmarks looking both upstream and downstream.
   d. Record the photo information on the photo data sheet (see SOP #5).
   e. Photograph the control points using the same methods.

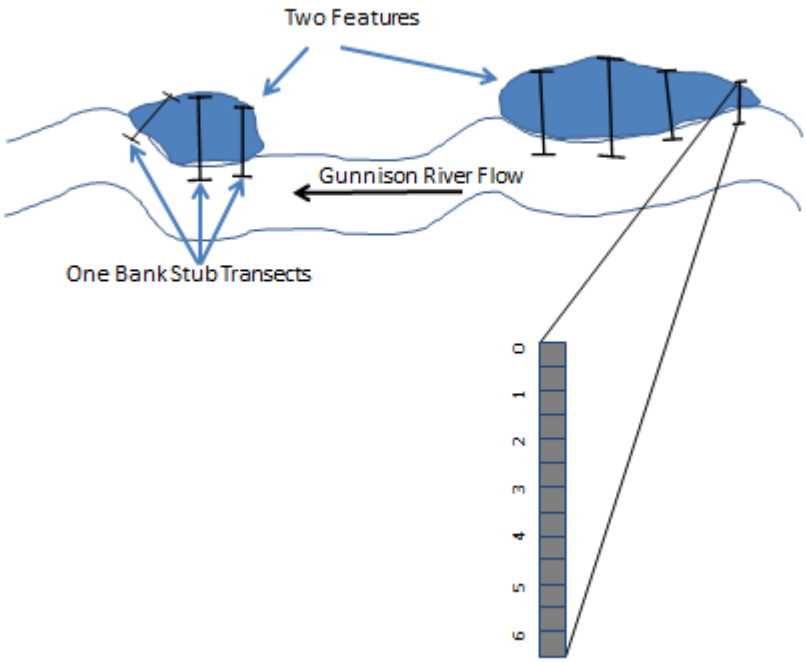

Figure 1. Two features and associated one bank stub transects with plot layout along continuous belt transect.

1.1.2 Setting up a transect

A. Have one person stand at the headpin location. On transects with thick vegetation, additional people may be needed to stand in line with the headpins to provide an accurate line of sight.

B. Drive a piece of temporary rebar into the ground on the upland side of the transect headpin.
   - Use the recorded azimuth to make sure the temporary rebar/stake is in line with the permanent transect and place an orientation pin (nail), when possible. There may be times when there is no suitable location to put the rebar on the upland side in line with the transect – getting the rebar into the ground is more important than being in line with the transect. Leave adequate space above ground on the temporary rebar for attaching the tagline and/or transect tape.

C. Attach the Kevlar tagline and/or the transect tape to the temporary rebar on river right as you face downstream.
   - Use a cord to extend the transect tape such that the 0 m mark falls over the permanent headpin.
   - Do not attach to the permanent headpins, as this may cause the headpins to move.

D. Run the tagline and/or transect tape from permanent upland head pin, in line with orientation pin, to another temporary head pin located at a safe wadeable distance into the river (usually about thigh deep, although it could be less if the current is fast, hopefully this is 5 m farther than the 300 cfs flow line). Life jackets shall be worn while establishing this headpin.
   - To avoid trampling vegetation sampling areas, walk on the downstream side of the transect whenever possible.
   - Keep the tagline and/or transect tape as straight as possible, both vertically and horizontally. Thread through vegetation as necessary.
   - Whenever possible, the line should not rest against any tree trunks or other obstacles such as boulders or debris.
   - Obstructing branches can be moved or tied back with flagging.

- If using both a tagline and a transect tape, run the tagline first, make any necessary adjustments, and then run the transect tape. Take up any slack in the tape by tying it to the tagline with flagging at regular intervals. This step is especially important in windy conditions.
- A longer piece of rebar works well for the temporary end in the water.

E. Attach the tagline and/or transect tape to the temporary rebar in the water.

F. Begin vegetation sampling (see SOP #6) and surveying (see SOP #8).

1.2 Sentinel Site Establishment – CANY and DINO

Record directions to the feature
Write directions to the feature (beach-eddy, lateral bar, tip of debris fan, etc.) and include sufficient detail for someone who has never been there to relocate it. Begin with nearest river mile and describe (and photograph) landmarks used to navigate to the feature. Note particular obstacles or hazards to be avoided at and en route to this particular site. Use specific language such as "southwest" and "downslope" rather than ambiguous terms such as "left" or "below." You may also GPS the route (see SOP #3). On the Yampa River, directions may also include hiking in from the Yampa Bench road for the Harding Hole and Laddie Park sentinel sites.

1.2.1 Establishing a monitoring feature (CANY and DINO)

At CANY and DINO there are only permanent control points. There are no permanent vegetation plots or transects.

A. Establish three control points that are permanent and elevationally stable that will be visible from multiple instrument locations. Try to use as little metal as possible. Hammer the rebar to within 5 cm of the ground surface.

B. Inscribe the feature and control point number on a metal tag or rebar cap. Tags can be prepared beforehand in the office or in camp.

C. Attach the metal tag to the rebar using galvanized wire or gently hammer the cap onto the rebar, protecting the cap with a leather strip.

D. Survey the locations of the control points according to SOP #8. Document the locations with notes and sketch maps. GPS the control point locations with the highest precision possible.

E. Take reference photographs to document the location of the control points, including the cliff line or other recognizable landmarks in the background.
   a. Label a chalkboard with the park code, site, reach, control point number, and date (e.g., DINO, HH, CP-01,14 Oct 2008).
   b. Prop the chalkboard by the rebar and pin flag.
   c. Take photos showing the rebar, chalkboard, and recognizable landmarks.
   d. Record the photo information on the photo data sheet (see SOP #5).

1.2.2 Establishing Vegetation Plots

A. Walk around the feature to get a feel for the flood zone, active floodplain, and inactive floodplain boundaries. While walking the feature, measure the length of the feature along the approximate center of the feature in paces.

B. Place temporary pin flags at the boundary of the flood zone and the active flood plain.

C. The goal is to place 50-100 vegetation randomly placed plots in the flood zone, active flood plain, and inactive flood plain. So determine a distance between transects and an average # of plots per transect.
D. While walking the boundary of the flood zone and the active flood plain, pace off the transect spacing number.
E. The transect originates in the IFP or Upland 5 m from the boundary of the AFP and IFP/UP. Plots are assigned using a random number table to assign to paces to establish plots in the AFP and FZ in proportion to their area. There may also be a few plots in the IFP/UP.
F. At each plot a pre-numbered sequential pin flag is placed designating it as a flood zone or active flood plain plot (FZ1, FZ2, FZ3…AFP1, AFP2, AFP3….). There is a bit of an art to the number of plots at each transect spacing #. The features are often wider at the middle and narrower at the upstream and downstream ends. The goal is to place plots roughly proportionate to the width of the feature at the different transect spacing numbers. Sometime plots may be in a transition from FZ to AFP or vice versa, in this case the flags are labeled FZ/AFP.
G. While laying out the plots, also place a different colored flag at the boundary between FZ, FZ/AFP (if applicable), AFP, and IFP. These flags will be used by the surveying crew.
H. Begin sampling.

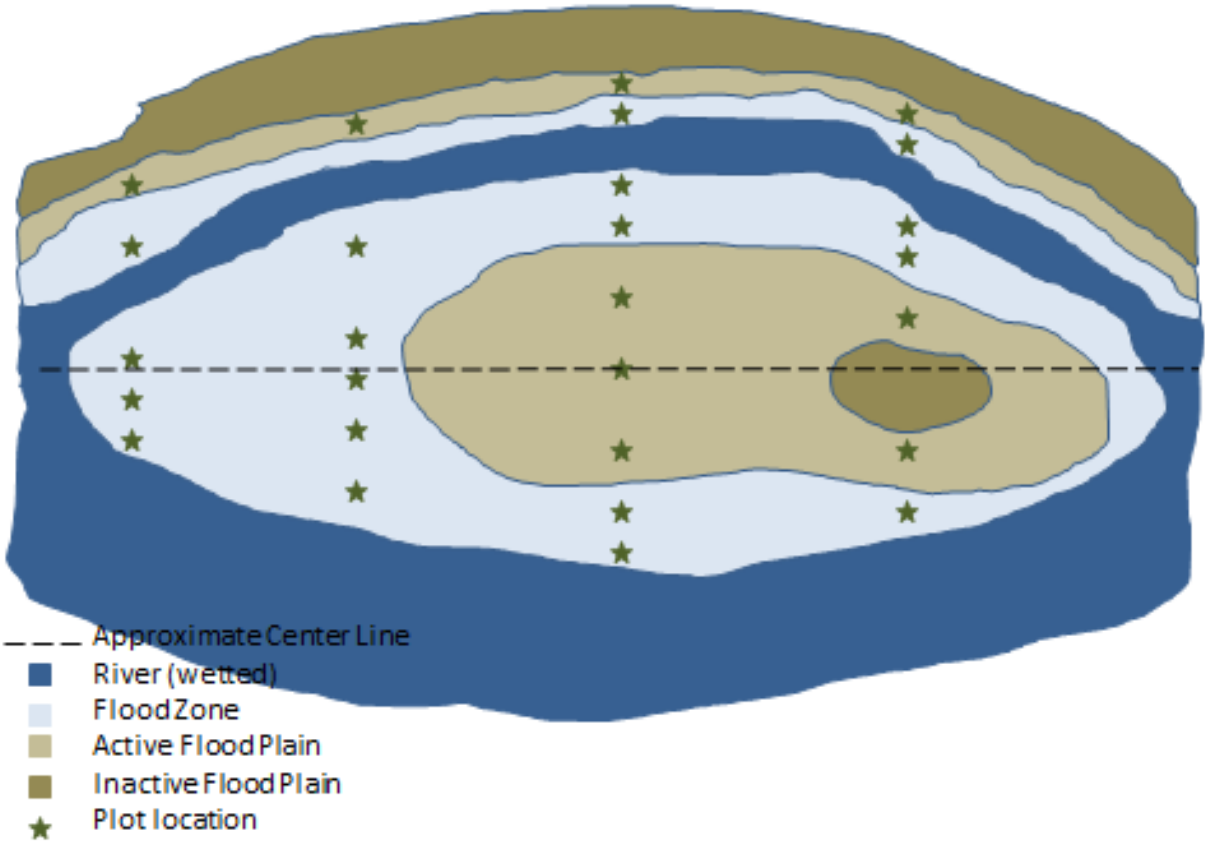

Figure 2. One sentinel site feature with geomorphic surfaces and plot locations (actual feature would have more plots).

2. Revisiting a Sentinel Site

2.1 BLCA

Relocating the transects

A. Before leaving the office, upload establishment survey data (control points, headpins, etc.) into datalogger.
B. Use the site description, topographic maps, GPSed coordinates and routes, and reference photographs to navigate to the sampling feature.
C. Use UTMs, azimuths, and reference photographs to locate the control points, transect headpins and associated orientation pins.
   - If the rebar is missing, use the total station and the establishment data to relocate the precise location rebar (stakeout to point).
   - If the headpin/control point/orientation point location is no longer available or has become unstable (e.g., active erosion zone, tree fall, etc.), establish a new location along the same azimuth as the previous headpin. If a headpin is moved, remove and relocate witness tree markers as needed.
   - Document the new headpin/control point/orientation point using the guidelines in Section 1.1.1F above.

D. Place a pin flag or flagging at the control points and headpins.
E. Check the length of the transect at establishment to make sure you are within 0.1 m of the original length during a re-visit.

F. Proceed as described in Section 1.1.2.

2.2 CANY and DINO

A. Before leaving the office, upload establishment survey data (control points, headpins, etc.) into datalogger.
B. Use the site description, topographic maps, GPSed coordinates and routes, and photographs to navigate to the sampling feature.
C. Use UTMs, azimuths, and reference photographs to locate the control points.
   - If the rebar is missing, use the information provided by the sources above to relocate the control point as accurately as possible.
   - If the control point location is no longer available or has become unstable (e.g., active erosion zone, tree fall, etc.), establish a new control point. If a control point is moved, remove and relocate witness tree markers as needed.
   - Document the new control point using the guidelines in Section 1.1 above.

D. Place a pin flag or flagging at the control points.

E. Because the vegetation plots are not permanent, new plots will be established every year based on the current geomorphology of the feature. Follow 1.2.2 for instructions to place approximately the same number of plots as the previous year.

F. Proceed as described in Section 1.2.F

References:

Montgomery, D.R. and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Report prepared for the SHAMW committee of the Washington State Timer/ Fish/ Wildlife Agreement. Report TFW-SH10-93-002.

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 5

Repeat Photographs

Version 1.11 (June 2014)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	8/8/2013	K. Lund	Edited data sheets & content regarding recording on photo data sheets	Clarification & efficiency of photo data sheets	1.1
1.1	6/3/2014	D. Perkins	Clarity and added overall feature photo section	This was not in the SOP before	1.11

This SOP provides instructions for taking photographs at each reach during vegetation sampling. Monitoring photos are taken at each transect headpin. Reference photos are taken as part of the sentinel site establishment (SOP #4).

Photo Points

Photos are taken using a digital camera. If a film camera must be used, procedures are the same, but the film-roll information is also recorded in the photo # column on the data sheet.

Fill out the top of the data sheet:

Park Code – The four letter park code

Site ID- The site designation:

- BLCA: EP = East Portal, RR = Red Rock Canyon
- DINO Yampa: DL = Deerlodge Park, HH = Harding Hole, LP = Laddie Park, EP = Echo Park
- DINO Lodore: LS = Limestone, SC = Seacliff

Feature ID – The feature ID number

Date – Use the format mm/dd/yyyy

1. Transect Photos - BLCA

Take transect photos from each end of each stub transect while the meter tape and/or tagline is stretched out along the transect.

A. Place pin flags at the ends of all transects. For the water's transect end, place the pinflag at the water's edge along the transect.

B. Label the chalkboard with the information below and lean it next to the rebar marking

the end of a transect.

Site – Park code and Site ID number (e.g., BLCA-EP)
Feature – The feature letter (e.g. A, B, C…etc.)
Transect # and side - i.e., #1-4 and R = river right, L = river left when facing downstream
Date – mm/dd/yyyy, e.g., 08/22/2010

If you are having difficulty propping up the chalkboard, use additional objects behind it rather than including field crew members or their body parts in the photos. You can also hang the chalkboard on vegetation.

C. Stand at the headpin of a transect, set the camera body on top of a fully extended laser monopod (1.5 m in height) or a 1.5m reference height on your body and point the camera down the transect.

D. Orient the camera so that it is rotated 90˚ and takes a vertical (portrait) format photo.

E. Check to ensure that the chalkboard is visible at the bottom of the field of view and the tape or tagline is visible in the middle of the photo. If a transect ends in the water, take photo from the temporary rebar location in the water with the chalkboard propped on the downstream side of the transect. Photographer shall have lifejacket on while in the water.

F. Take a photo and record the photo information on the Transect Photo data sheet (Figure 1):

Feature – The feature letter (e.g. A, B, C…etc.)
Transect # and side - i.e., #1-4 and R = river right, L = river left when facing downstream
Direction (facing) – direction the photographer is looking
Photo # - see directions below
Photographer – use first name initial and full last name
Location - Record the location of the photo point as 0 m on river right or as the meter location to the nearest 0.1 m of the transect end on river left.

Recording the Digital File Name

a. While the camera is in "play" mode, you will be able to view the number assigned to the photo. *Do not record this number*. This number changes when the photos are downloaded from the camera. Instead, use the following instructions to record the digital file name on the data sheet.
b. The last 4 digits of the number displayed on the camera (those following the dash) represent a unique photo number.
c. The template for the number you will record is P*mdd9999*, where P=photos, *m* = month (Jan – Sept are coded 1-9, Oct = A, Nov = B, Dec = C); *dd* = day (01-31); and *9999* = the unique number of the photo. For example, photo 0300 taken on October 1 would be recorded as PA010300.

2. Feature Photos (BLCA)

These photos are to monitor the overall geomorphic feature.

A. Make sure there are still pin flags at a meter mark near the water's edge of the most upstream transect and the most downstream transect. This meter mark should be the same as was used in previous years if possible. Remove the pin flags on all other transects.

B. On the furthest downstream end of the feature, stand at the pin flag on the streamward-end of the downstream-most transect. Looking upstream, center the camera on the pin flag at the streamward-end of the upstream -most transect. Photo needs to be taken at 1.5m height; can use a folding engineer ruler, an extended monopod, or a 1.5m reference height on your body. Orient the camera so that it takes a horizontal (landscape) format photo.

C. On the furthest upstream end of the feature, stand at the streamward-end of the upstream-most transect and center the camera on the pin flag at the streamward end of the downstream -most transect. Set the camera body on top of a folding engineer ruler or monopod extended to 1.5 m high, and point the camera downstream (Figure 2). Orient the camera so that it takes a horizontal (landscape) format photo.

D. Record the photo information on the Feature Photos data sheet:

Feature – The feature letter (e.g. A, B, C…etc.)
Taken from (US or DS end) – Use "US" for upstream and "DS" for downstream as where the photo is taken from
Direction (facing) – direction the photographer is looking
Photo # - see directions above
Photographer – use first name initial and full last name
Location - Record the approximate location of the photo point along the transect tape, which should be at a m mark.

E. If the feature has changed and the picture cannot obtain an adequate picture of the feature go to a meter mark that is closest to the river and take the picture. Record the meter mark and take all future pictures from this location.

3. Overall Feature Photos (BLCA, DINO, CURE, CANY)

These photos are taken from above the feature.

A. Initial Visit - The observer selects points where the entire feature or in BLCA, multiple features can be seen from one picture.
B. Take photo.
C. GPS photo location.
D. Take reference photos (see below) of the location where the photographer was located.
E. Repeat visits. Print out the overall feature photos as well as the reference photos that showed the location of the photographer. Use the GPS and reference photos to get to the location.
F. Use the previous year's photo to center the photo on the same place. When possible the

same time of day is desired.

4. Reference Photos (BLCA or DINO)

Take reference photos to document locations of all survey control, headpins, or other specific features or items that need to be located in the future. Include the cliff line, surrounding perennial vegetation, and/or other recognizable landmarks in the background to help the returning field crew relocate these points.

- Label a chalkboard with the park code, site ID, specific description of what is being photographed (i.e. CP1, G2LHP, etc.), river right or left, and direction facing (upstream [US], downstream [DS], right to left [R -> L], or left to right [L->R], etc.) (e.g., BLCA, EP, G1RHP, US). The date does not need to be included.
- Place the chalkboard in a location where it will be easy to read in the photo.
- Clearly mark the location of the control, headpin, etc. in relation to recognizable landmarks. This location should be marked by bright-colored pin flags, placed either in the soil at the point or held above the point where they will be visible in the photo. Unlike repeat photos, you may include anything in reference photos that may assist with re-locating the point (i.e., crew members, bright-colored flagging, etc.).
- Take a photo and check the quality. If the photo is blurry or otherwise not acceptable, delete it and take another one.
- Record the specific description, direction (facing), digital file name, photographer, and any comments on the Reference Photos data sheet. .

5. Other Photos

Crew members are encouraged to take other photos to document specific aspects of a reach or to provide scenic or fieldwork photos for publications. This information can be filled out on the bottom of the Transect and Feature Photo data sheets.

A. Fill in the type of photograph: archeology, disturbance, fauna, fieldwork, flora, scenic, or other.

B. Record the photo number, photographer, and a description of the photo.

Figure 1. Example transect photo taken from the transect end in the water looking towards the upland end of the transect.

Figure 2. Example feature photo taken from the upstream most transect with the pin flag placed at the water's edge of the downstream most transect being the center of the photo.

3. Photosynth (DINO and CANY)

These directions are modified from directions found on at www.photosynth.net (last accessed 12/14/2011) and will create a synth - stitched together photos by Photosynth.

A. Start by walking around the outside of the border (inactive floodplain) of the feature. It's important to get lots of overlap around a feature and to walk around it. You'll want to take a photo approximately every 15 degrees (Figure 1). Fifty to 100 pictures is not uncommon. Make sure that the center of the feature is in the middle of the picture, and that the picture frames the entire feature.

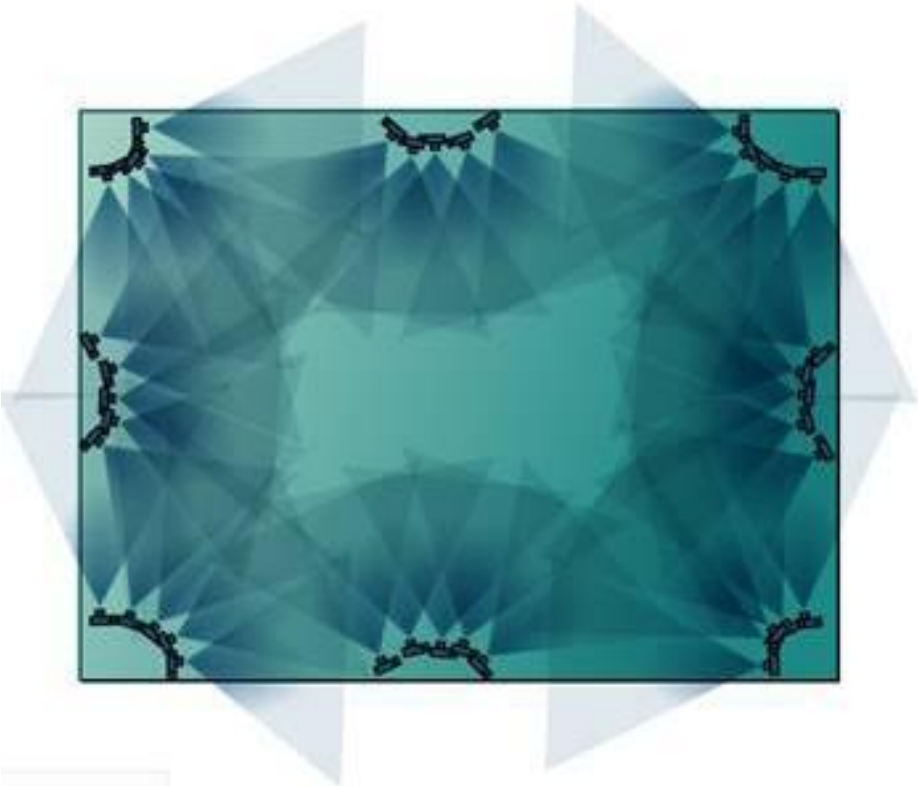

Figure 1. Depicts the number and angle of pictures necessary to get a feature covered with Photosynth.

B. Whenever possible make sure the most interesting parts of the synth can be completely seen in at least one image (i.e. control points). Make sure there's at least one photo that shows the control point and associated landmarks in the middle of the picture. The synther doesn't need that shot but users will appreciate the context.

C. Next go to the center of the feature, or a high point on the feature where you can see the entire feature. Standing in the center of the feature with your camera zoomed wide. Spin around, taking overlapping shots as you go. Make sure successive photos are overlapped by at least 50%. Depending on how wide your lens goes, you‘ll probably need to take 15-30 photos to go all the way around (Figure 2).

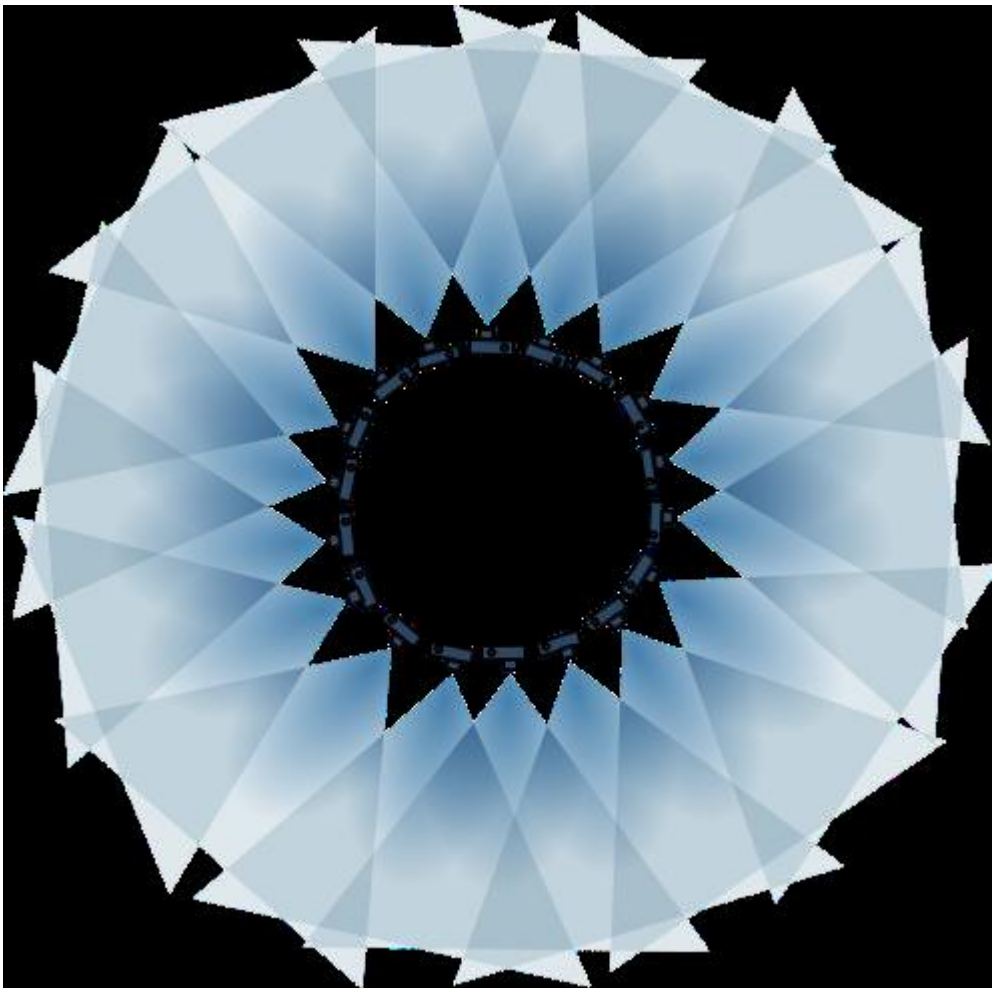

Figure 2. Pictures taken from the center of the feature.

Tips:

- Remember the “Rule of 3”. Each part of the feature you‘re shooting should appear in at least three separate photos taken from different locations. This rule means that you are going to shoot a lot more photos for a synth than you would for any other purpose.

- Panorama first, then move around. Start by taking a panorama of your feature, then move around and take more photos from different angles and positions. If you just do a panorama you won‘t end up with a good 3-D experience.

- Have lots of overlap when shooting panoramas. Try for at least 50% overlap between photos.

- Limit the angles between photos. When moving around objects, try to get one photo every 25 degrees or so. That will make the synth work better. Larger angle differences on a subject won‘t match up.

- Don’t crop images. It confuses Photosynth.

- Shoot wide shots. Wide angle shots (photos taken from farther away, or with your camera‘s lens zoomed all the way out) reconstruct more reliably than closer shots. It‘s good to have close-ups, too, but you‘ll want to have good coverage of your subject with lots of nice overlapping wide shots.

- Orientation. Make sure your photos are all right-side-up before you start synthing.

Transect Photos

Data entered by:

NCPN Big River Monitoring

Park: **Site ID:** **Date:**

Feature	Transect	Direction (facing)	Photo #	Photographer	Location (m)

Other photos

Type	Photo #	Photographer	Description

Type = archeology, disturbance, fauna, fieldwork, flora, scenic, other

Feature Photos

Data entered by:

NCPN Big River Monitoring

Park: **Site ID:** **Date:**

Feature	Taken from (US or DS end)	Direction (facing)	Photo #	Photographer	Location (m)

Other photos

Type	Photo #	Photographer	Description

Type = archeology, disturbance, fauna, fieldwork, flora, scenic, other

Reference Photos

Data entered by:

NCPN Big River Monitoring

Park: **Site ID:** **Date:**

Specific description	Direction (facing)	Photo #	Photographer	Comments

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) #6

Measuring Vegetation

Version 1.02 (October 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	8/15/2012	H. Thomas	Updated BLCA vegetation sampling instructions and data sheet.	To reflect new version of vegetation sampling data sheet.	1.01
1.01	10/1/2012	D. Perkins	Updated BLCA vegetation sampling instructions and data sheet. Added percent cover of fines for BLCA, CANY & DINO.	To reflect changes in vegetation sampling. For BLCA, plot size changed from 1 x 1 m to 2 x 0.5 m.	1.02

This SOP describes methods used to conduct vegetation sampling at a sentinel site feature. At BLCA vegetation sampling includes cover of indicator species along permanent repeated cross-sections in a 2-m belt. At CANY and DINO vegetation sampling includes cover by species in non-permanent 1 m^2 quadrats. Plant walks to detect species are done at all three parks.

After transect and plot establishment, vegetation sampling can generally be done by one person in an equivalent time to geomorphology surveying by three people. If available, a two-person team comprised of a data recorder and an observer skilled in plant identification can efficiently complete the tasks described below.

Canopy cover is done by visually estimating the percentages of vegetation within a 1x1m plot. Train crew members on visual estimation techniques and calibrate everyone together frequently to ensure data consistency.

Visual estimation is based on a plan view projection of outline polygon of plant. Stand over the plot to get a proper view of the species within a plot.

For all vegetation sampling, record the full Latin name of each species the first time it is encountered at a reach. Any additional times the species is encountered, use the six-letter code composed of the first three letters of the genus and specific epithet.

1. Two Meter Belt Transects - BLCA

A. Fill out the top of the data sheet including:

Park Code: Use the standard 4-letter code to indicate the park unit.
Site ID: A pre-assigned, unique code provided for each site (i.e. EP for East Portal).
Date: mm/dd/yyyy
Feature: the letter of the geomorphic feature
Transect: 1-4, downstream to upstream.
Observer: Record the initials of the person calling out the intercept data if applicable.
Recorder: Record the initials of the person recording the data.

B. Fill out the Tag Line Measurements at the top of the data sheet:

Height above head pin at 0: Record the the distance the tagline is suspended above or below the top of the headpin.

Height above water at river stake: the distance the tagline is above the surface of the water where it is anchored to the rebar set in the river. Both these measurements can be positive (above the headpin / water) or negative (below headpin /water).

Line distance of river stake: Record the total length of the tag line; this measurement is made with a carpenter ruler to measure the distance between the last known meter mark to the river stake.

Line distances at slope changes: Record the line distances (m) of any sharp changes in slope. Line distance at slope changes is the distance from the headpin where the tagline bends. Usually the tagline is set such that it is a straight line from headpin to river stake. At times, however, the line bends over vegetation or ground surfaces, particularly over sections of steep slope. These bends "stretch out" the tagline over a flat line distance. To normalize this stretched out line distance to a flat line distance, we measure not only the line distance at all slope changes, but also how far the tagline is from the ground at this slope change.

C. Line Distance: The 2-m belt transect is surveyed in a series of 2m by 0.5 m plots centered on the transect. Starting at the river right headpin (0m), center the plot frame on the tagline, moving from uplands towards the stream. Record the line distance of the plot location by documenting the starting distance along the transect tape ("DistUp (small)") and ending distance ("DistRiv (Large)") on the datasheet.

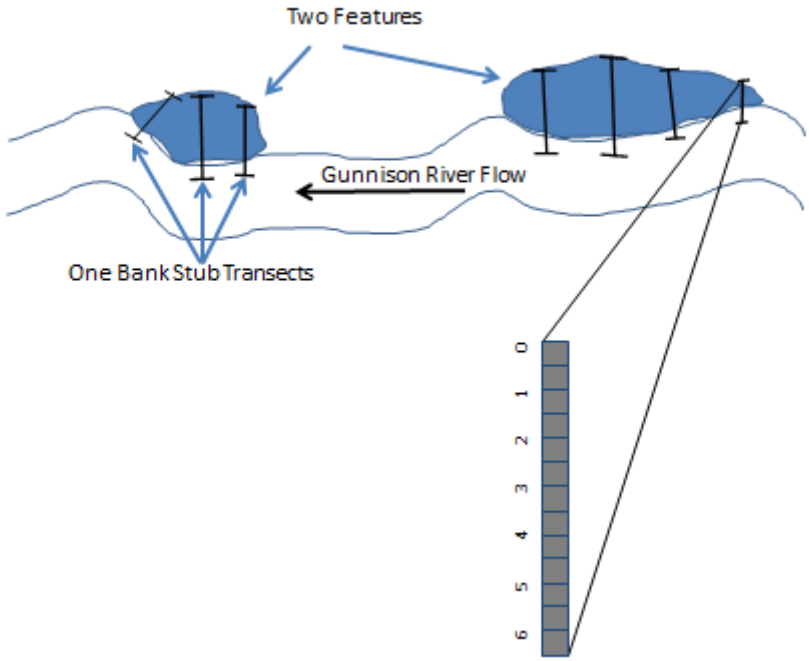

Figure 1. Two features and associated one bank stub transects with plot layout along continuous belt transect.

D. Modal Sediment Size (SedMode): Record the modal particle size (Wentworth scale) by visually estimating a plan view projection of substrate within the plot. Estimate the substrate size with the largest fraction of plot by area, not average (e.g. if plot has 25% sand, 30% gravel, and 45% boulder, the modal particle size would be boulder). Look at the diameter of the intermediate axis of the particles. Do not include litter or organic matter. Write down the corresponding code based on the Modified Wentworth Scale.

Modified Wentworth Scale		
Class Size range	**Code**	**Diameter (mm)**
Sand, silt, clay	S	<=2
Fine Gravel	FG	>2 to 4
Medium Gravel	MG	>4 to 8
Coarse Gravel	CG	>8 to 16
Small Pebble	SP	>16 to 32
Large Pebble	LP	>32 to 64
Small Cobble	SC	>64 to 128
Large Cobble	LC	>128 to 256
Boulder	B	>256 to 512

Bedrock, Hardpan	BED	>512

E. Percent Sand/Fine (% sand or finer): Record the percent cover of the plot that is sand or finer.

F. Understory (Rooted) Cover: Record the percentage of total plant cover rooted in the plot (any species below 1.5 m), regardless of species, to nearest 5%. Record a "T" for trace percentage. Visually estimate a plan view projection from 1.5 m down of outline polygons of plants. Pool all live plant species and do not count dead plant parts. Do not double-count overlapping areas of cover below 1.5 m (i.e., 100% is max overall plot cover below 1.5 m). This measurement will continue into the inundated channel recording total plant cover of rooted or attached macrophytes and filamentous algae (long enough to move with current, about ½ cm).

G. Plot Density (1/4, 1/2, 1/1) at Beginning and End of Zone: Record the fraction of plots sampled (1/4, 1/2, 1/1). To avoid bias in sample size of vegetation plots that experience inundation under a range of flow rates, we adjust plot density along transects. Without a variable plot density, flatter areas, which represent a narrow range of flow rates, would be sampled more heavily than steeper areas, which experience a wider range of flow rates per linear distance. We use three different plot densities: 1/1 is one plot every half-meter, 1/2 is one plot every meter, and 1/4 is one plot every two meters. Elevation and slope are the primary factors to consider when choosing the appropriate plot density for a plot along a transect. We use a plot density of 1/1 on steep slopes to capture more plots at these different elevations; this would be slopes approximately greater than 20-25%. 1/2 plot density can be considered the standard plot density, which would be used for slopes between 2% and 20-25%. On terrain with a slope of 2% or less, we can use 1/4 plot density. For example if you did every plot, then record 1/1. If you did every other plot, then you would record 1/2.

H. Woody Canopy Cover: Record the percentage of live woody canopy cover by species (above 1.5m) to the nearest 5%. Record a "T" for trace percentage. Visually estimate plan view projection of outline polygon of plant regardless of where plant is rooted. Record by 6-letter code for the species on data form. Each unique species should be recorded separately. Be sure to look overhead for tall vegetation that might be present. Do not count dead woody canopy. Do not double-count overlapping areas of a single species (i.e., 100% is max for an individual species). Filamentous algae cover (code FA) is recorded as if it were a canopy woody species.

I. Understory (Rooted) Species Presence in Vegetation Plots: Record indicator species presence in each plot by writing a "1" for presence and "0" for absence [if obsessive-compulsive]. Make a definitive entry in row ***None*** if none of the indicator species are present (to distinguish from a missed plot). List of indicator species is:

ACENEG (*Acer negundo*)
Agrostis stolonifera
Artemisia ludoviciana
CIRARV (*Cirsium arvense*)
Eleocharis palustris
Epilobium ciliatum

Equisetum hyemale-laevigatum
Euthamia occidentalis
Filamentous Algae (FA)
Melilotus alba-officinale
NONE
PHAARU (*Phalaris arundinacea*)
POPANG (Populus angustifolium)
Rhus trilobata
SALEXI (*Salix exigua*)
TRAIL
Verbena bracteata
Veronica anagallis-aquatica
VERTHA (*Verbascum thapsus*)

J. If there are more than 2 botanists, at least once per day cross calibrate on cover and particle size estimates including some recorded replicate measurements.

K. In field book record all plant species observed in bottomland of site (e.g., East Portal), noting dates and approximate time spent looking.

2. One Meter Square Plots – DINO and CANY

A. Fill out the top of the data sheet including:

Park Code: Use the standard 4-letter code to indicate the park unit.
Site ID: A pre-assigned, unique code provided for each stream reach.
Feature ID: A unique code for the geomorphic feature.
Observer: Record the initials of the person calling out the plot data if applicable.
Recorder: Record the initials of the person recording the data.
Date: mm/dd/yyyy

B. Vegetation surveying will consist of randomly locating 50 to 100 (layout described in SOP 4), 1 m x 1 m plots on both the flood zone and the active flood plain. Pre-labeled pinflags will be marking the location of veg plots. The pinflag will be the center of the plot.

C. Visually estimate vegetation cover using a plan projection of the outline polygon of each unique species rooted within a plot. For tree species (*Acer, Populus, Salix, Tamarix*), individuals that are over >1m tall are recorded as separate species from those =<1m tall. Record to the nearest 1%.

D. Record modal particle size (Wentworth scale) – See 1.D (above) for instructions.

E. Record percent of plot inundated with water.

F. If there are more than 2 botanists, at least once per day cross calibrate on cover and particle size estimates including some recorded replicate measurements.

G. After all belt plots are done on a feature conduct a 30-60 minute timed search for the presence of additional species. Record the beginning and end time of the search. Make a list of all species.

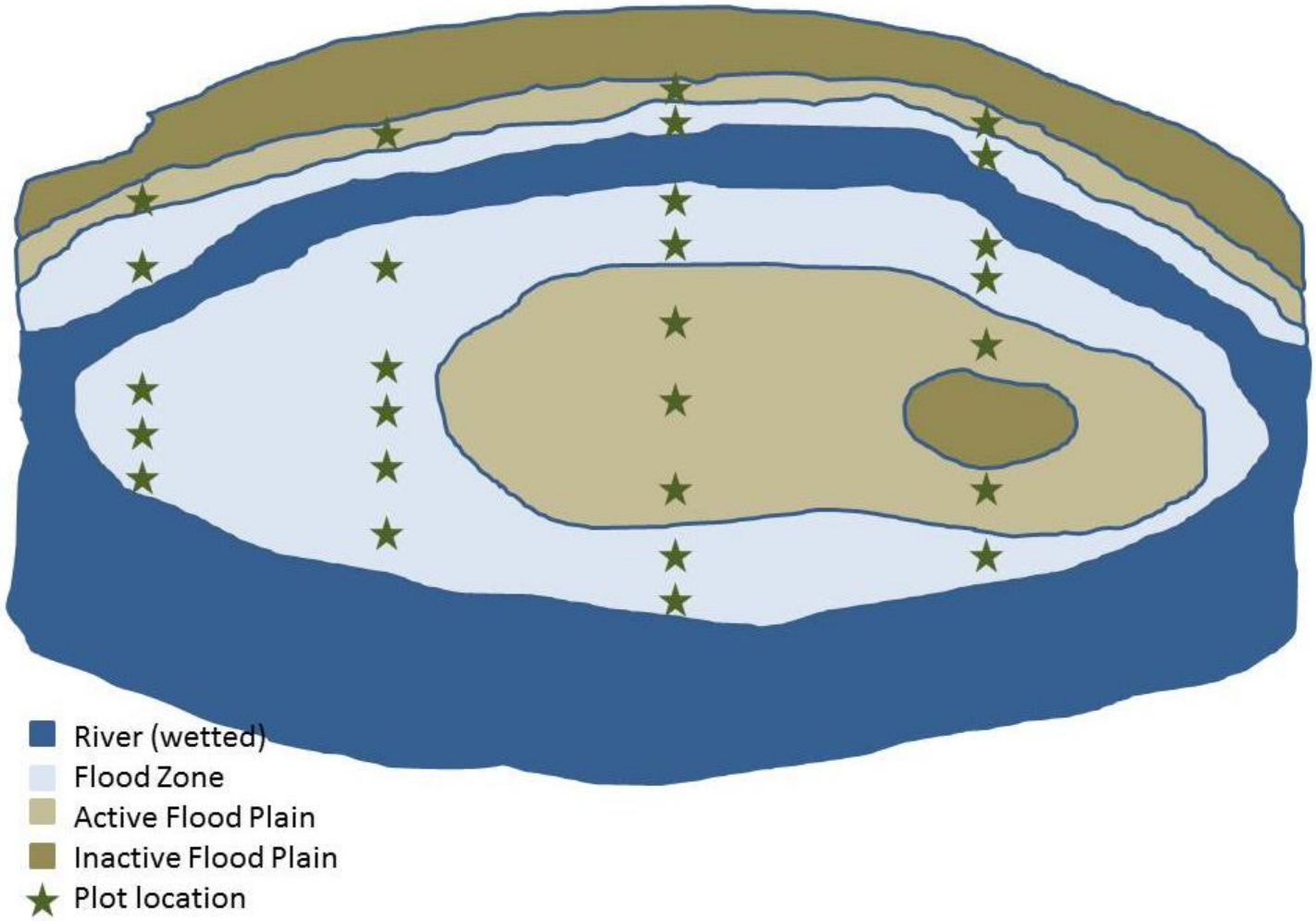

Figure 2. One feature with geomorphic surfaces and plot locations (actual feature would have more plots).

3. Unknown Plants

Sometimes it may be difficult or impossible to determine the specific identity of individual plants encountered during sampling. Crews may be unfamiliar with a plant or unable to distinguish one species from other similar species at the time of sampling. Before sampling, review previously collected unknown species from the stream and use existing unknown names whenever possible.

When an unknown plant is encountered

A. Search the immediate area surrounding the point or transect, looking for specimens of the unknown plant that are more readily identifiable (i.e., due to the presence of flowers or fruits from current or previous seasons).

B. If an identifiable specimen cannot be found, create a unique name using the following code: unk + 4 letter park code + reach number + your initials + collection number for the

reach (e.g., unkZION-P1-ST1). Record this code in the appropriate column on your vegetation sampling datasheet instead of the species name.

C. Take a photograph of the unknown plant.

D. As you proceed through the reach, continue to attempt to find identifiable specimens of unknowns.

E. It is permissible to identify a plant only to the genus level if no identifiable parts are present for keying, or if hybridization makes species delineation difficult. Record the full Latin name of the genus followed by "sp." (e.g., *Opuntia* sp., *Tamarix* sp., etc.).

Collecting unknown plants

Once it has become apparent that no identifiable plants can be found or that a plant with identifiable features cannot be keyed out in the field, a collection of the plant should be made.

A. Collect specimens from outside of the monitoring transects whenever possible.

B. Attempt to collect as many identifiable parts as possible, including flowers, fruits, leaves, and roots. It is especially important to collect roots of forbs and grasses. You may need to collect from more than one plant to achieve this goal.

C. If you must collect from a monitoring feature, remove only a minimal amount of plant material. Do not remove roots of perennial species that are collected within the transect.

D. Wrap a piece of masking tape around the plant and use a fine-point Sharpie to label it with the unknown species code.

E. Carefully place the specimen inside a resealable plastic bag labeled with the reach number, unknown species code, date, and collector.

F. Place the sample in your backpack and in a shady spot until you get back to camp. Attempt to identify the plants when you return to camp.

G. If the specimen cannot be identified right away, preserve the bag in a cooler as soon as possible. Make sure the specimen does not get wet. If a cooler is not available, press the plant between two sheets of newspaper.

H. Fill out an unknown species datasheet for each specimen. It is especially important to fill out datasheets for specimens that do not have identifiable characteristics in this sampling year, but may be identified in future years.

Datasheets

When filling out the datasheet, give a detailed description of each characteristic. This allows greater potential for future identification when crews return to the site. Fill in the top of the data sheet and record the following information:

- **Unknown Code:** unk + 4 letter park code + reach number + your initials + collection number for the plot (e.g. unkZION-P1-ST1).

- **Plant type and General Description:** Circle the appropriate categories and provide a succinct description of the overall appearance (e.g., tiny *Eleocharis*).
- **Most Salient Feature:** A unique characteristic that identifies the plant from others.
- **Leaf Characteristics (optional):** Describe the leaf type, leaf margin, leaf surface, petiole, etc.
- **Stem Characteristics (optional):** Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.
- **Flower Characteristics (optional):** Describe the floral formula, location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.
- **Microhabitat Characteristics:** Describe the microhabitat in which it was found if unique on the plot (e.g., wash bottom, limestone outcrop, etc.).
- **Collected:** Circle yes or no, whether a specimen was collected.
- **Best Guess:** Preliminary guess about species in field.

Annotating datasheets

When updating data collection data sheets with identified plants, draw a line through the unknown code and write in the correct species code in the nearest available space. Initial and date the change on the datasheet.

BLCA Vegetation Data Sheet

Park: _____		Date: _____					Feature: _____					Page ____ of ___			
SiteID: _____		Observer:____		Recorder:____				XS: _____				within this XS-Feature			
Tag Line	Height above head pin at 0: _____							Line distances at slope changes							
Measurements	Height above water at river stake:_____									_____				_____	
	Line distance of river stake:_____									_____				_____	
DistUp (small)															
DistRiv (Large)															
SedMode															
% sand or finer															
Understory (rooted) cover															
Plot density (1/4, 1/2, 1/1) at beginning and end of zone															
Woody Canopy Cover by sp and Filamentous Agae															
filamentous algae (FA)															
NONE															
Understory (rooted) SPP Presence															
ACENEG															
Agrostis stolonifera															
Artemisia ludoviciana															
CIRARV															
Eleocharis palustris															
Epilobium ciliatum															
Equisetum hyemale-laevigatum															
Euthamia occidentalis															
Filamentous Algae (FA)															
Melilotus alba-officinale															
NONE															
PHAARU															
Rhus trilobata															
SALEXI															
TRAIL															
Verbena bracteata															
Veronica anagallis-aquatica															
VERTHA															

DINO Vegetation Data Sheet

Sentinel sites - DINO **DATE:** **OBS:** **REC**

Park:	**Site:**				**UTM:**						
PLOT #:						**PLOT #:**					
GEO. SURFACE TYPE:						**% Fines**					
% cover by species:						**% cover by species:**					
Acer negundo seedling						Juncus bufonius					
Agrostis stolonifera						Juniperus sp seedling					
Alopecurus aequalis						Lactuca serriola					
Alyssum desertorum						Lactuca tatarica					
Ambrosia tomentosa						Lepidium latifolium					
Apocynum cannabinum						Melilotus officinalis					
Argentia anserina						Mentha arvensis					
Aristida purpuria						Muhlenbergia asperifolia					
Artemesia drancunculus						Oenethera biennis					
Artemesia ludoviciana						Panicum capillare					
Asclepias speciosa						Pascopyrum smithii					
Aster ascendens						Phragmites australis					
Betula occidentalis						Plantago major					
Bromus inermis						Poa compressa					
Bromus japonicus						Poa fendleriana					
Bromus tectorum						Poa palustris					
Carex emoryi						Poa pratensis					
Carex sp.						Polygonum amphibium					
Celtis reticulata						Polygonum lapathifolium					
Chamaesyche glyptosperma						Polygonum persicaria					
Chamaesyche serpyllifolia						Polygonum spp					
Chenopodium glaucum						Polypogon amphibium					
Chenopodium rubrium						Populus fremontii seedling					
Chenopodium sp.						Potentilla sp.					
Chrysothamnus linifolius						Psoralidium lanceolatum					
Chysothamnus nauseosus						Ranunculus cymbalaria					
Cirsium arvense						Ranunculus testiculatus					
Cirsium undulatum						Rhus aromatica					
Cirsium vulgare						Rorripa tenerrima					
Clematis lligusticifolia						Rumex crispus					
Conyza canadensis						Rumex maritumus var. fueginus					
Crypsis alopecuroides						Salix exigua seedling					
Distichlis spicata						Salsola tragus					
Echinochloa crus-galli						Schizachyrium scoparium					
Eleocharis palustris						Schoennoplectus americanus					
Elymus canadensis						Schoennoplectus pungens					
Elymus elymoides						Scirpus microcarpus					
Elymus glaucus						Scirpus pungens					
Elymus lanceolatus						Solidago canadensis					
Elymus repens						Solidago sp					
Elymus sp						Soncus asper					
Elymus trachycaulus						Soncus sp.					
Equisetum arvense						Spartina pectinata					
Equisetum hyemale						Sporobolus cryptandrus					
Equisetum laevigatum						Stipa comata					
Eragrostis hypnoides						Stipa hymenoides					
Euthamia occidentalis						Tamarix ramosissma seedling					
Glycyrrihza lepidota						Taraxicum officinale					
Gnaphalium palustere						Trifolium repens					
Grindelia squarrosa						Verbascum thapsus					
Helenium autumnale						Veronica anagagallis-aquatica					
Heterotheca villosa						Xanthium strumarium					
Hordeum jubatum						Unknown					
Iva axillaris											
Juncus arcticus											
Juncus arenaria						Dominant Particle Size					

Timed Plant Walk | Data entered by:_____ | Data verified by:_____

NCPN Big River Monitoring

Park Code: _____ | Site:_____ | Date:_____/_____/_____

Feature: _____ _____ | Observer:_____ | Recorder:_____

Start Time: _____ | End Time:_____

Species found:

Unknown Plant Species

Data entered by: Data verified by:

NCPN Big River Monitoring

Park Code: **Reach ID:** **Date:** **Collected by:**

Transect: 1 2 3 4 5 6 7 **Position on transect (m) / method:** **Photo #s:**

Unknown species code: _____

Plant Type & General Description: *tree* *shrub* *grass* *forb* *other*_____

Forbs and grasses: *annual* *perennial*

Perennial Grasses: *bunchgrass* *rhizomatous*

General Description:

Most salient feature:

Leaf Characteristics (optional):

Leaf Type: (compound/simple, arrangement, etc.)

Margin:

Other: (pubescence, sap, stipules, etc)

Stem Characteristics (optional): (shape, pubescence, bud)

Flower Characteristics (optional): (color, location, floral formula)

Microhabitat Characteristics:

Collected: *Yes* *No*

Best Guess:

Confirmed to be:

Identified by: Date:

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) #8

Surveying

Version 1.00 (April 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP gives detailed instructions for surveying the stream channel using a total station and post-processing survey data after returning from the field. A list of necessary equipment for these procedures can be found in SOP #1.

A three-person team comprised of a survey lead and two rod persons can efficiently complete the tasks described below. The survey lead should be skilled in total station operation at remote field sites and have experience with rod duties (i.e. running rod) and post-processing survey data.

1. Surveying

1.1 Establishing the survey layout

A. Locate headpins (BLCA only) for all transects, control points and benchmarks. Mark with pin flags and flagging.

B. Identify potential instrument setup locations, including occupied points and backsight positions. The survey lead should determine these locations with the help of one of the other crew members to check lines-of-sight. Make sure to describe these locations in the field notes.

Survey field notes (see Figure 1 for an example)

- Record the date, park unit, ReachID, field crew members and their duties (i.e. total station operator or rod crew), scale factor, and general notes (foliage present, weather conditions, etc.).
- Record all rod heights before the survey begins.
- Make a list of surveyed control points including detailed descriptions of all occupied points, backsights, and reference marks shot during the survey.
- Document instrument and backsight heights for each occupied position.
- Record the numbers of the photos taken at each control point and reference mark.

- Record stub transects and stream profile points. These may be grouped in your notes since details of every point are stored in the datalogger.
- List all errors made during the survey so they can be corrected later (e.g. mis-naming of points and rod height errors).
- Define all codes that are not established in Table 1 of this SOP.
- Sketch the reach including relative locations of transects, reference marks, instrument setups, and the riparian corridor.

Table 1. Definitions and abbreviations for survey terminology.

Survey terminology	Code	Definition
Occupied point	OP	Points occupied by the total station during a survey
Backsight position	BS	A measurement taken back towards a point of known elevation (or arbitrary elevation entered in the total station), or a point previously occupied by the total station used to maintain survey control
Control point	CP	Monumented occupied point,backsight location, or a monumented point used to maintain control in survey
Reference marks	RM	Other points used as controls that are not monumented or used as instrument setups (e.g., bedrock, boulder, benchmark, etc.)
Instrument height	HI	Height of the total station above the top of the rebar marking an occupied point
Rod height	HR	Height of prism rod from the bottom of the rod to the center of the prism (to the nearest millimeter)
Top of headpin	XSTOP	Shot taken with the rod on top of the headpin. For BLCA, include feature letter, transect number, RHP or LHP (right or left headpin) and number on rebar in description.
Headpin ground surface	XSGS	Shot taken with the rod on the ground surface next to each headpin. For BLCA, include feature letter, transect number, RHP or LHP (right or left headpin) and number on rebar in description.
Bankfull elevation	BF	Shot taken with the rod at bankfull elevation
Edge of water	W	Shot taken with the rod at the edge of flowing water
Cross-section transect points	XS	All other points shot along each transect, including shots taken at 1-m intervals and at surface breaks. Include feature letter and transect number in code (BLCA).
Thalweg length	TL	Shots of the thalweg
Channel Unit Perimeter	U	Point describing channel unit perimeter within the wetted channel, also describes the wetted channel topography.
Channel Topography	TOPO	Points describing the channel topography.
Maximum Depth	MAX	Points describing the maximum depth of slow-water channel units.
Tail Crest Depth	TC	Points describing the tail-crest depth of slow-water channel units.
Toe of Bank Line	TOE	Points making lines describing the toe of bank line, or the line separating the flood zone from the beginning of the

		bank.
Flood zone	AC	Boundary of the active channel
Active Floodplain	AFP	Boundary of the active flood plain
Inactive Floodplain	IFP	Boundary of the inactive flood plain.
Extent of survey	BIFP	Points making lines describing extent of the survey, beyond inactive floodplain.
High Water	HW	High water mark when it can be determined for the year that the survey is occurring.

C. Monument the initial occupied point and backsight position. Flag the area around the instrument setup for easy visibility while surveying. The initial backsight will ideally be the second occupied point.

Monuments

All permanent monuments must be cleared ahead of time with the park unit. Check to see what is permitted before you leave for the field. Permanent monuments are typically established with 0.5-m lengths of 3/8" rebar. Place an aluminum cap on top of the rebar stamped with NCPN, the FeatureID, and the appropriate code for the control point.

Date: Park: ReachID: Crew: Scale factor: Conditions:

Point no.	OP	BS	Notes	# of rods	RHs (m)
1	CP 1		rebar with aluminum cap "CP1", HI = 1.452 m	1	1.853
2		CP2	high point on boulder ~210 m DS of CP1; valley left; 4 m up on bench	2	3.054
			(photos- P8090402, P8090403, P8090404) --shot with rod	3	etc.
3			RM 1 is the obvious knob on a grayish 10-ft boulder on valley right	4	
			~60 m US of CP1 (photos- P8090405, P8090406, P8090407)	5	
100-152			XS1 starting at left pin	6	
153-206			profile from DS of XS 1 through XS2		
TURN TO CP3					
4	CP3		high point on reddish, flat 12 ft x 5 ft x 8 ft boulder, valley left, at base of bluff		
			(photos- P8090408, P8090409, P8090410, P8090411), HI = 1.530 m		
2		CP2	setup tripod BS; RH = 1.278 m		
5			re-shot RM 1		
6			RM 2 is the high point on oblong reddish boulder, valley right, ~120 m DS of CP3. Boulder is		
			~4 ft x 4 ft x 6 ft, near bases of 3 much larger, whiter boulders (photos- P8090412, P8090413, P8090414). HI = 1.530 m		
210-264			profile from XS2 through XS4		
260			2 RH not 4		
265-304			XS2 starting at right pin		
305-348			XS3 starting at right pin; incomplete; flagged for completion from CP4		
TURN TO CP4…					

Codes
DS = downstream
US = upstream

Figure 1. Example of survey field notes. Codes are defined in Table 1.

D. Locate control points that will be monumented with rebar and a stamped cap. These are best located so at least two (preferably 3) can be seen from multiple instrument locations with at least one (preferably 2-3) points in common. Any benchmarks located near the reach should be used ascontrol points. Make sure to describe these in the field notes.

E. Locate at least two reference marks. These are best located on natural features (i.e. highpoint of very stable boulders, bedrock, etc.). Reference marks provide a control on survey precision and are used to triangulate positions if control points are lost. Make sure to describe these in the field notes.

F. Take reference photos of each control point and reference marker looking upstream and downstream. The photos should include 1) a few shots with enough background topography for anyone returning to the reach to find the approximate location, and 2) at least one close-up of the precise position of the point.

G. Record the location of each control point and reference mark using the highest grade GPS unit available at the highest precision possible. These will be used to translate and rotate the survey data into real-world coordinates.

The next section describes steps to set up the total station, datalogger, and backsight. Most of these steps are performed by the survey lead while the rod crew members run the tagline (BLCA) or lay out plots (DINO and CANY) (see SOP#4 for instructions), install monuments, take photos, and hold the rod for any control shots.

A. Set up the total station at the initial occupied point, using standard leveling procedures. Measure the height of the instrument (HI), to the nearest millimeter, from the top of the permanent rebar to the horizontal axis indicator mark on the side of the instrument. Document how the measurement was obtained in the field notes.

B. Measure the height of each rod, to the nearest millimeter, from bottom of rod to center of prism. Make sure that prisms are set so that the heights of both rods are identical. Always raise the rod from the top section (the smallest rod), followed by the next-to-top section, etc. Document rod heights in the field notes (e.g., 1HR = 1.768 m, 2HR = 2.987 m, 3HR = 4.151 m…6HR = 7.680 m). If rod heights are changed during survey, the rod person will immediately notify the survey lead.

C. Set up the backsight in the initial position. If the backsight will be established with a tripod/tribrach/prism, set up the tripod and tribrach using standard leveling methods. Measure the height, to the nearest millimeter, from top of the permanent rebar to the center of the prism. If the backsight will be established using a rod and prism, make sure it can be shot at a single rod since higher rods are less precise.

D. Turn on the datalogger and open Survey Pro. Turn off all unnecessary features in the datalogger and make sure is set to automatically shut off. You may run the Spectra Precision Ranger datalogger until it runs out of power since it automatically saves and backs up the data. Losing power will not impact saved data or configurations other than the real time clock.

E. Set the initial parameters for the survey. In File, select Open to open a file from a previous survey or New to begin a new survey. Enter the following information:

- Default units
  - Azimuth Type: North Azimuth
  - Units for Distances: Meters
  - Units for Angles: Degrees
  - Do not check Adjust for Earth Curvature / Refraction
  - Do not check Use Scale Factor.
  - Make sure prism constant in datalogger matches prism (our's is -30mm; printed on the actual prism). Do not set prism constant in gun.
  - Click Next.
- Enter First Point
  - Point Name: 1
  - Northing: 5000.0 m (Y coordinate)
  - Easting: 5000.0 m (X)
  - Elevation: 1000.0 m (Z). *Note: the initial survey at each reach establishes an arbitrary coordinate system that is translated and rotated into UTM coordinates during post-processing in the office.*
  - Description: Enter code/description of point you're shooting (i.e., CP1).

F. Go to Job to adjust additional settings. Under Settings, choose between Bluetooth (wireless option) or using the manual cord to connect to the total station. If you need to look at a point later in the survey, you can also do this under Jobs, Edit Points.

G. Enter the instrument location set up information. Go to Survey, then Station Setup, and enter the following:

- Setup Type
  - Known Point: Setup at a point with known or assumed coordinates.
  - Unknown Point/Resection: Setup at an unknown location by observing 2 or more known points.
- Occupy Point: Enter the code for this point.
- Do not check the 2D survey box.
- Enter HI (Instrument Height)
- Do not click Remote Elevation.

The Information Box displays previously entered assumed coordinates. Click Next after you finish entering the information.

H. Enter the backsight settings in the datalogger.

- Select one of the following:
  - New Point: Observe and store a new reference point for orientation
  - BS Point: Use an existing point for a reference. This is generally used after starting the survey and backsighting to a known location that was already shot.

  - BS Azimuth: Orient along an assumed reference azimuth. This is generally used when shooting the first backsight at the beginning of the survey. A compass is used to get the general bearing (i.e., 0, 90, 180, etc. degrees).
- Choose one of the following:
  - Fixed Target: Use a dedicated target for the backsight, usually on a tripod.
  - Roving Target: Use a single target for both the backsight and the foresight, usually a rod and prism.
- Enter the rod height (HR).

I. Perform the backsight circle. **The total station needs to be on the record screen (not the bubble screen) to take readings. Use the yellow REC/ENT button on the instrument to go to the correct screen.** Sight the backsight prism precisely on the center. If a rod is used to shoot in the backsight, use the total station crosshair to ensure that the prism is on a precise vertical line above the backsight point and a rod level to ensure front-to-back leveling. Make sure that the crosshairs visible through the total station sight are sharp and dark to reduce parallax.

- In the datalogger, click Read Circle. An acceptance sound indicates that this is complete.
- Click Send Circle. Wait for the acceptance sound.
- Click Next.
- Station Check: Use this to check errors before continuing with survey.
  - Choose from three options: By Distance, By Angle, or By Point to check for errors and double-check the station set-up. Do not continue if errors are outside the acceptable range. Stop and remedy the problem.

Acceptable errors

Horizontal (includes the northing and easting): 0.000 - 0.030 (3 cm).
Ideally, it is best to have < 0.020 (2 cm) error.

Vertical (includes elevation): 0.000-0.010 (1 cm).
Ideally, it is best to have <0.005 (0.5 cm) error.

This is the process for setting the total station angle to zero (i.e., zeroing the instrument). **Make no changes along the horizontal axis once the total station has been zeroed**.

J. Now the actual location of the backsight can be established. Go to the "Traverse/Sideshot" menu. The foresight number should automatically be set to "3." Make sure that the height shown on the screen is the same as the tripod or rod height at the backsight. Enter a description (e.g., BS1 = CP2), and shoot the point as a sideshot. Return to the backsight setup screen. Change the backsight point to "3." Rerun the two backsight checks described above. Both the horizontal and vertical distance errors should now be 0.000.

G. Shoot all the control points or reference markers next. Make sure that all control shots are documented in detail in the field notes.

H. Begin the rest of the survey.

1.2 Surveying transects - BLCA

Shots along each transect are taken at 1) one-meter intervals marked on the tagline, 2) slope break points that provide an accurate depiction of topography (see Figure 2), and 3) the edge of the water.

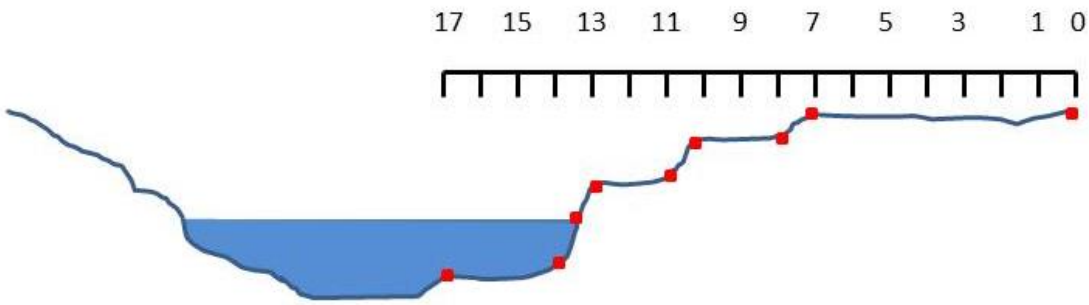

Figure 2. Example of slope breaks points (red) and one-meter intervals (black) surveyed.

A. Begin at one end of the tagline. Shoot as much of the transect as possible from initial instrument setup. Use codes in Table 1 to name shots in the datalogger and field notes (see Figure 1). Code names for each point should include the transect number, but there is no need to distinguish between 1-m interval shots and slope break shots along the transect.

Rod technique

Raising the rod – Shots are generally taken at the lowest rod height (1 rod) unless there is an obstruction. If the total station does not have a clear line of sight to the prism, try raising the rod, one section at a time, until the shot is successful. Always raise the rod from the top section (the smallest rod), followed by the next-to-top section and so forth. Make sure each time you raise a rod that it snaps into place before the shot.

Rod positioning - Each shot should be taken with the rod flush against the downstream side of the tagline. Use the rod level to make sure that you are holding the rod precisely vertical. When two crew members are running rod, they should "leapfrog" across the tagline or down the profile for the greatest efficiency.

Communication - Use radios to communicate. The survey lead uses an ear piece and microphone attached to the radio to free their hands for operating the total station and datalogger. The rod person should always let the total station operator know how many rods are up before the shot is taken. The total station operator will let the rod person

know when the shot has been successfully completed. When two rods are being using to survey a transect, only the prism of the current shot should be facing the total station operator. Crew members running rod need to make sure their prisms are facing away from the total station while setting up for their next shot. Any shot errors (e.g. rod not raised to full height, incorrect rod height relayed to survey lead) should be relayed to the survey lead immediately, documented, and corrected by re-taking the shot, if necessary.

Shooting through dense vegetation
If you are unable to get a shot at any of the standard rod heights, the following alternatives may be attempted.

- Move the rod slightly upstream or downstream while keeping the bottom of the rod on the same geomorphic surface. The rod person will need to estimate the distance upstream or downstream of the tagline and relay this to the total station operator to document in the field notes. Make sure to level the rod in the new location.
- Use an alternative rod height. The total station operator finds a section of the rod that is visible and sets the crosshairs to the elevation shown on the rod face (e.g. 1.5 m). The rod person then adjusts the rod so that the prism is at this height. The total station operator instructs the rod person to raise or lower the prism until it is centered in the pre-set crosshairs, takes the shot, and enters the appropriate rod height.
- Take a shot using the horizontal or vertical offset functions in Survey Pro (see instructions for the software).

B. Rod crew members should alert the total station operator when they reach a headpin. If it has a permanent monument, set the rod on top of the rebar, notifying the total station operator that the shot is "Top of Pin." The next shot should be on the ground surface next to the rebar. If endpoints are not monumented, shoot the ground surface at the pin flag. Note that both headpins on a transect are coded with the same name.

C. After surveying transects along the tagline, use the data in the total station to extend the transects beyond the headpins onto the upland terrace. Points should be surveyed at approximately 1-m intervals and all surface breaks until you reach a very stable upland surface, even when this surface is located behind the permanent transect headpin.

Woody debris and other obstacles along the survey transect
Where large woody or other debris precludes placing the base of the rod on the ground surface, the rod person should place it on the object for the shot, and relay to the total station operator the height of the debris above the ground surface. This can be measured using the increments marked on the face of the rod. The total station operator should document this information in the field notes in order to make later adjustments to the survey data.

D. If you can shoot additional transects from the existing instrument setup, perform the following checks before beginning the next transect.

- Check the backsight and correct any errors reported by the datalogger.

- Re-shoot any reference marks.

E. If the total station must be moved to accommodate the next transect, shoot as much of the stream profile as possible before moving the instrument.

F. If a transect needs to be shot from two different instrument setups, mark the location where you stopped surveying with flagging so that you can begin surveying at the correct location from the new instrument setup.

1.3 Surveying – DINO and CANY

Shots are taken at each vegetation plot and then follow the CHaMPs methodology (Bouwes et al. 2011) to create a continuous surface of topography for the feature. These methods are taken with minor modification from (Bouwes et al. 2011). Features such as edge of water, the spatial arrangement and perimeter of channel units, top and bottom of banks, and topographic points are used to capture the shape and gradient breaks during the survey. A 3-dimensional topographic surface of the feature is created by connecting a series of points that have X, Y, and Z coordinates. During the survey of a site, the job of the person operating the rod is to effectively and efficiently survey points and lines that will collectively represent the feature as accurately as possible. The points selected by this person determine the ultimate utility of the site survey and should be done carefully.

A. Locate benchmarks (rebar with labeled caps/tags) at the sentinel site. Mark with pinflags. Survey these first when instrument is set-up.
B. Survey in all vegetation plots as described in SOP 4 (Figure 3).

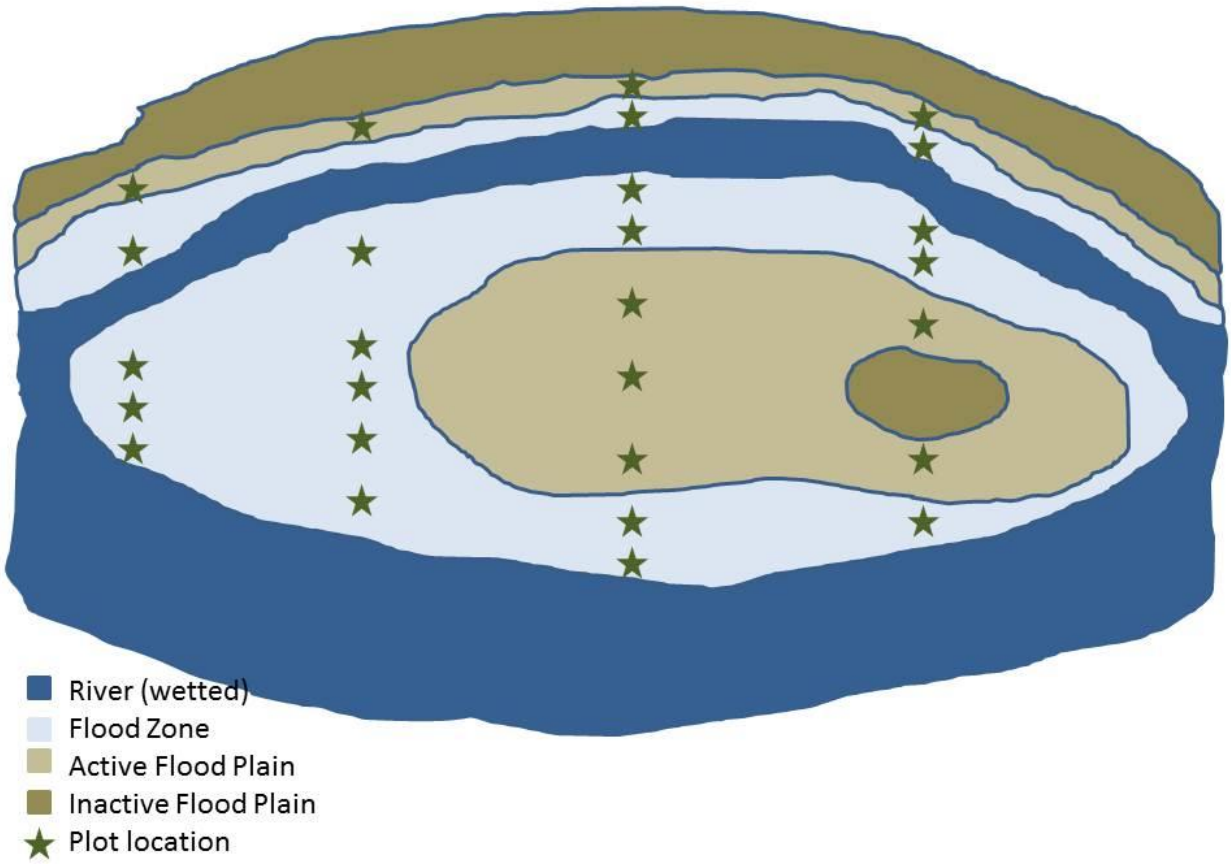

Figure 3. Locations of vegetation plots to be surveyed in. The topographic survey should also capture the boundaries of the geomorphic surfaces shown here.

C. Survey using CHaMPS methodology:
    a. Determine the channel units that will be surveyed and number these (Fig. 4).
    b. Collect points defining the perimeters of channel units. Figure 4 shows the different points taken to define the plan form view of channel units and bars. Table 1 defines the codes used to delineate the survey points (i.e. W, FZ, AFP, IFP, etc.).
        i. Beginning with the most downstream channel unit collect points along the edge of water of the unit in a manner that characterizes the plan form view of the unit. Label these wetted perimeter points with a W followed by the channel unit number.
        ii. Where the perimeter of a channel unit is within the wetted channel, label the point U followed by the channel unit number.
    c. Survey high water (HW) points when conditions are appropriate.
    d. Collect points defining the perimeters of mid-channel bars. A mid channel bar is completely surrounded by a wetted perimeter. Label these edge of water points as B followed by the channel unit number.
    e. Perimeter points that are shared by multiple channel units or bars require additional coding. Some perimeter points of channel units and bars will require

additional coding to represent the perimeters of two or possibly three channel units or bars.

f. Locate and collect points at the maximum depth and tail crested depth of pools. Label maximum depth points as MAX followed by the channel unit number. Label crested depth points as PTC followed by the channel unit number. Pool crested depth points also define the perimeter of multiple channel units and should be additionally coded to reflect the perimeters of these units. These measurements should only be done up to a safe wadeable distance and the surveyor shall have a life jacket on.

g. Topographic shots (TOPO): Survey enough TOPO shots to capture the shape of the feature. The channel topography survey captures the gradient changes of the flood zone. These topographic points should describe all features of the channel up to and at least 1 m horizontally beyond the first flat floodplain found at or above the bankfull elevation. Label these points TOPO.
    i. TOPO points should be distributed longitudinally throughout the length of the site, and extend laterally to the survey extent.
    ii. Spacing of topo points will depend on the complexity of a stream. A stream with more gradient breaks or inflexion points will require a higher density of topo points. The density and distribution of topo points will determine the quality of the survey.
    iii. Side channels will be surveyed using the same set of procedures as the main channel.
    iv. It is not necessary to label thalweg points (TL) in non-primary sections of channel; however the deepest points should be surveyed using TOPO points.

D. Survey as much as the topography of the flood zone at a safe wadeable depth. Figure 2 or 7 shows how points (red dots) are selected that represent changes in gradient in the cross-sectional view. Gradient changes in the longitudinal view must be captured as well.

E. Survey breakline features (i.e. FZ-AFP boundary; AFP-IFP boundary, etc.) and the extent of the flood zone . Figures 4 and 5 show the importance and placement of these breaklines.
    a. Breakline features are changes in the gradient of the cross-sectional profile along the streambank. Figure 5 shows how surveying a series of breaklines that run parallel to the streambanks are essential for effectively representing these topographically complex areas of channel. Also include shots of the water's edge.
    b. There are six types of breaklines that need to be surveyed if present (Figures 6, 7):
        i. Toe-of-bank (TOE): The first break line encountered working toward the bank is the toe-of-bank. This breakline, if present, is a change in cross-sectional gradient below the bankfull elevation. Toe-of-bank points may be in the wetted channel but must be near the bank and represent the beginning of the bank. Toe-of-bank is where the streambed meets the streambank and is often marked by a transition from streambed material to streambank material. Label toe of bank breakline points TOE.
        ii. Flood zone (FZ): The second breakline encountered working toward the bank is the flood zone (FZ) breakline. Points along this breakline should

be spaced in order to capture significant gradient breaks or nick points in this breakline. Flood zone in a constrained stream is identified as changes in substrate or vegetation.

iii. Active floodplain-Inactive floodplain (AFP-IFP): The breaklines of the active floodplain (AFP) and inactive floodplain (IFP) (Figures 2, 7) will also be surveyed in a similar manner as the FZ breakline.

iv. Top-of-bank (TOB): Beyond the bankfull a breakline must be surveyed that represents the extent of the survey. This breakline is called top of bank and is labeled TOB.

v. Beyond Inactive Floodplain (BIFP): Alternatively, the extent of the survey in constrained reaches requires a point beyond the IFP. There is not necessarily a feature to determine where this breakline is. Locate these points 1 m beyond the IFP elevation. Label these points beyond inactive floodplain points as BIFP.

Tips for breaklines:

- At a minimum 2 breakline features need to be sampled at any given cross-section. Breaklines can change within a survey but at least two breaklines must be present and continuous from top to bottom of the reach for each side of the channel.
- Breaklines should be composed of enough intermediate points to capture the general shape or any TOB or TOE of bank features (Figures 6, 7).
- It is not necessary to survey breaklines along sections of streambank that lack an apparent TOB or TOE.

Survey in upland boundary.

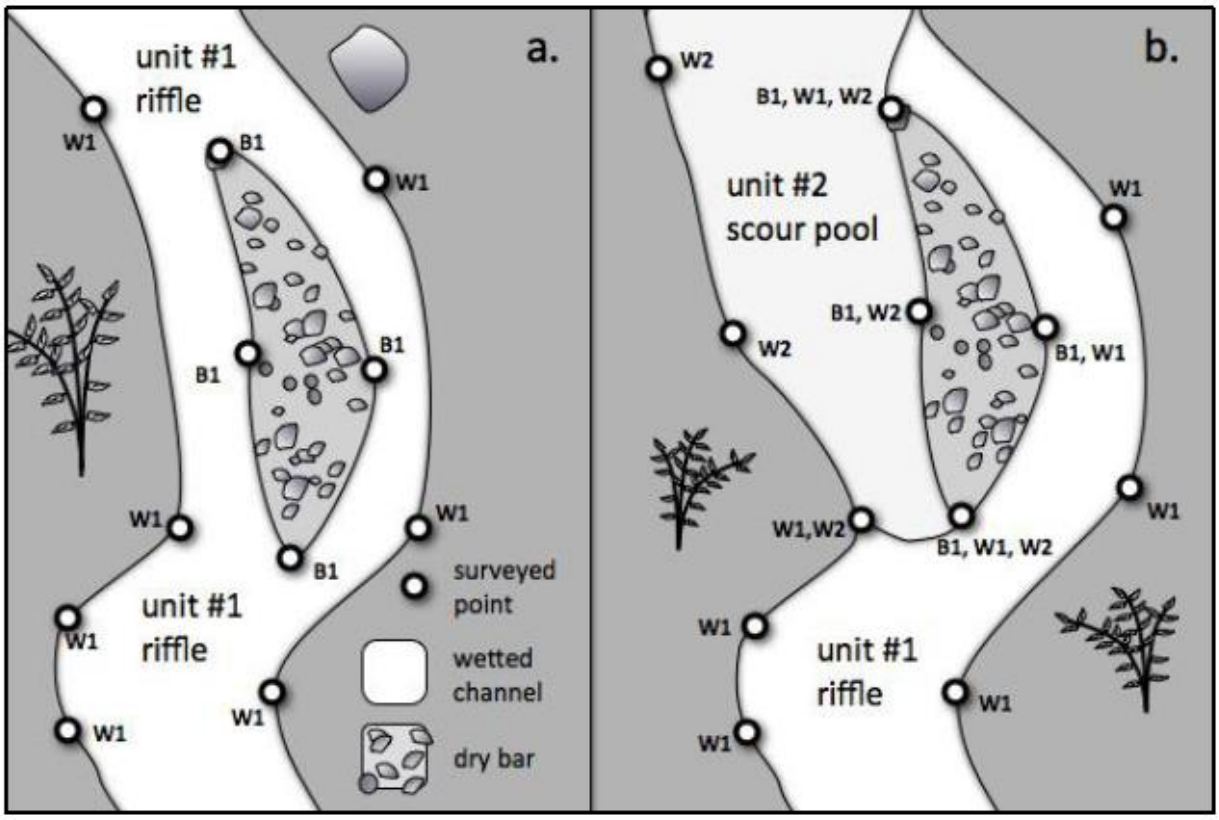

Figure 4. Example of coding points to describe the perimeters of channel units and bars showing which points require multiple codes.

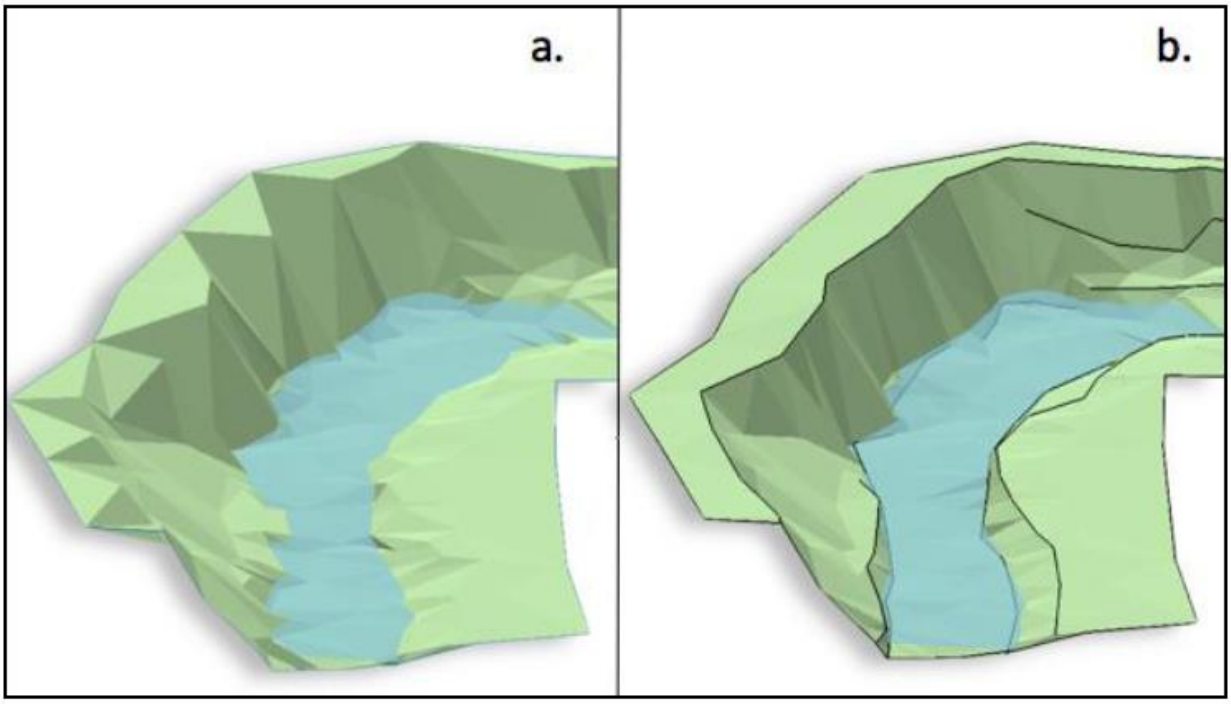

Figure 5. Example of streambank surfaces rendered a) without, and b) with breaklines surveyed at the TOB and TOE of the bank.

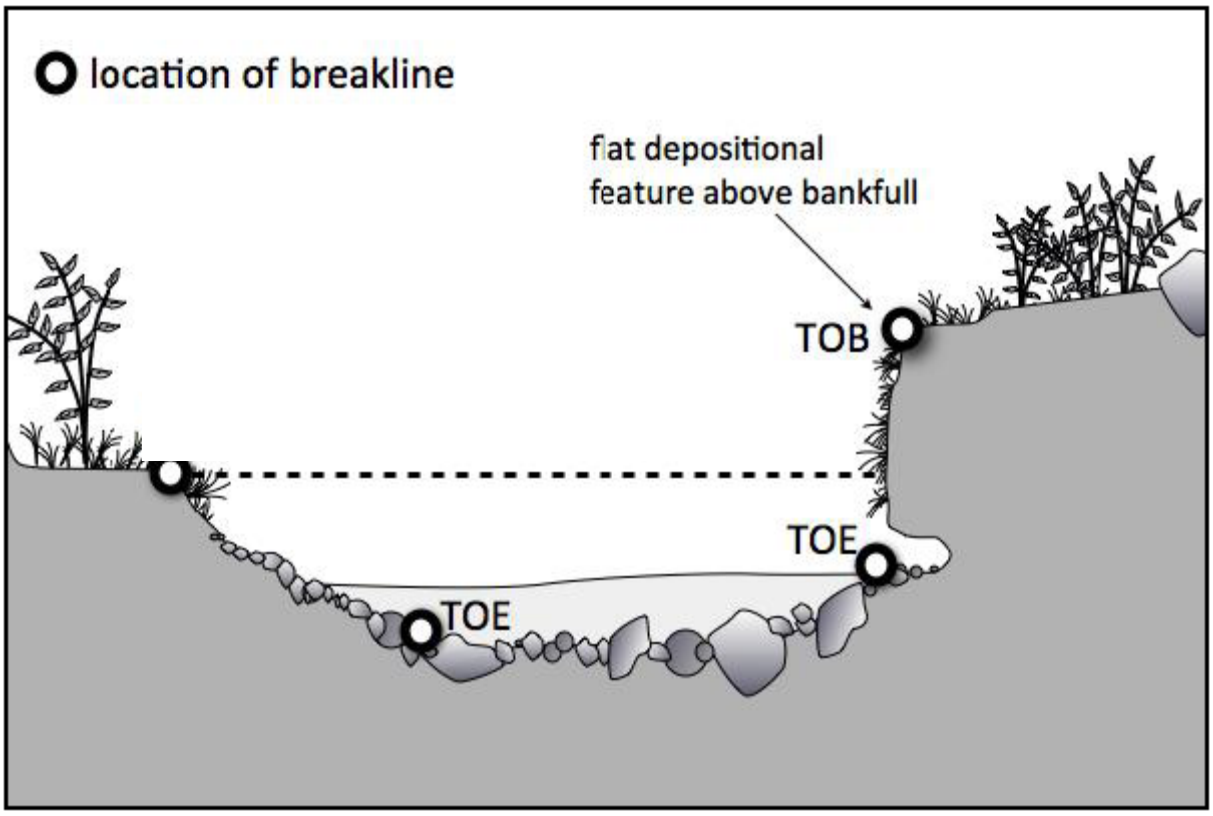

Figure 6. Cross-sectional view of a stream channel demonstrating the appropriate placement of TOB, and TOE breaklines.

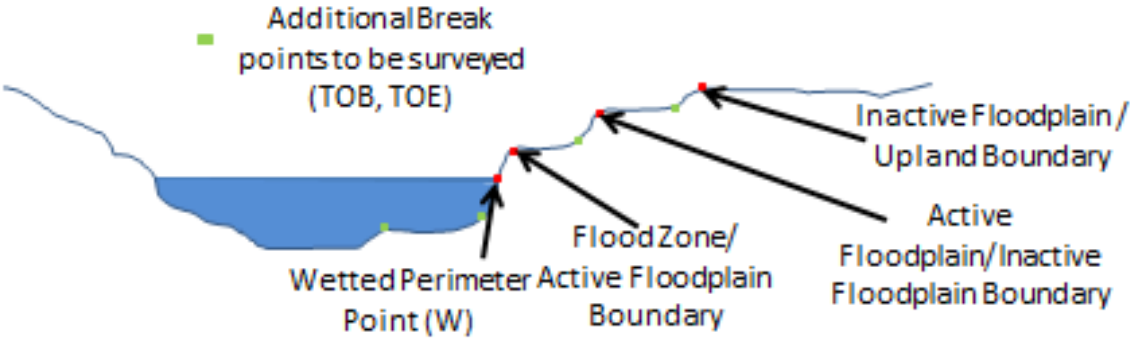

Figure 7. Cross-sectional view of a stream channel demonstrating the wetted perimeter, flood zone, active floodplain, inactive floodplain, upland, and break points. .

1.4 Establishing a new instrument setup

Make as many shots as possible from each instrument setup, including transects, stream profile, and hydrologic instrumentation. Follow the instructions below to establish a new instrument setup.

A. Move the total station to the backsight location, and use the previous occupied point as the new backsight. Adjust the appropriate settings in the datalogger, and shoot the

backsight and reference marks from the new location. Shoot as many transect and stream profile points from this location as possible.

B. Shoot in a new instrument setup location (CP3). Use one of the existing controls (CP1 or CP2), an existing reference mark, or any headpin that has already been surveyed as the new backsight. Monument, flag, and photograph the new instrument setup as described in section 1 above, and shoot in the new point before moving the total station. Make sure to document any additional instrument locations and backsights used in the field notes.

C. Shoot in additional instrument setup locations as necessary to complete the survey. In dense vegetation, you may need as many as 4 or 5 instrument setup locations.

1.5 Collecting waypoints

In order to transform the survey data into real-world coordinates, GPS data are collected at all instrument setups and reference marks. In the field notes, record the time GPS waypoints are collected for each occupied point or reference mark.

1.6 Locating positions and lines from previous surveys

Follow instructions in the Survey Pro documentation to locate positions and lines from previous surveys.

2. After the field visit

2.1 Downloading total station survey data

Survey data should be downloaded as soon you return from the field.

A. Make a copy of the original data and paste it into the corrected data folder. Rename the file so that it begins with “corr” and ends with the extension .txt (see Figure 3). Make sure to keep a copy of the original data for the archives.

B. Open the copied coordinate file (corrFremont01crd.txt in Figure 3) in Excel. The file should have five columns: point number, x, y, and z coordinates, and point description. Save the file as an .xls file using the naming convention in Figure 3.

C. Make corrections from field notes in the Excel file. For example, where an incorrect rod height is documented in the field notes, locate the appropriate point number in the Excel file, and make the needed correction to the elevation recorded for the shot. Notes describing each correction can be made to the coordinate and raw data files in the corrected data folder. When all corrections are complete, save the worksheet as a comma-delimited file (.csv) in the corrected folder.

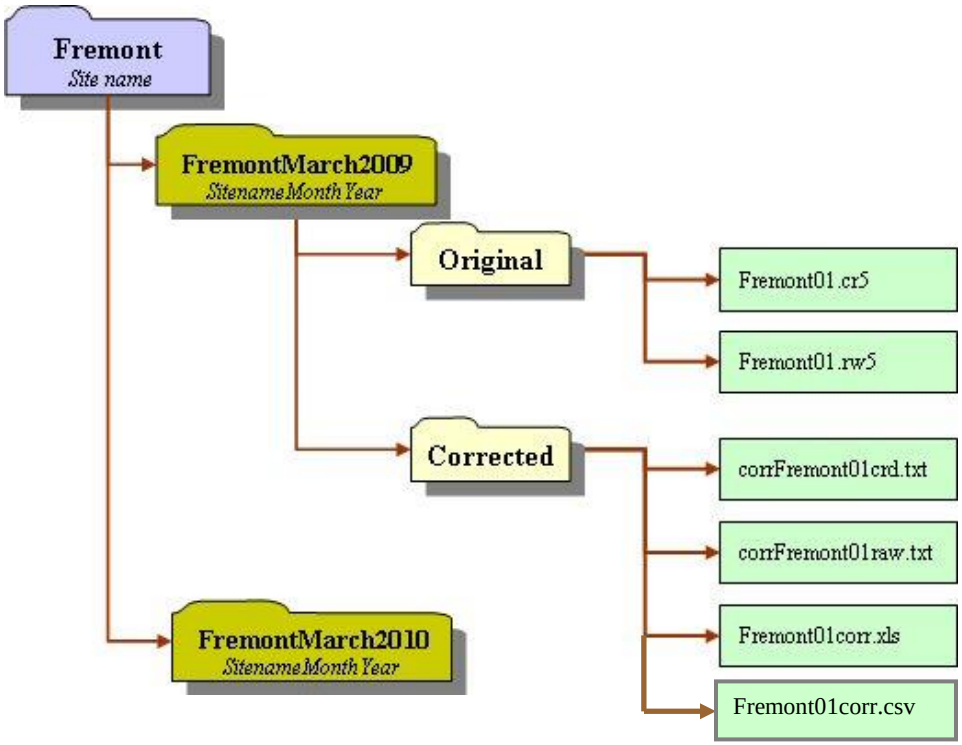

Figure 3. Folder and file naming conventions for survey data.

2.2 Downloading waypoints

Each GPS waypoint should be downloaded and differentially corrected as soon as you return from the field.

2.3 Post-processing survey data

Using Traverse PC software, survey data are converted to UTM coordinates, and profiles are created for each transect and feature.

A. Convert total station survey data to UTM coordinates.

a) Import the corrected .csv file into Traverse PC.

b) Obtain differentially-corrected data for all instrument setup and reference mark points. Examine the GPS report to identify points with the lowest PDOP values and reported errors. Select the most accurate point, and move all surveyed points so that coordinates of the selected point match the GPS data.

c) Modify the elevations of all points so that this point's elevation is the same as that reported by GPS. This change is to modify the surveyed elevations to within ~1 m of real world elevations. It is the only change to surveyed elevations that should be made, as the relative elevations recorded by the total station will be more accurate than elevations collected by GPS.

d) Reproject all survey data to UTM coordinates. Use NAD83 for the datum and the zone appropriate for the reach.

e) Select the second-most accurate GPS point. Rotate all survey data around the initial point so that the coordinates of this second point are as close as possible to those reported by GPS. Check the northing and easting coordinates for the remaining setup locations and reference marks to make sure that they are within a few centimeters to those reported by GPS. If the error is greater than this, check all transformations and rotations to identify any errors and correct them.

f) Separate all control shots from transect and profile shots. Export all control point coordinates into the "final control" worksheet in your Excel file. Repeat for all transect and profile shots and label this one "final topography." These coordinate values will be used to overlay the transect and profile points on aerial photos.

B. Obtain detailed cross-sections for each transect and exporting the coordinate values for all points along each transect into the Excel file. Use a separate worksheet for each transect and label each by its transect number. The Pythagorean theorem equation can be used to translate x,y coordinates into stationing values. The left endpoint should be considered the "100" station. Generate cross-section drawings in the Excel file, using uniform scales for the x and y axes.

C. Export the thalweg profile shots into a separate Excel worksheet. Transform into stationing values, from downstream-most to upstream-most point. The downstream point should be labeled as station "0." Generate a profile drawing in Excel using an appropriate vertical exaggeration.

D. In the Traverse PC file, appropriately label control shots (distinguish between occupied points and reference marks), transects, and the points shot along the thalweg profile. Label the drawing with survey dates and other appropriate information for the archive.

2.4 Archiving

Create shape files and the accompanying metadata for the finalized survey data. The following should be archived:

1) Traverse PC file.
2) Shape files of all spatial data.
3) Metadata file.
4) Excel file consisting of transect worksheets with finalized survey coordinates, transformed stationing/elevation values, and drawing; 1 profile worksheet with finalized survey coordinates, transformed stationing/elevation values, and drawing; 1 control point and 1 topography worksheet with coordinate values and descriptions, and the original coordinate correction worksheet.
5) Field notes with sketch of reach.
6) Photographs of all control points and reference marks.
7) Original coordinate and raw data files.

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 9

After each Field Visit

Version 1.00 (May 2012)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP details procedures performed at the end of each field trip, including equipment maintenance, data management, and trip reports.

Procedures

1. Follow check-out procedures with Glen Canyon dispatch detailed in the NCPN Backcountry Safety Plan.

2. Report all broken or missing equipment to the field crew coordinator. Repair equipment if possible or indicate if new equipment needs to be purchased before the next field hitch.

3. Check-in cameras, lasers, satellite phones, and GPS units. Also check-in lasers, total station, data logger, water level meter, and/or PDA if used.

4. Remove plant collections from the press or cooler, and store them in a secure location where they will not be damaged.

5. If boating equipment was used, make sure it is clean and dry before putting away.

6. Complete data entry and verification. Resolve any questions with the crew members who collected the data.

7. Organize and file datasheets.

8. Download photos and organize by park code and reach name.

9. Download data from total station surveys (see SOP #8) and perform any post-processing.

10. The crew leader should complete a trip report detailing the dates of field work, crew members participating, work completed, travel and housing availability, safety concerns and how they were accommodated, weather conditions, any equipment problems or needs, and any other pertinent information. Also note any interesting or unusual findings, observations of disturbance, human or animal activity, deviations from the SOP, or access issues.

11. Organize monitoring boxes for the next hitch.

12. Charge camera and satellite phone batteries. Also charge batteries for the total station, data logger, PDA, and field laptop if these electronics were used.

13. Return GPS units to the GIS technician for downloading and charging.

14. Clean the insides of vehicles. Especially dirty or muddy vehicles may be washed as often as monthly when needed. Report vehicle repair needs to the field crew coordinator.

15. Decontaminate all equipment, personal items, and clothing that have come into contact with water or mud. The following procedures are to be used to prevent the spread of exotic invasive organisms.
    - Remove all mud and debris using a scrub brush.
    - Spray with 5% Quat solution and allow to rest 10 minutes.
    - Rinse with water.
    - When feasible, allow to dry completely before entering another body of water.

16. Tidy the conference room before leaving for multiple days off.

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 10

After the Field Season

Version 1.00 (December 2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP details procedures performed at the end of the field season, including equipment maintenance and data management.

Procedures

1. Equipment maintenance. Inspect all equipment for damage and note any missing equipment. Clean and repair all equipment prior to returning it to the project leader.

2. Equipment inventory. Ensure that adequate supplies are on hand for the next field season and create a list of supplies that need to be ordered.

3. Complete identification of unknown plants. The field crew leader is responsible for ensuring complete resolution of all unknown plants. Plants are identified to species, family, or at least life form. Annotate the data sheets with the correct identifications and ensure that species are entered correctly in the database.

4. New species follow-up. The field crew leader is responsible for ensuring that plant species not on current park lists are submitted for NPSpecies updates. The field crew leader is also responsible for mounting, labeling, and preparing voucher specimens for any new species collected in a park unit. Update park plant species lists and the species list in the database.

5. Field herbaria. The field crew leader mounts and labels appropriate specimens for the field herbarium.

6. Data management. The field crew leader is responsible for ensuring that all data sheets are completed properly.

7. Data entry. The field crew leader is responsible for ensuring that all data are entered and verified according to procedures outlined in SOP #12. Also download all photographs to the X:\ drive and make sure they are correctly labeled.

8. Field season review procedures. Prior to the departure of the field crew, the project manager will query the field crew for issues with existing monitoring protocols and field logistics and will seek recommendations for improvements.

9. Logistics. The field crew leader updates access documents with new and updated access and logistical information, such as road closures, park personnel turnover, etc.

Big River Monitoring Protocol for the Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 12

Data Analysis and Reporting

Version 1.00 (December 2011)

Revision History Log:

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

This SOP provides an overview of analysis and reporting procedures. After raw data from the field season are quality checked and certified, they are then summarized to the feature level. Additional QAQC is performed comparing these data to previously collected data to catch misidentified species and values that represent unlikely amounts of change between years. Once data quality issues are resolved, analyses can be conducted. Two general types of analyses are performed: 1) annual reporting of the most recent monitoring observations (annual reports and briefs), and 2) comprehensive assessments of the long term data set (variance estimation of the overall sampling design, evaluation of status and trends, and correlations with other vital signs).

1.0 Data Summary

The sampling unit for all big river analyses is the feature, and sub-samples recorded on plots must be scaled to this level. Vegetation and geomorphology data may be integrated at the transect level, but ultimately need to be summarized to the feature level. Summary queries should be created in Access to expedite this process.

Vegetation Summaries

Richness

Data from the 1-m belt transect (BLCA) and 1-m plots (DINO and CANY) are used to calculate species richness, or the number of unique species encountered. For each reach, calculate richness of all species and of native species.

Percent Cover
Percent cover is calculated for each species, life form, wetland status group, ground cover attribute, and disturbance using data from 1-m belt transects and 1 m plots. It is derived by summing the percent cover from each plot and dividing by the total number of plots, times 100 (eq. 1, Table 1).

Exotic frequency
Exotic frequency is derived from the number of detections of each exotic species in the 1-m^2 quadrats, and reported as the percent of detections.

Geomorphology Summaries
After total station survey post processing, relevant geomorphic surfaces are delineated by elevation or abrupt surface breaks on each transect. The data can then be integrated with other measurements or summarized to the reach-level.

Channel morphology
The mean active channel width and depth in meters (eq. 2, Table 1) and the channel gradient in percent slope are calculated for the feature using data from the geomorphology survey transects. The distribution of particle sizes in the channel bed is derived from the modal particle size.

Flood plain morphology
The mean flood plain width and elevation in meters is calculated for the reach using data from the geomorphology survey transects. The delineation of the flood plain will be estimated until enough hydrologic data are collected to determine this.

Integrated Summaries
Vegetation data are integrated with the geomorphology survey transects to derive mesic to xeric plant cover by surface elevation and species richness and percent cover by geomorphic surface elevation.

Inundation duration of the floodplain (% of growing season) will be determined using geomorphology surveys and hydrologic data, and will be more meaningful as additional floods are recorded. Inundation frequency of the floodplain (return frequency in years) requires multiple years of hydrologic data in addition to a survey of the flood plain.

Table 1. Formula for deriving reach-level measures.

Percent Cover

$$PC = (h / n)*100 \quad (1)$$

where PC = percent cover
h = percent cover of each species by plot
n = the total number of plots per feature by geomorphic surface

Mean (channel width, etc.*)

$$M = (\sum_{i=1}^{v} c_i) / v \quad (2)$$

where M = mean channel width in m
c_i = channel width in m for transect i in a reach
v = the total number of transects in the reach

* channel width shown in this example, but this formula is also used for channel depth, flood plain width and elevation, annual and growing season stream stage, annual and growing season stream discharge, annual flood stage, and depth to ground water.

2.0 Data Quality Assessment

Before data analysis and reporting, reach-level data should be additionally evaluated for reasonable levels of change based on historical conditions at each reach. For instance, a measure may appear to be valid based on the database domain, but represent an unreasonable (and unlikely) change in reach conditions since the last field visit. Summarized attributes should be compared between years, and all suspect values (large increases or decreases) should be flagged and resolved before the data are analyzed. In addition, data should be evaluated for the omission of historically dominant species or the appearance of dominant species not detected in previous years. New occurrences of a species should be compared with the park-level species list and species-range limits.

Suspect measures or species should be evaluated by field crew members and by field verification if possible. Any corrections made to the database should be recorded in the QAQC log. Suspect data that are not resolved should also be flagged in the QAQC log so that it can excluded from analyses, if appropriate. Suspect data that cannot be resolved in the office should be brought to the attention of the field crew at the next monitoring visit so that they may eventually be resolved.

3.0 Annual Reporting

Annual Reports

The primary objectives of the annual report are to 1) document monitoring activities for the year, 2) summarize annual data and describe the current condition of resources, and 3) provide information to park managers in a timely manner that increases data utility and communication. A separate annual report is completed for each NCPN park unit with riparian monitoring. Existing NCPN annual reports should be consulted for formatting.

Annual Briefs
Each year, information from annual reports and other analyses is further summarized in 1-2 page briefs that provide resource managers with a concise summary of issues of concern. NCPN produces two types of briefs: vital signs briefs and park briefs. The riparian vital signs brief summarizes findings from riparian monitoring in all NCPN parks. Park briefs are produced for each NCPN park unit and contain a section on riparian monitoring. Existing vital signs briefs and park briefs should be consulted for formatting.

4.0 Comprehensive Assessments

Comprehensive analyses and reports are completed periodically on the long term data set. Comprehensive reports should be structured like typical scientific manuscripts (introduction, methods, results, discussion, and literature cited sections) and may include any of the analyses described in this section.

Sampling-Design Variance Assessment
The sampling design for riparian monitoring at each stream is documented in a separate report that outlines specific sampling objectives. Periodic checking of the assumptions of the sampling design affords timely opportunities to invoke enhancements to meet the original monitoring and sampling objectives. Sampling designs are evaluated by calculating variance and power for trend, and assessments are recommended every 5-7 years.

Variance estimates are derived from all years of monitoring data, not just observations from the current field season. Where necessary, alternative survey designs are evaluated to determine appropriate enhancements, such as an increase in sample size or more frequent visits to established reaches, to achieve the original sampling objective. Power-for-trend is evaluated with alternative numbers of panels, sample sizes, and re-visit schemes. A trend may be reported as a yearly rate or a rate over a set number of years. This conversion is outlined for increasing (eq. 3, Table 2) and decreasing (eq. 4, Table 2) rates of trend. Results are then used to determine which survey designs best meet the original sampling objectives.

Table 2. Formula for converting a yearly rate of trend to a rate of trend over a set number of years.

Conversion for rate of trend

$$I = e^{rt} \quad (3)$$

$$D = 1 - e^{rt} \quad (4)$$

where;

I = % increase over t years
D =% decrease over t years
r = the yearly rate of increase or decrease
t = the total time period of increase or decrease

Status and Trend Assessments

The underlying motivation for using survey designs to monitor big rivers is the ability to make inferences to a finite, target population. Alternatively, model-based designs and assessments rely on modeled relationships, and thus tend to have inherent assumptions, and in some cases, limitations in terms of the scope of inference. However, model-based assessments may be useful to help explain reasons for trends observed in survey-design efforts, and information from other vital signs monitoring (e.g., climate, air quality, land use, land condition) or other sources may prove critical to interpreting observed riparian trends. Bayesian methods may detect trends earlier than frequentist methods and should be developed over time.

Status and trend analyses are performed after at least 5 years of monitoring data are collected. When significant trends are detected, reasons for these trends should be evaluated by literature reviews, comparison with similar data sets, and additional assessments using ancillary information. When unidirectional trends are not detected, correlations may help us understand system drivers.

Frequentist Methods

Frequentist trend assessments of complex survey designs are performed using a mixed-effects model (Larsen et al. 1995). Reach-scale measures are used in the model and evaluated on the basis of time. The output from this model is a measure of the intercept and slope, the significance of the slope and intercept being different from zero, and measures of the variance and covariance of the regression parameters. A significant slope indicates a significant trend at the alpha level used to assess significance or below.

Status is the condition of the attribute and is derived in two ways. If the trend slope is not significantly different from zero, mean and variance of status is simply the mean and variance of all measures of the attribute up to the current time period. If the slope is significant, then status is the solution of the regression model for the latest time period of the data used to generate the trend line (eq. 5 in Table 3). Variance measures of mean status are derived from the covariance matrix of the regression coefficients (eq. 6 in Table 3).

Table 3. Formula for deriving status and trend estimates.

Mean Status From a Trend Line

$$ST_t = b_0 + b_1 * t \quad (5)$$

where;

ST_t = estimate of mean status at time = t
b_0 = the estimated intercept parameter
b_1 = the estimated slope parameter
t = the most recent time period of the data (in the same units used to generate b_0 and b_1)

Standard Error of Status

$$SeSTt = \sqrt{(\sigma^2_{b0} + 2t\,\sigma_{b0b1} + \sigma^2_{b1}t^2)} \quad (6)$$

where;

$SeST_t$ = the standard error of the mean-status estimate at time = t
σ^2_{b0} = the variance of the intercept parameter
σ_{b0b1} = the covariance of the regression parameters
σ^2_{b1} = the variance of the slope parameter
t = the most recent time period of the data

Model-Based Methods

Model-selection procedures consider a range of potential factors influencing directional change in resource conditions. Even if a significant trend occurs as a function of time, the relationship between other explanatory variables and riparian measures should be evaluated to determine potential 'causal' factors of trends. These other explanatory variables can include biophysical features of the reaches as well as measures from other vital signs monitoring (e.g., climatic conditions).

Model selection methods (Burnham and Anderson 1998) evaluate the explanatory power of different models of trends in big river measures. Multiple models are considered, each with different combinations of independent variables and interaction terms. All models should be based on hypothesized, ecologically meaningful relationships. Adjusted AIC (Akaike's Information Criterion) values generated with a mixed-effects model are used to determine the best predictive model as well as the importance of independent variables.

The primary model in this model-selection procedure is the response of interest vs. time (see frequentist methods above). Alternative models can be based on measures of climate, air quality, land use, and land condition, as well as other measures that may be considered important. When evaluating other variables, they are either included in an interaction with time or time is replaced with the variable.

The result of the model-selection procedure is the selection of the model (i.e., set of independent variables) which best predicts the trend of the response variable. This, in turn, aids in explaining reasons for the observed trend. For instance, if alternative models with one or more driver attributes (e.g., drought days) accounted for more variance than just using time, trends may be attributed to these attributes in a correlational relationship, but not necessarily a causal relationship. If alternatives to time account for less variance, other avenues of investigation should be considered to explain reasons for observed trends.

Bayesian Methods

Bayesian methods for trend assessment identify the probability of different slope-parameter values (Gelman et al. 2000, Wade 2000) given the observed data. This differs from frequentist methods which calculate the probability of observing data given a specific value for a parameter, such as the null hypothesis. Assessing the probability of different slope values is potentially important for various reasons. First, sampling designs are largely based on a few key features. The minimum detectable trend at a reasonable power level for many of the other responses will likely be much higher. Estimating the probability of slope values may be the best way to provide insight into trends for these attributes. Second, even for the key features around which sampling designs were based, Bayesian methods may reveal the potential of declining trends before rejecting the null hypothesis that the regression slope equals 0 with conventional statistics.

Bayesian methods use a likelihood distribution generated from the sample data that provides the probability of observing the data for every possible parameter value. Combining this with a prior distribution produces a posterior distribution which is used to make inference about parameters. The prior distribution reflects previous knowledge about the distribution of parameters. In the absence of such knowledge, a non-informative distribution can be used, which essentially is a uniform distribution across the range of the likelihood distribution. In subsequent analyses, the posterior distribution of previous assessments is used as the prior distribution. The posterior distribution allows assessments of the probability of user-selected parameter values. The probability of various increasing and decreasing slopes should be evaluated based on the posterior distribution and the consequences of not alerting management of a potential trend. The result of this assessment is the derivation of the probability of different levels of decline/increase. Even though conventional statistics may not reveal a significant trend, relatively high probabilities (e.g., $\geq$0.70) of trends with a Bayesian method may warrant special attention.

Correlations

There will be instances where a monitored attribute fails to exhibit a trend (i.e., a direction change), but instead may have periods of decline followed by recovery. In other words, natural variation may be more evident than a precipitous decline or increase, and it may mirror the variation in a key driver attribute. Discerning this variation and reasons for it can involve many complex procedures. As a first step, however, correlational methods can provide useful insight and are relatively simple.

For attributes that fluctuate between declines and increases, correlations with climate, air quality, land cover/use, land condition, and other potential drivers should be considered. Strong correlations between a response and driver may be sufficient to understand reasons for the observed variation over time (e.g., strong correlation between shrub cover and annual precipitation).

Another type of correlation assessment is path analysis (Lindquist 2000). This method accounts for the inter-correlated structure among factors by decomposing correlations to direct and indirect effects. For instance, changes in grass cover in a shrub-steppe system may be influenced by shrub cover alone or by climate alone or by the influence of climate on shrub cover. A path analysis would decompose the effects of climate and of shrubs on grass cover, while considering the combined influence of climate and shrubs. The result of a path analysis is the indication of the strength of direct and indirect factors on a response, thus providing insight into reasons for the observed changes in a response. Path analysis is based on correlation values and the simultaneous solution of structural equations. Simple examples of the construction and use of path analysis are provided in Lindquist (2000) and Van Bruggen and Arneson (1986); details of path analysis are provided in Pugesek et al. (2003).

5.0 References

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Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 13

Revising the Protocol Narrative and SOPs

Version 1.02 (January 2013)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	1/1/2012	H. Thomas	Updated master version table.	To reflect new versions of SOPs.	1.01
1.01	1/1/2013	H. Thomas	Updated master version table.	To reflect new versions of SOPs.	1.02

This Standard Operating Procedure (SOP) explains how to make and track changes to the protocol narrative and SOPs for the Northern Colorado Plateau Network (NCPN) big river monitoring protocol. Following these guidelines ensures that data collection and processing procedures are documented and retained for use and interpretation of historical data sets. Project staff should refer to this SOP when any changes to an approved protocol document are necessary. The procedures in this SOP are based on the NCPN Protocol Versioning Guidance Document (NCPN 2009).

Procedures

1. Modifications must be reviewed for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by NCPN Inventory and Monitoring staff. An outside review is required for substantive changes in methods. Regional and national staff of the National Park Service (NPS) and experts outside of the NPS with familiarity in geomorphology, hydrology, vegetation monitoring, and data analysis will be used to review major changes.

2. Record all changes to a protocol document (narrative or SOP) in the document's revision history log, even minor edits like fixing typos or formatting changes. It is not necessary to record the specific edits made, rather just the fact that typos were fixed or formatting changes were made. For minor edits, record the same document version number in the revision history log. For actual protocol changes (e.g., changes in methods, equipment), assign a new version number in the revision history log. Depending on the significance of the changes, it may be okay to combine multiple changes in the same entry in the revision history log. 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, and the reason for the changes along with the new version number (if applicable).

3. Narrative and SOP updates may occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs; a narrative update may not require SOP modifications. The NCPN tracks the narrative and SOP version numbers in a Master Version Table (MVT), which is maintained in the big rivers database and is reported in this document (SOP #13). Any time a narrative or an SOP version change occurs, the MVT is updated to reflect the date of the change and the versions of the narrative and SOPs in effect. *The protocol narrative, SOPs, and data should not be distributed independently of this table*.

4. The current version of the protocol narrative and SOPs will be posted on the NCPN web site. Previous versions of the protocol narrative and SOPs will be archived in the NCPN Big River Protocol Library (R:\Monitoring_Archive\Big_Rivers\Protocol) and in the NPS Data Store (https://irma.nps.gov/DataStore).

Big River Monitoring, Northern Colorado Plateau Network
Master Version Table

SOPs that are numbered 100 or higher are ones that have been retired for various reasons. In some cases, SOPs were retired because the methods were not suitable. In other cases, SOPs were split into park-specific SOPs that ultimately did not work as well as expected. The park-specific SOPs were subsequently combined again and the individual park SOPs were retired. A dash ("-") in a cell indicates that the narrative or SOP is not applicable during the corresponding time period.

Effective Date	Narrative	1-Prep. for field season & equip. lists	2-Hiring & training observers	3-Using GPS units	4-Sentinel site setup	5-Photographs	6-Measuring vegetation	7-Hydrologic monitoring	8-Surveying	9-After each field visit	10-After the field season	11-Data management	12-Data analysis & reporting	13-Revising the protocol	14-Facies mapping & grain size dist.	15-CURE non-survey field methods	16-Trimble RTK field operating instructions	17-Trimble Business Center QA/QC	18-Vegetated vs. non-vegetated mapping	100-Rapid assessment	101-CURE non-survey field methods	102-BLCA non-survey field methods	103-CANY non-survey field methods	104-DINO non-survey field methods	105-CANY field prep. & equip. list	106-DINO field prep. & equip. list	107-DINO sentinel site setup	108-DINO photographs	109-DINO measuring vegetation	110-DINO facies mapping & grain size dist.
1/1/2011	-	1.00	1.00	-	1.00	1.00	1.00	-	1.00	1.00	1.00	-	1.00	1.00	1.00	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
1/1/2012	-	1.00	1.00	-	1.00	1.00	1.01	-	1.00	1.00	1.00	-	1.00	1.01	1.00	-	-	-	-	1.00	1.00	-	-	-	-	-	-	-	-	-
1/1/2013	-	1.00	1.00	-	1.01	1.11	1.02	-	1.00	1.00	1.00	-	1.00	1.02	1.01	-	-	-	-	2.00	-	-	-	-	-	-	-	-	-	-

References

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Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 14

Facies Mapping

Version 1.01 (June 2013)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	6-1-2013	D. Perkins	Added more details on grain size distributions	Clarification	1.01

This SOP gives detailed instructions for constructing a facies map of sentinel sites at DINO and CANY.

1. Mapping

1.1. After completing the vegetation work, the person should have a good idea of how the sentinel site is laid out. Begin by mapping the most dominant facie and proceed to the less dominant facies. The mapping is done either on an iPad or on a hard copy map of the sentinel site. At each facie:

A. Record the primary attribute name by dominant size – Boulder, cobble, pebble, gravel, sand, fines. If bimodal add a modifier – Bouldery, cobbley, pebbly, gravely, sandy, silty, non. The first modifier is the more dominant. For example Bouldery cobble would indicate that the site had more boulders than cobbles. Boulder (>256 mm); Cobble (64-256 mm); Pebble (16-64 mm); Gravel (2-16 mm); Sand (1-2 mm); Fines (<1mm). Name the features with a number in sequential order, i.e., Cobble 1, Pebbly cobble 2, Sand 3,…..
B. How is the facie vegetated (bare to sparse <5%, sparse 5-25%, becoming vegetated 26-50%, vegetated >50%)?
C. Are there wake or shadow deposits downstream of sparse individual plants or stands?
    a. Are the wake or shadow deposit sedimentologically different than the rest of the facie?
    b. Are ridges forming (>30 cm) in wake/shadow deposits?
D. Is there any large woody debris?
    a. Are wake or shadow deposits associated with these?
    b. Are the wake or shadow deposit sedimentologically different than the rest of the facie?
    c. Are ridges forming (>30 cm) in wake/shadow deposits?
E. Is there any fine woody debris?

1.2 If wake or shadow deposits are sparse (<5) and have a different grain size distribution than surroundings, consider mapping as an individual facie. We will decide our minimum mapping unit on the July 6 trip.

1.3 Take Photosynth from center of facie.

2. Grain Size Distributions

For each facie at a sentinel site, record grain size distributions at two sites with sieves and scales for finer textured surfaces. For boulder bars we will not do a grain size distribution. At each site record a surface and sub-surface grain size distribution.

2.1 Draw a sketch of the facies on the feature and label facies.

2.2 Surface Grain Size Distribution

A. Take 2-5 shovelfuls from the surface and place them in a 5-gallon bucket. It is important to take a representative sample. On fine textured surfaces (sand) two shovelfuls will likely be sufficient, but if the surface material is made of small boulders or large cobbles, 3-5 shovelfuls would be needed.
B. Place material from the bucket into the sieves. Shake vigorously to ensure that all smaller sediment has made it to the next sieve. Remove 63 mm sieve with any material and place to the side.
C. Shake vigorously to ensure that all smaller sediment has made it to the next sieve. Remove 16 mm sieve with any material and place to the side.
D. Shake vigorously to ensure that all smaller sediment has made it to the next sieve. Remove 2 mm sieve with any material and place to the side.
E. Any remaining material should be in the bottom bucket and is finer than 2 mm.
F. Weigh all buckets. Be sure to account for weight of sieves. Record weights on data sheet.
G. Take photo of sample location.

2.3 For the sub-surface grain-size distribution, strip off the top layer. Then repeat the above process with the aim of digging ~20 cm into the subsurface.

Site	Date	Facies #	Location	Photo	Weight (kg)			
					>63 mm	16-63 mm	2-16 mm	<2 mm

Sketch of Feature with Facies and Locations Labeled

Big River Monitoring Protocol for Park Units in the Northern Colorado Plateau Network

Standard Operating Procedure (SOP) # 100

Rapid Assessment

Version 2.00 (June 2013)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	6-1-2013	D. Perkins	Drastically revised methods	2012 pilot season methods not successful	2.00

This Standard Operating Procedure (SOP) describes the rapid assessment procedures for DINO.

Goal: Detect encroachment and persistence of vegetation onto active channel surfaces.

Background: That is, increases in the cover of vegetation on channel surfaces that are regularly inundated and mobilized by stream flow, and therefore have low background vegetation cover and frequency of occurrence. Along the Yampa in Park settings like Deerlodge, total cover on fine-grained bars is very low, ranging from 0.04 to 0.3%. In canyon settings cover on sand to cobble bars is higher, ranging from 4.0 to 15%. Certain plant species are characteristic of active channel settings and thus are not indicative of narrowing even if they occur with higher than average cover and frequency (see Details). However, the presence of *Tamarix ramosissima* and *Salix exigua* **seedlings**, even though they are commonly found in the active channel, may indicate the potential for narrowing, as these species are known to participate in narrowing along the Yampa.

The presence of tamarisk and willow **saplings** on a mid-channel bar or bank-attached gravel bars in wider canyon settings, especially in association with a sand cap, or on narrow, lateral benches in narrower canyon settings, suggest active, localized narrowing by floodplain construction (Manners et al. in review). In addition, Both tamarisk and willow saplings/adults are significant indicators of floodplain surfaces as are the herbaceous species *Conyza canadensis, Equisetum hyemale*, *E. laevigatum* and *Distichlis spicata*. Floodplain surfaces are distinct from active channel surfaces in that they are finer-textured, higher in elevation and have higher average vegetation cover than do active channel surfaces. Along the Yampa, in canyon settings, average total vegetation cover is >20% on active floodplain surfaces and 30% on inactive floodplain surfaces.

Objectives: 1) assess persistent increases or decreases in the frequency of indicator species and total vegetation cover on those portions of active channel surfaces that are known to be sensitive to flood plain construction, and thus the channel narrowing process; 2) perform assessment rapidly (<20 minutes per site/feature); 3) use a quick plot- and/or a feature-based approach, which provide categorical, semi-quantitative metrics for the presence of indicator species and total vegetation cover; and 4) provide early and broad-scale evidence of channel narrowing.

Proposed approach: 1) use the 2011 high-resolution imagery as a baseline for vegetation cover; 2) use geomorphic mapping of active channel features, with active channel and active floodplain surfaces delineated, based primarily on elevation from 2011 LiDaR data to bound the feature; 3) a feature-based assessment—using the imagery, walk the feature delimited on the imagery and assess the total vegetation cover on the feature compared with the image. Also while walking the feature, do a feature-wide census for the presence of flood plain indicator species (see Details and Table 1); and 4) a quick-plot assessment will be used to sample portions of larger features that have been shown to form the locus for flood plain construction (i.e., elevated sand caps on gravel/cobble bars).

Details: Maps of each feature, using 2011 imagery will be stored on an iPad and used in the assessment along with structured data collection forms. Imagery will be updated and a series of images over time will be available for subsequent assessments.

Feature-based sampling: For active channel features with no obvious loci for flood plain construction, like low profile gravel/cobble bars without sand caps, fine-textured eddy bars or narrow, lateral bars with high cover of active channel species (see Table 2), only a feature-wide assessment will be performed by walking the feature and answering the following questions: 1) has overall vegetation cover increased compared to the supplied imagery? If yes, provide an estimate of the percentage increase (e.g., 5% to 20%); 2) are there flood plain indicator species anywhere on the surface? If yes, indicate the presence of any species listed in Table 1 (see data sheet draft).

Plot-based sampling: A number of active, coarse-textured channel bars (mid-channel islands e.g.), have sand caps. These sand caps can serve as loci for flood plain construction and expansion and are identified on the imagery as active flood plain polygons (see Figure 1) within a larger active channel feature that are: (a) vegetated to some degree with perennial vegetation (typically sandbar willow and/or tamarisk); (b) are typically fine-textured; and (c) at the same average elevation as active flood plain surfaces. Quick-plot sampling of these flood plain polygons will be integrated with the feature-wide assessment where they occur and 2-4 plots will be used to sample them for total cover and the presence of flood plain indicators, regardless of their size. Rather than evaluate changes in these polygons individually across sampling periods, they will be evaluated collectively, whereby a general increase in cover and the occurrence of flood plain indicator species, would provide evidence of broad-scale channel narrowing. Based on the work of Manners et al. (in review), these sand caps have the potential to become permanently vegetated by perennial vegetation (most notably willow and tamarisk) and expand by latteral and vertical accretion, as part of a channel narrowing process. Because of the known sensitivity of such features to channel narrowing, we will focus more specifically on these incipient flood plains in our assessment by using a quick-plot sampling of such vegetating

surfaces to quantify total vegetation cover along with the presence and frequency of flood plain indicator species.

Incipient flood plain features will be assessed with circular "quick-plots" with a radius of 1 m (3.14 m^2 sample area). Quick plot locations have been preselected on the imagery and sampling will proceed as follows: 1) navigate to the plot location, hold out a meter stick and trace out a 2 m diameter circle by rotating in place. Within the circle record (a) the presence of any flood plain indicator species listed in (Table 1), (b) the total vegetation cover to the nearest 5% and (c) percent cover of sand, silt and clay (see data sheet draft).

In some hydroeomorphic settings, where shear stresses appear to be low, even during high flows, active channel surfaces can have high vegetation cover values (see Figure 2). In these cases, high cover values are associated with a guild of active channel species (see Table 2) that are tolerant of prolonged inundation and therefore not suggestive of a localized narrowing process. In these settings, cover values alone are less informative and should be considered in the context of the presence or absence of flood plain indicator species, which should be assessed by a census of the entire feature and no quick- plot sampling would be conducted.

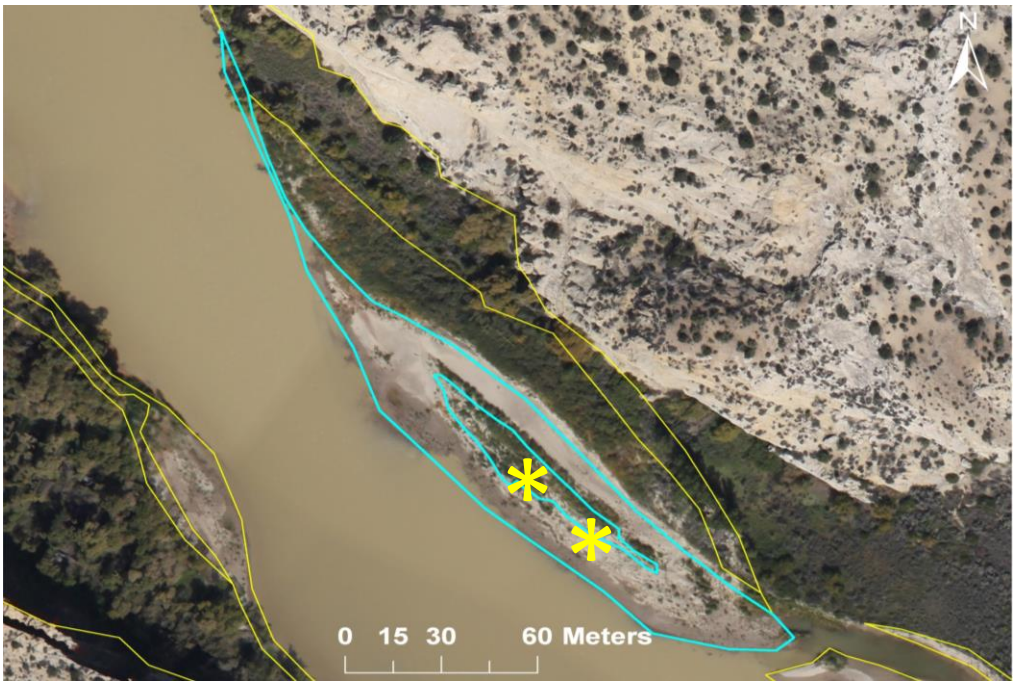

Figure 1. A lateral bar located just downstream of the Deerlodge USGS gage. The blue polygon delineates the active channel surface. At the center of the bar is a vegetated sandcap, which corresponds in elevation and total vegetation cover with an active flood plain surface. The yellow asterisks mark locations of the quick-plots to be sampled on the sand cap.

Table 1. Flood plain indicator species to be evaluated for presence for both the feature-wide and quick plot based assessments. These species have been shown to be significant indicators of either active or inactive flood plain surfaces. *Salix* and *Tamarix* seedlings are common on active channel features, but may be early indicators of active flood plain construction and thus channel narrowing.

Flood plain indicator species (active and inactive flood plains)
Salix exigua (seedlings)
Salix exigua (saplings/adults)
Tamarix ramosissima (seedlings)
Tamarix ramosissima (saplings/adults)
Conyza Canadensis
Equisetum hyemale and *E. laevigatum*
Distichlis spicata
Pascopyrum smithii
Euthamia occidentalis
Phragmites australis

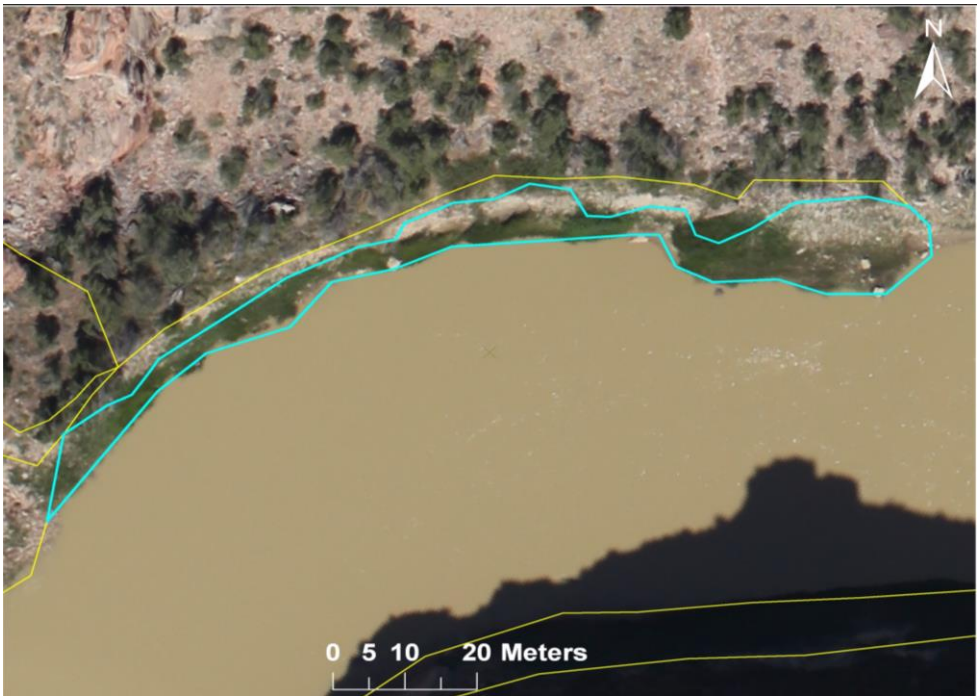

Figure 2. An active channel feature outlined in blue, associated with a pool immediately upstream of a debris fan. In such settings, where shear stresses presumably remain low even during high flows, a guild of active channel plant species (see Table 1) can show high cover even within the active channel zone. Such situations are not indicative of channel narrowing unless they are vertically accreting and/or have a persistence presence of flood plain indicator species.

Table 2. A list of plant species typically found in the active channel zone along the Yampa River and particularly in canyon settings. Although they typically occur with relatively low cover and frequency, they

may be locally abundant in certain hydrogeomorphic settings, such as pools or eddies above or below debris fans.

Active channel species guild
Apocynum cannabinum
Ambrosia tomentosa
Asclepias speciosa
Carex emoryi
Eleocharis palustrus
Equisetum hyemale
Glycyrrhiza lepidota
Iva axillaris
Polygonum amphibium
Spartina pectinata

Feature bounding: Features are delineated as polygons based on the 2011 imagery, airborne LiDaR data and a river stage at approximately 850 cubic feet per second at the Deerlodge gage. Thus, surveys should be conducted as close to this discharge as possible. If the discharge is more than a few hundred cfs less than this discharge, it should be noted on the imagery or in the field notes. Sampling should not be conducted if the discharge is more than a couple hundred cfs greater. Unless the feature is highly mobile and fundamentally shifts location, the initial boundary should be used in subsequent Rapido surveys and any deposition or erosion that adds to or removes portions of the feature should be noted and can be approximately drawn on the imagery or mapped with the iPad. The feature, if there are unidirectional changes in size, shape and elevation over time, can be re-mapped (re-bounded) the next time detailed imagery and/or airborne LiDaR is flown. The idea here is that we are tracking changes in the nature of the core feature as defined in the 2011 imagery and LiDaR data. Minor changes in the appearance of a feature due to differences in stage/discharge should be considered noise. It is assumed that significant erosional sculpting or vertical and/or lateral accretion of features will be noted and characterized during the Rapido surveys. If the surveys suggest consistent, widespread changes in both geomorphic form and vegetation on surveyed features, new, remotely sensed imagery could then be used to quantify the pattern and extent of the changes.

Rapido field-assessment—suggested work flow: The following is a proposed outline for a Rapido vegetation assessment: 1) with an image of the feature loaded on an iPad or as a hand-held paper copy, do a feature-wide assessment by walking the feature, looking for any vegetation patches that may appear on the image. If there are visible patches of vegetation on the imagery, determine if they are *about the same*, *smaller*, or *larger* now, compared to how they appear in the image; 2) if a significant portion of the feature has eroded, or a large area has been added by accretion, make a note of the change and roughly sketch it on the iPad or paper copy; 3) continue to walk the feature, noting the presence of any flood plain indicator species listed on the data sheet (electronic data sheet); 4) try to complete the feature-based assessment in 10 to 15 minutes; 5) if the active channel feature has a delineated flood plain surface that is vegetated or vegetating (see Figure 1), use enough quick-plots to sample ~0.5% of the features total area; and 6) if the active channel feature has a new vegetating flood plain surface not appearing in the image,

quickly trace the approximate boundary using the iPad and sample with quick-plots as described in step 5.

Rapido Vegetation Data Sheet Draft 1

Date: _____ Time: _____

Geomorphic Unit: _____

Feature-based assessment

Has overall vegetation cover increased compared with the imagery? Yes _____
No _____
Same _____

If increased, estimate the percentage increase (e.g., 5% to 20%) _____

Are there flood plain indicator species anywhere on the active channel surface?
Check if present:

Salix exigua (seedlings) _____
Salix exigua (saplings/adults) _____
Tamarix ramosissima (seedlings) _____
Tamarix ramosissima (saplings/adults) _____
Conyza canadensis _____
Equisetum hyemale and *E. laevigatum* _____
Distichlis spicata _____
Pascopyrum smithii _____
Euthamia occidentalis _____
Phragmites australis _____

Plot-based assessment

Check if the following flood plain indicators are present in the plot:

Quick Plot Number:	___	___	___	___	___	___	___
Salix exigua (seedlings)	___	___	___	___	___	___	___
Salix exigua (saplings/adults)	___	___	___	___	___	___	___
Tamarix ramosissima (seedlings)	___	___	___	___	___	___	___
Tam. ramosissima (saplings/adults)		___	___	___	___	___	___ ___
Conyza Canadensis	___	___	___	___	___	___	___
Equisetum hyemale/laevigatum	___	___	___	___	___	___	___
Distichlis spicata	___	___	___	___	___	___	___
Pascopyrum smithii	___	___	___	___	___	___	___
Euthamia occidentalis	___	___	___	___	___	___	___
Phragmites australis	___	___	___	___	___	___	___
Total veg. cover (nearest 5%)	___	___	___	___	___	___	___
Percent cover of sand	___	___	___	___	___	___	___
Percent cover of silt	___	___	___	___	___	___	___
Percent cover of clay	___	___	___	___	___	___	___

Notes: _____
_____