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 1.03 (November 2017)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	April 2014	K. Lund	Updated equipment list	Purchased more equipment	1.01
1.01	December 2015	D. Perkins	Updated equipment list	Changes to needs	1.02
1.02	Nov 2017	A. Washuta	Updated equipment list	Reorganized for Red Rocks/EP	1.03

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. Big river 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 July and late- 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 are often planned 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 needs with appropriate parks, and acquire backcountry camping permits, if necessary.
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.

Data sheets

Refer to appropriate SOPs for data sheets for vegetation, transducers, grain size distributions and photos.

Photos

Refer to appropriate SOPs for park specific photo data sheets.

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.
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. This information is also quickly available at the NCPN Climate Analyzer (http://www.climateanalyzer.org/NCPN/map_html) Applicable gages include:

   BLCA
   09128000 Gunnison River below Gunnison Tunnel, CO

   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
   09328920 Green River at Mineral Bottom, 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. **Make sure that the batteries are fully charged for all rechargeable equipment.**

BLACK CANYON OF THE GUNNISON EQUIPMENT LIST

Equipment needed to bring to BLCA is listed first (what goes in the vehicle), followed by a concise list of what to backpack into the Red Rocks site.

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		
Permit	2 per vehicle		one on dashboard, one with crew
Wilderness Entry Form	1 per site		Available from BLCA
Maps	1 per 2 people		
SOPs	1 per 2 people		
Clipboard/Binder	1 per 2 people	lightweight with interior storage	Ask crew for preference
Field notebook	variable	small, Rite-in-the-Rain©	field notes
Pencils & permanent markers	5 – 10 each		
Waders	1 per person	3 mm neoprene	optional during hot or cold weather
Wader repair kit	1	Includes Aquaseal and patches	Fix holes in waders
Magnetic Locator	1	Metal detector in hard case	Magna-Trak brand
Safety Equipment - *necessary for all SOPs*			
Backcountry first aid kit	1 per 2 people		Use if not rafting. Content list in NCPN Backcountry Safety Plan
Satellite phone	1		
Satellite phone charger	1 per phone		
DeLorme InReach	1		Include charging cable
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
Gloves	1 pair/botanist		For poison ivy
Tecnu	2		For poison ivy

Item	Number needed	Description	Notes
Sunscreen	2		Sun PPE
Equipment Necessary for ALL Vegetation Monitoring			
Veg Plot Datasheets	40		
Veg Walk Datasheets	20		
Unknown Plant Datasheets	10		
Compass	2	with declination setting	set declination, take transect bearings
Pin flags	30	narrow steel pins with flag top	mark locations
Flagging	3 rolls	Fluorescent	Mark locations
Permanent markers	6		Sharpie brand
Hand lenses	2		
2-gallon resealable plastic bags	min. 6	2- gallon or larger	collect plants
Masking tape	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	
Photo Datasheet	15		Printed 2-sided on Rite in Rain paper
Chalkboard	2	5 x 7"	label photos
Chalk	2		
2-way radios	One per person plus 4 extra		crew communication
Extra radio batteries	min. 24	AA alkaline	radios require 3 per unit
Reach species list	2	species previously recorded at reach	
100-m Kevlar taglines	7	Kevlar string with meter markings	set up transects
Rebar	min. 6 short & 6 long	3/8" diameter cut into 18" and ~36” lengths	secure taglines on uplands and in water
Sledgehammer	1		Placing rebar
Clawhammer	2		Placing rebar, includes spare
Cam straps	6	6 footers	Tighten taglines
Stakes	6	Heavy duty	Tighten taglines
100-m transect tapes	3	fiberglass reel tapes	cross-section transects. Includes spare.
Chaining pins	min. 6	striped metal pins	secure tapes
0.5 x1 m quadrat frames	2	Pvc pipe	Use for veg plots
Folding carpenter rulers	6	2m	Use for veg plots

Item	Number needed	Description	Notes
Transect relocation photos	R - 2	reference photos taken during establishment	
Compass	2	with declination setting	set declination, take transect bearings
BLCA Surveying Equipment			
Survey Rods	4		
Bipods	2		
Prisms	4		
Small Aluminum Tripod	1		
Tripod	1		For Total Station
Total Station	1		
Controller	1		Fully charged
Total Station Batteries	6		Fully charged
Survey Notebook	1		Rite in the Rain
Survey Revisit Sheet	2		
Tape Measures	4		
Metal Detector	1		
Turning Pins	20		Large nails
Metal Number Tags	20		Attach to Turning Pins
Chisel	1		
White Paint Marker	2		
Small Boat Equipment,			
PFD	2/boat		
Inflatable kayak (“Duckie”)	2		NCPN 2-person inflatable kayak
Duckie seats	4		Back support; fits inside boat
Paddles	4		
Duckie repair kit	2		In small blue box
Throw bag	2 small		
Alpaca packraft	1		In duffel bag
Airbag	1		Used to inflate boat
Packraft paddle	1		
Packraft repair kit	1		In small blue repair box
Transducer Equipment- All Trips (Establishment & Revisit)			
Hammer Drill	1	Charge batteries before leaving	
Hammer Drill charger	1		
Eye protection	1		

Drill bits	3	¼" bit (eyebolt) and 1/8" bit (extra holes)
Air can	1	Clear out hole during drilling
Transducers	5+	At least 4 leveloggers and 1 barologger
Casing	1 per transducer	Pre-Assembled (see "Big River logger deployment" document for full list)
Paint	2-3 cans	Match the rock color (tan, black, rust, gray)
Expanding anchor bolts	10 per site	Mostly ¼" x 2 ¼" and a few ¼" x 1 ¾". Includes 6 spares
Brackets	6 per site	U-shaped; single side-mount clasping. Includes spares
Washers	10 per site	¼". Includes 6 spares
Nuts	10 per site	¼" Includes 6 spares
Spare well casing or PVC in 5 foot length	2	1 ¼" diameter. Spare
PVC couplers	A few	1 ¼" diameter
PVC primer & glue	1 can each	In case PVC needs to be glued in field
3'-5' Well casing	1-5	Dependent on how many transducers are being put in
Hack saw	1	For cutting PVC
Hammer	1	
Spare Kevlar Line	~10 m	
Plumber's tape	1 roll	
Wrench	3	Includes 2 spares. Tightening nuts. 7/16", ¼", 5/16"
PVC wrench	1	
Crescent wrench	1	
Plumber's grease	1 tube	
Hose clamps or Zip ties	2 per site	For attaching barologger. Includes one spare.
Level	1	
Carpenter rulers	2	
Measuring tape	1	Rolling metric tape
Laptop computer	1	With HOBO software loaded and a working USB port
HOBO Shuttle	1	Connects to laptop via USB cable

GPS with transducer locations	1	
Transducer Reference Photos	1 set	
Transducer Datasheet	2	Write in rain paper, Checking reference mark measurements

Equipment to Backpack into Red Rocks (a subset of equipment listed above) NOTE: Stashed gear: sledgehammer, 7 rebar (4 long and 3 short). The gear is stashed on river left downstream of the fin just downstream of Feature C. It is on a shelf.		
Backcountry first aid kit	1 per 2 people	Use if not rafting. Content list in
NCPN Backcountry Safety Plan	1	
Satellite phone/DeLorme InReach	1 each	

Satellite phone/InReach charger	1 per unit	
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
Gloves	1 pair/botanist	For poison ivy
Tecnu	2	For poison ivy
Permits	2	
SOPs	1 per 2 people	
Wilderness Entry Form	1	Obtained at BLCA
Park plant list(s)	1/botanist	
Reach species list	1/botanist	List of species recorded previously
Field notebook	1 per person	For field notes
Radios	1.5/person	
Radio batteries	3 sets/radio	
GPS	1	
Maps	5	
Pinflags	~20	
Chaining Pins	6	
Pencils	2/person	
Sharpies	5	
Sunscreen	2	
Flagging	3 rolls	
Packraft	1 (2 is ideal)	Includes paddles, repair kit, air bag
Camera	2	Includes spare battery for each camera
Chalkboard	1	
Chalk	1 pack	
Reference photos	1 set	Transects, Transducers
Photo Datasheet	6	Printed 2-sided on Rite in Rain paper
Taglines	7	
Stakes & Cams	7	Same number as taglines
Survey Rods	4	
Bipods	2	
Prisms	4	
Small Aluminum Tripod	1	
Tripod	1	For Total Station

Total Station	1	
Controller	1	
Total Station Batteries	6	
Survey Notebook	1	Rite in the Rain
Tape Measures	4	
Metal Detector	1	
Turning Pins	20	Large nails
Metal Number Tags	20	Attach to Turning Pins
Chisel	1	
White Paint Marker	2	
Transducer Datasheets	2	Printed 2-sided on Rite in Rain paper
Laptop Computer	1	With transducer software installed
HOBO shuttle device	1	Check that it is the best one
Levels	2	1 large, 1 small
Grip-It Strap Wrench	1	
Channellock Tongue & Groove Plier	1	
Binder/Clipboard	1/botanist	
Folding Ruler	2/botanist	
PFD	2/boat	
Throw bag	2 small	
Alpaca packraft	1	In duffel bag
Airbag	1	Used to inflate boat
Packraft paddle	1	
Packraft repair kit	1	In small blue repair box
Unknown Plant Kit	1/botanist	
Veg Plot Datasheet	25	Printed 2-sided on Rite in Rain paper
Veg Walk Datasheet	8	Printed 2-sided on Rite in Rain paper
Small Drybags or Bear Cans	0.5-1/person	For bear-hanging food
Transducer Datasheet	2	Printed 2-sided on Rite in Rain paper
Photos Datasheet	5	Printed 2-sided on Rite in Rain paper
Rope/Cord		For bear-hanging food
Small Carabiners	1/Small Drybag	For bear-hanging food
Water Filters	2	
Stoves	2	
Stove Fuel	2	
Pot Sets	2	

Wag Bags	2/person
Trowel	1

CANYONLANDS EQUIPMENT LIST

Item	Number needed	Description	Notes
General Equipment			
GPS with extra batteries	3	Trimble GeoXM or more accurate	main unit and backup
CANY Permit	2		May not be needed if trip is organized by SEUG
River Shuttle Agreement	1 per vehicle		If using a private shuttle company
Maps	variable		Of each sentinel site
Belnap River Guide	1		Waterproof map with river miles
SOPs	1 per 2 people		
Clipboard/Binder	1 per 2 people		As crew for preference
Field notebook	1 per person	small, Rite-in-the-Rain©	field notes
Pencils & permanent markers	5 – 10 each		
2-way radios	1/person + 2 extras		crew communication
Extra radio batteries	many	AA alkaline	radios require 3 per unit
Magnetic Locator	1	Metal detector in hard case	Magna-Trak brand
Safety Equipment			
Check with CANY River Shop to see what equipment they're providing (river major first aid kit?)			
Satellite phone	1		
Satellite phone charger	1 per phone		
DeLorme InReach	1		
DeLorme InReach charger	1		
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
Transect, Photo and Vegetation Monitoring Equipment			
Rubber bands	Bag		Used for grouping pin flags in 10s

Item	Number needed	Description	Notes
Rebar	Transects: min. 18 short & 8 long Control (if est): 6 med pieces	3/8" diameter cut into 18" and ~36" lengths	For transects, use short ones to secure taglines on land and longer ones for in water. Includes spare. Control pieces are for establishing survey control points.
Sledgehammer	1		Placing rebar
Clawhammer	2		Placing rebar, includes spare
Compass	2	with declination setting	set declination, take transect bearings
Pin flags	100+	narrow steel pins with flag top	mark locations. Need 4 different colors.
Pin flag holder	2	So that surveyors can hold flags while laying out plots, belt attachment or shoulder strap	
Permanent markers	6		Sharpie brand for marking pinflags & unknown plant collections
Flagging	4 rolls	brightly colored	mark locations
Digital camera	3		
Extra battery for digital camera	3		
Chalkboard	2	5 x 7"	label photos
Chalk	2		
1 x1 m quadrat frames	2	Pvc pipe	Use for veg plots
Folding carpenter rulers	6	2m	Use for veg plots
Hand lenses	2		
2-gallon resealable plastic bags	min. 6	2- gallon or larger	collect plants
Masking tape	2		label plant collections
Trowel	2	small garden tool	extract specimen roots
Plant press in dry bag	1	field press with card, blotter, and paper	store plant collections for identification
Relevant floras and park species lists		various by park	
Previous plant walk lists for each sentinel site	2	species previously recorded at sentinel site plant walks	

Item	Number needed	Description	Notes
Datasheets: - CANY Establishment/Revisit - CANY Vegetation Plots (Keyed & Continuation) - CANY Timed Plant Walk - Unknown plants - CANY Photos			
Boating Gear Necessary – CANY will provide most of boating gear			
Check with CANY River Shop to see if NCPN needs to bring any boating equipment			
PFD	One per person		Personal Floatation Devices
Small dry bags	One each per person		Used as day bags
Large dry bags	One each per person		Used for overnighter gear
Carabiners	One each per person		Clearly labeled NCPN. Clip gear into boat.
Rocket boxes	4		Store science gear
Inflatable kayak ("Duckie")	2		NCPN 2-person inflatable kayak
Duckie seats	4		Back support; fits inside boat
Paddles	4		
Duckie repair kit	2		In small blue box
Throw bag	2 small		
Alpaca packraft	1		In duffel bag
Airbag	1		Used to inflate boat
Packraft paddle	1		
Packraft repair kit	1		In small blue repair box
Surveying Equipment			
RTK base	1		In yellow Pelican case including Trimble R6 receiver, 2 batteries, 1 antennae, 1 tribracht with optical plummet, 1 extender, 1 battery charging cradle, 1 charging power cord, 1 tape measure. Make sure batteries are fully charged before leaving
Base Battery	1		Small yellow jug Trimble battery. Make sure batteries are fully charged before leaving.

Item	Number needed	Description	Notes
Container of cords	1		3 cords for RTK base (2 black, 1 yellow). 1 black cord for RTK rover.
Tripod	2		For base radio. In orange canvas cases.
Base Radio	1		In yellow Pelican case, including cord to connect to base and battery
Base Radio antennae	1		35 Watt high-powered radio antennae
Base Radio battery	1		Usually a motorcycle or car battery
RTK rover	1		In yellow Pelican case, including Trimble R6 receiver, 2 batteries, 1 antennae, 1 battery charging cradle, 1 charging power cord
Seco carbon rod	1		For rover. Comes with quick-release attachment for receiver and flat topo boot
Data collector	1		Trimble TSC 3 with all the necessary files uploaded before leaving
Data collector holder	1		Attaching to rod. Two pieces.
Data collector charger	1		Power cord
Survey rebar caps	I - 12	1 1/2" pre-stamped with NCPN and dot in center	label rebar and cover top for safety
Stamp kit	1		Label rebar caps
Sledgehammer	1		Placing rebar
Screwdriver, pliers, and allen wrench set	1 each		attach prisms, tighten rods, troubleshoot equipment
10-m engineer's tape or rolling metric tape (>5m)	1 per surveyor + 2 spares		measure instrument and rod heights
Survey notebook	1		
Field notes from previous survey			Includes files to be uploaded to data collector
Reference geomorphology photos	R -2	reference photos taken during survey control establishment	
Generator	1	Honda EU1000i	Used to recharge batteries

Item	Number needed	Description	Notes
Gas & oil for generator	one 5 gallon + enough oil		
Chisel	1		Marking control points in rocks
White marker	1		Marking control points in rocks
Transducer Equipment- All Trips (Establishment & Revisit)			
Spare well casing or PVC in 5 foot length	2		1 ¼" diameter. Spare
PVC couplers	A few		1 ¼" diameter
PVC primer & glue	1 can each		In case PVC needs to be glued in field
3'-5' Well casing	1-5		Dependent on how many transducers are being put in
Hack saw	1		For cutting PVC
Hammer	1		
Spare Kevlar line	A bunch		To adjust height of transducer in casing and attach air transducers
Plumber's tape	1 roll		
Wrench	3		Includes 2 spares. Tightening nuts. 7/16", ¼", 5/16"
PVC wrench	1		
Crescent wrench	1		
Plumber's grease	1 tube		
Hose clamps	2 per site		For attaching barologger. Includes one spare.
Level	1		
Carpenter rulers	2		
Measuring tape	1		Rolling metric tape
Transducer Datasheet	2		Checking reference mark measurements
Hammer Drill	1		Charge batteries before leaving
Hammer Drill charger	1		
Air can	1		Clear out hole during drilling
Eye protection	1		
Drill bits	3		¼" bit (eyebolt) and 1/8" bit (extra holes)
Transducers	3 per site		2 leveloggers and 1 barologger

Item	Number needed	Description	Notes
Casing	1 per transducer		Pre-Assembled (see "Big River logger deployment" document for full list)
Paint	2-3 cans		Match the rock color (tan, black, rust, gray)
Expanding anchor bolts	10 per site		Mostly ¼" x 2 ¼" and a few ¼" x 1 ¾". Includes 6 spares
Brackets	6 per site		U-shaped; single side-mount clasping. Includes spares
Washers	10 per site		¼". Includes 6 spares
Nuts	10 per site		¼" Includes 6 spares
Chisel	1		
Paint Marker	2		
Laptop computer	1		With Solinst 4.0.3 software loaded and a working USB port
Solinst shuttle device	1		
Reference photos of transducer locations	1		
GPS with transducer locations	1		
Spare transducers	3		Should have a minimum of one set – 2 leveloggers and one barologger
Spare Brackets	6 per site		U-shaped; single side-mount clasping. Includes spares
Spare Washers	10 per site		¼". Includes 6 spares
Spare Nuts	10 per site		¼" Includes 6 spares

CURECANTI EQUIPMENT LIST

Item	Number needed	Description	Notes
General Equipment - *necessary for all SOPs*			
GPS with extra batteries	5+	Trimble GeoXM or more accurate	main unit and backup
GPS car charger	1		
Ziploc bags	6+	For GPS	
Digital camera	3		Transect, reference and overview photos
Chalkboards and chalk	3		
DBH tapes	3		
Extra battery for digital camera	3		
Permit	2		one with crew leader, one with a crew member
SOPs	1 per person		
Maps	Variable		Created by GIS tech for each site
Datasheets: 1. Photo	Variable		
Clipboard/binder	1 per person	lightweight with interior storage	As crew for preference
Field notebook	1 per person	small, Rite-in-the-Rain©	field notes
Pencils & permanent markers	5 – 10 each		
2-way radios	1 per person + 3 spare		crew communication; with cord to hang around neck
Extra radio batteries	lots	AA alkaline	radios require 3 per unit. In Good/Bad baggie system.
Waders	1 per person	3 mm neoprene	optional during hot or cold weather
Wader repair kit	1	Includes Aquaseal and patches	Fix holes in waders
Duckies	2		
Alpacka	1		

Item	Number needed	Description	Notes
Vehicles	2+	For shuttling duckies	
Paddles	5		
PFDs	1 per person, 1 spare for 3 people		
Throw bags	2		
Electric pump	1		
Barrell pump	1		
Ducky repair kit	1		
Cam straps	Varies		
Small day dry bags	1 per person		
Carbineers	6		
Kitchen box	2		
Roll-a-table	2		
Rain shelter	1		
Unknown plant kit	1		
Flora set	1		
Plant press	1		
Sharpies	5		
Safety Equipment - *necessary for all SOPs*			
Backcountry first aid kit	1 per 2 people		Content list in NCPN Backcountry Safety Plan
Satellite phone	1		
Satellite phone charger	1 per phone		
DeLorme InReach	1		
DeLorme InReach charger	1		
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

DINOSAUR EQUIPMENT LIST

Item	Number needed	Description	Notes
General Equipment - *necessary for all SOPs*			
GPS with extra batteries	3	Trimble GeoXM or more accurate	main unit and backup
GPS car charger	1		
iPad	1		For data collection. In waterproof Pelican case.
iPad charger	1		
Digital camera	3		transect headpins and mid-channel, survey monuments and reference marks, wells and piezometers
Extra battery for digital camera	3		
Permit	2		one with crew leader, one with a crew member
SOPs	1 per person		
Maps	Variable		Created by GIS tech for each site
Datasheets: 2. Est/Revisit 3. Veg Plots (keyed) 4. Plant walk 5. Facies & Grain Size 6. Photo 7. Transducers 8. Unknown plants	Variable		
Clipboard/Binder	1 per person	lightweight with interior storage	Ask crew for preference
Field notebook	1 per person	small, Rite-in-the-Rain©	field notes
Pencils & permanent markers	5 – 10 each		
Magnetic Locator	1	Metal detector in hard case	Magna-Trak brand
2-way radios	1 per person + 3 spare		crew communication; with cord to hang around neck
Extra radio batteries	lots	AA alkaline	radios require 3 per unit. In Good/Bad baggie system.
Radio harness	2		

Item	Number needed	Description	Notes
Waders	1 per person	3 mm neoprene	optional during hot or cold weather
Wader repair kit	1	Includes Aquaseal and patches	Fix holes in waders
Safety Equipment - *necessary for all SOPs*			
River major first aid kit	1	In small red ammo can.	Content list in NCPN Backcountry Safety Plan. Use if rafting
Backcountry first aid kit	1 per 2 people		Use if not rafting. Content list in NCPN Backcountry Safety Plan
Satellite phone	1		
Satellite phone charger	1 per phone		
DeLorme InReach	1		
DeLorme InReach charger			
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
DINO Vegetation Monitoring			
Rubber bands	Bag		Used for getting pin flags in groups of 10
1 x 1 m quadrat frames	2	PVC pipe	Use for veg plots
Folding carpenter rulers	6	2m	Use for veg plots
Pin flags	100+	narrow steel pins with flag top	mark veg plot locations
Permanent markers	6		Sharpie brand
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
Field plant press	1	field press with card, blotter, and paper	store plant collections for identification
Relevant floras and park species lists		various by park	
Flagging	2 rolls	Neon color	For flagging plots in dense vegetation
Sentinel site species list	1 per botanist	species previously recorded at reach	
Blue Number Tags	1 Set		

Item	Number needed	Description	Notes
DINO Plant Synonyms Sheet	1 per botanist		Utah & Colorado names
DINO Facies & Grain Size Mapping			
Sieves	1 set		In gray bag. Used to sample substrate
Foldable shovel	1		
Scale	1		In orange stuff sack
Bucket	1		5 gallon. To measure substrate
DINO Photos			
Chalkboard	2	5 x 7"	label photos
Chalk	2		
Compass	2	with declination setting	set declination, take transect bearings
Repeat Photo Binder	1 per site		Compiled overview photos

Camping Equipment

Group Camping Equipment – *Necessary for all field work that requires car camping*			
Stove	1-2		Include spare, if available
Propane	1-2		Ideally full containers
Kitchen box	1	Includes pots, pans, plates, bowls, silverware	
Tarp / rain shelter	1		If available. For tarp, bring ropes necessary to put it up.
Roll-a-table	1		If available when the crew is not camping in a campground
Water jugs	1 gal/person/day		
Tent repair	1	Tent tape and zipper wax	
Duct tape	1		
Backpacking Equipment – *Necessary for backpacking when flows are too low to raft*			
Water filters	2	MSR Sweetwater	Hand pump
Bucket	1		For settling water
Alum	1	Spice used to help settle particles out of water	
Water bladders	2		For water storage

Backpacking stoves	2		One that attaches to canister fuel bottle; one that attaches refillable fuel bottle
Fuel	various	White gas for refillable fuel bottle or canister fuel bottles	Bring extra
Lighters	2		For stoves
Cook set	2		Includes pots of various sizes
Trowel/shovel	1		
Wagbags	1/person/day		Use if camping in main basecamp
Spare tent	1		If available. Works out well to store extra equipment and use as back-up.

Rafting Equipment.

Rafting equipment, *Necessary for all multi-day rafting trips.*			
River Shuttle Agreement	1		For all rafting trips requiring a separate company to do the shuttle
River Map	1 per boat		Belnap's Waterproof Dinosaur River Guide
Raft	1-2		Including bowlines and chicken lines
Frame, including floor	1 per raft		
Frame straps	Four 2"-wide cam straps/frame		Attaching frame to boat
Aluminum dry box	1 per raft		Currently on long-term loan from CANY river office
Floor	1 per raft		Wooden pieces that attaches to the frame or solid metal floor
Floor straps	4 for wooden-floored frame		Two 3 ft cam straps & two 1 ft cam straps. Attaches floor to frame.
Cooler	1 per raft	80 qt	
Table	1 per raft		Fits on frame over drop bag bay. Needs two 6' cam straps
Drop bag	1 per raft		
Beaver Tail	1 per raft		Cargo floor for stern

Beaver Tail straps	3 per beaver tail	Two 4 ft cam straps & one 6 ft cam straps. Attaches cargo floor to raft.
Oars	3 per raft	Includes one spare
Oar locks	3 per raft	Two on frame + 1 spare in Repair Kit
Oar leashes	2 per raft	Cord attached from oar to frame
Oar counterbalances	2	Optional. Helps with rowing heavy oars.
Flip lines	2 per raft	Attaches to frame
Raft Repair kit	1 per raft	Includes spare oarlock. Double-check equipment list in repair kit. In designated red ammo can.
Hand pump	1	NRS barrel pump
Electric pump	1	Attaches to vehicle battery
Throw bag	1 big per raft	
Wrap Kit	1	In designated dry bag
PFD	One per person + one spare per raft	Personal Floation Devices
Helmets	One per person + spare	
Small dry bags	One each per person	Used as day bags
Large dry bags	One each per person	Used for overnighter gear
Cargo strap bag	~21 per raft	Various cam straps (2 of 15 ft, 2 of 10 ft, 5 of 8ft, 3 of 6 ft, 6 of 4 ft, 2 of 1 ft)
Water jugs	3 or more	Heavy-duty 5 gallon. General formula is 1 gal/person/day.
Stove	1	4 burner Partner stove
Propane	Enough for trip	Double-check stove fittings
Kitchen box	1	Double-check for necessary kitchen equipment, including bleach for dishes
Firepan	1	Only needed if fires intended
Fire blanket	1	In the Firepan bag
Kitchen floor	1	Mesh floor to put under tables
Bucket for charcoal	1	Used for straining ashes

Strainer	1	Used for straining dishwater
Hand Wash & hand soap	1	In designated blue bag
Dishtubs	4	Washing dishes with 4 tub system.
Dish drying mesh	1	Attaches to Roll-a-table
Dish washing accessories	Variable	Dish soap, sponges, brushes
Bleach	1 small bottle	Water sanitation
Groover	1	Necessary if on backcountry stretches. In designated rocket box
Groover seat & accessories	1	Includes seat, gloves, bleach, soap, spray bottle, brush. In designated rocket box.
Toilet paper	Necessary amount	In designated ammo can
Groover hand wash	1	Take every time we take the groover
Sandstake	1/raft	
Mallet	1/raft	Pounding in sandstake
Brush	1/raft	Used for cleaning raft
Sponge	1/raft	Used for cleaning raft
Buckets	3	5-gallon buckets. Two have screw-on lids.
Carabiners	7	Clearly labeled NCPN
Rocket boxes	4	
Roll-A-Table	optional	
Rain shelter	1	NRS River Wing
Small Boat Equipment		
Inflatable kayak (“Duckie”)	2	NCPN 2-person inflatable kayak
Duckie seats	4	Back support; fits inside boat
Paddles	4	
Duckie repair kit	2	In small blue box
Throw bag	2 small	
Alpaca packraft	1	In duffel bag
Airbag	1	Used to inflate boat
Packraft paddle	1	
Packraft repair kit	1	In small blue repair box

Survey equipment needed (RTK and Total Station (TS - Lodore WR only)).

Item	Number needed	Description	Notes
RTK Surveying			
RTK base	1		In yellow Pelican case including Trimble R6 receiver, 2 batteries, 1 antennae, 1 tribracht with optical plummet, 1 extender, 1 battery charging cradle, 1 charging power cord, 1 tape measure. Make sure batteries are fully charged before leaving
Base Battery	1		Small yellow jug Trimble battery. Make sure batteries are fully charged before leaving.
Container of cords	1		3 cords for RTK base (2 black, 1 yellow). 1 black cord for RTK rover.
Tripod	2		For base radio. In orange canvas cases.
Base Radio	1		In yellow Pelican case, including cord to connect to base and battery
Base Radio antennae	1		35 Watt high-powered radio antennae
Base Radio battery	1		Usually a motorcycle or car battery
RTK rover	2		In yellow Pelican case, including Trimble R6 receiver, 2 batteries, 1 antennae, 1 battery charging cradle, 1 charging power cord
Seco carbon rod	2		For rover. Comes with quick-release attachment for receiver and flat topo boot
Data collector	2		Trimble TSC 3 with all the necessary files uploaded before leaving
Data collector holder	2		Attaching to rod. Two pieces.
Data collector charger	2		Power cord
Rebar	variable		To establish new survey control
Survey rebar caps	I - 12	1 1/2" pre-stamped with NCPN and dot in center	label rebar and cover top for safety
Stamp kit	1		Label rebar caps
Sledgehammer	1		Placing rebar
Screwdriver, pliers, and allen wrench set	1 each		attach prisms, tighten rods, troubleshoot equipment
10-m engineer's tape or rolling metric tape (>5m)	1 per surveyor + 2 spares		measure instrument and rod heights

Item	Number needed	Description	Notes
Survey notebook	1		
Field notes from previous survey			Includes files to be uploaded to data collector
Laminated survey code cheatsheet	1 per surveyor		
Reference geomorphology photos	R -2	reference photos taken during survey control establishment	
Generator	1	Honda EU1000i or GoalZero	Used to recharge batteries
Gas & oil for generator	one 5 gallon + enough oil		
Chisel	1		Marking control points in rocks
White marker	1		Marking control points in rocks
Total Station Surveying			
Total station with 6 batteries	1		make sure batteries are fully charged before leaving
Charger for total station	2		use when electricity is available. Includes battery cradle and power cord.
Battery charger for total station	2		Battery cradle
Power cords for total station charger	2		
12V battery total station & datalogger charger	1		Attaches directly from battery and does not need the inverter
Datalogger with Survey Pro software	1		make sure batteries are fully charged before leaving
Charger for datalogger	1		
Hand-held weather unit	1		Highgear brand, WeatherPort model. Used for calibrating temperature & pressure in total station. Stored in total station case.
Tripod	2	1 wooden and 1 metal with screw-mount adjustable legs	to mount total station, includes spare & carrying cases
Prism poles	3	identical	includes attached levels and both flat foot and a point on the end
Prism poles extenders	3	orange & white stripe sections	good for visibility in thick vegetation
Leveling rod	3	identical, telescoping to 5 m	with adapters to mount prisms
Levels for leveling rods	3		need to attach to rods before surveying

Item	Number needed	Description	Notes
Bipods	2		used to turn a prism pole into a free-standing tripod
Prisms	4	identical	for rods and backsight, includes spare & padded cases for each prism
10-m engineer's tape or rolling metric tape (>5m)	4		measure instrument and rod heights; one for each person, includes spare
Tool pouch	1		holds equipment for survey lead
Survey notebook	1		
2-way radios	1/person + 1 spare		
Extra radio batteries	many		For 2-way radios
Ear piece with microphone	1	compatible with radios	for person running total station
Survey umbrella	1		
Umbrella stand	1	separate tripod to support the umbrella	
Rebar	I - min. 12, R - 4	3/8" diameter cut in 0.5 m lengths	permanent survey markers
Survey rebar caps	I - 12	1 1/2" pre-stamped with NCPN and dot in center	label rebar and cover top for safety
Stamp kit	1		Label rebar caps
Sledgehammer	1		Placing rebar
Screwdriver, pliers, and allen wrench set	1 each		attach prisms, tighten rods, troubleshoot equipment
Flagging	4 rolls	brightly colored	mark locations
GPS	2	survey grade with horizontal accuracy < 0.1 m	includes spare
Field notes from previous survey			Includes files to be uploaded to datalogger
Reference geomorphology photos	R -2	reference photos taken during survey control establishment	
Total station & Survey Pro manuals	1 each		
Marine battery (12 V)	1		charging electronic equipment on raft trips
Multimeter	1		checking charge of batteries
Battery Inverter	1	plugs into marine battery	charge electronic equipment
Car Inverter	2	Plugs into car	charge electronic equipment

Transducer Equipment

Transducer Equipment- All Trips (Establishment & Revisit)		
Spare well casing or PVC in 5 foot length	1	1 ¼" diameter. Spare
PVC couplers	A few	1 ¼" diameter
PVC primer & glue	1 can each	In case PVC needs to be glued in field
Hack saw	1	For cutting PVC
Hammer	1	
Spare Kevlar line	A bunch	To adjust height of transducer in casing and for barologgers
Plumber's tape	1 roll	
Wrench	3	Includes 2 spares. Tightening nuts. 7/16", ¼", 5/16"
PVC wrench	1	
Crescent wrench	1	
Vise Grip		
Plumber's grease	1 tube	
Epoxy	1	
Zip ties	1 small bag	For attaching barologger
Hose clamps	2 per site	For attaching barologger. Includes one spare.
Level	1	
Carpenter rulers	2	
Measuring tape	1	Rolling metric tape
Transducer Datasheet	1	Checking reference mark measurements
Transducer Reference Photos	1 per site	
Spare Ziplocks	3	
Hammer Drill	1	Charge batteries before leaving
Hammer Drill charger	1	
Air can	1	Clear out hole during drilling
Eye protection	1	
Drill bits	3	¼" bit (eyebolt) and 1/8" bit (extra holes)
Transducers	3 per site	2 leveloggers and 1 barologger
Casing	1 per transducer	Pre-Assembled (see "Big River logger deployment" document for full list)
Paint	2-3 cans	Match the rock color (tan, black, rust, gray)
Expanding anchor bolts	10 per site	Mostly ¼" x 2 ¼" and a few ¼" x 1 ¾". Includes 6 spares
Brackets	6 per site	U-shaped; single side-mount clasping. Includes spares
Washers	10 per site	¼". Includes 6 spares

Nuts	10 per site	¼" Includes 6 spares
Chisel	1	
Paint Markers	2	
Laptop computer	1	With Solinst 4.0.3 software loaded and a working USB port
Solinst shuttle device	1	
Reference photos of transducer locations	1	
GPS with transducer locations	1	
Spare transducers	3	Should have a minimum of one set – 2 leveloggers and one barologger
Spare casings	1-2	
Spare Brackets	6 per site	U-shaped; single side-mount clasping. Includes spares
Spare Washers	10 per site	¼". Includes 6 spares
Spare Nuts	10 per site	¼" Includes 6 spares

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

Standard Operating Procedure (SOP) #2

Hiring and Training Observers

Version 1.01 (December 2015)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	12/17/15	D. Perkins	Editing for current practices	Previous version was largely a copy of wadeable streams	1.01

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 to five 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), CPR and/or Swift Water Rescue are assets. 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 Big River 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/RTK and post processing survey data.
- 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. Due to the differences in measuring vegetation on the different rivers, all training is done in the field as part of the scheduled field hitch. Crew members from previous seasons normally do not need as much training in plant-identification skills as new crew members. 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.

4. 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. A river talk (hand signals, what to do in the water, proper positioning for rapids, sunburn, etc.) is given by an experience boater prior to the boats launching. In addition, safety talks are given prior to the first big rapid and are repeated and reviewed depending on the day's plans and conditions.

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

Standard Operating Procedure (SOP) #3

Using Global Positioning System (GPS) Units

Version 1.02 (December 2016)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	1/4/16	D. Perkins	Editorial and due to methods changes in other SOPs. Removed rapid assessment portion.	Clarity. Currently not doing rapid assessments.	1.01
1.01	12/2016	A. Wight	Rewrote SOP to reflect Big Rivers methods	To capture updated protocol changes	1.02

This SOP explains the procedures and considerations that all observers should follow when navigating to and/or collecting geospatial data at big river monitoring locations.

This SOP assumes that each observer is familiar with the operation and function of the GPS unit to be used for this project. This SOP is intended to complement, not replace, the operations manual accompanying the GPS unit. Each observer should be familiar with the use of their particular GPS unit before entering the field to collect data or navigate to points. This SOP does not require the use of a specific brand of GPS unit; however, the unit must meet the minimum standards listed below.

Definitions and Acronyms

Accepted data	Data that have undergone all QA and QC procedures as defined in the published protocol and associated SOPs.
Coordinate system	Any three-dimensional reference frame that locates objects in space.
Data dictionary	Information (data) that describes features that will be located in the field.
Feature	A physical object or location of an event. A feature can be a point, line, or polygon (area).
FGDC	Federal Geographic Data Committee. The interagency committee that promotes the coordinated development, use, sharing, and dissemination of geographic data.
GIS	Geographic Information Systems. A computerized system used to input, manage, manipulate, analyze and display geographic data in digital form.

GPS	Global Positioning System (unit/receiver/datalogger). A three part system of 1) 25+ Department of Defense satellites, 2) Control segment, 3) Users with receivers.
I&M	Inventory & Monitoring Program of the National Park Service
Master database	Project-specific database that stores the full project dataset and is used for viewing, summarizing, and analysis. Contains only accepted data.
NCPN	Northern Colorado Plateau Network
NPS	National Park Service
Quality assurance (QA) procedures	Procedures used to ensure collection of data with minimal errors.
Quality control (QC) procedures	Procedures used to flag or modify data to ensure that data meet established data quality standards.
Raw data	Data that have not been subjected to either quality control or documentation procedures; includes data recorded by hand on hard-copy forms, digital files from handheld devices, GPS receivers, telemetry data loggers, etc.
SOP	Standard Operating Procedure
Spatial dataset	A dataset that is natively read by mapping software; often produced by mapping software, such as ESRI ArcMap and ArcInfo; also includes georeferenced imagery, geodatabases, as well as hardcopy aerial photographs, satellite imagery and maps.
Tabular dataset	A dataset organized in a table or group of tables where each column and row has a specific interpretation; often produced by MS Excel, MS Access, database, or statistical software, and managed as text, spreadsheet, or relational databases.
Working database	A project-specific database for entering and processing data for the current season (or other logical period of time).

1. GPS overview

The primary role of GPS for Big Rivers Monitoring is to get an idea of the layout of the sentinel site (monitoring location), and what features are there as well as their relation to each other. Minimal, if any, data are collected with GPS, as most locational data is collected during the survey part of the monitoring of each sentinel site. The NCPN requires the use of a mapping grade GPS unit to navigate to and record any data.

1.1 Minimum GPS Receiver Requirements

- Capable of uploading pre-determined (potential) monitoring locations
- Capable of utilizing data dictionary utilities (NCPN *PARK* Big Rivers Data Dictionary, see section 2.3)
- Capable of utilizing park-specific background GIS data layers
- Capable of navigation
- Capable of maintaining 4 or more satellites

- Capable of maintaining horizontal errors of less than 5 meters (PDOP (or equivalent error reading) of less than 6)
- Capable of post data collection correction (differential correction)
- Capable of storing date, time, elevation and coordinates of features collected (in addition to data dictionary items)
- Capable of exporting features collected to a GIS data format

1.2 GPS Unit Setup

The NCPN currently uses the Trimble line of mapping grade GPS units and TerraSync Professional software to capture minimal spatial data for the Big Rivers Protocol. The requirements should be transferable to other mapping grade GPS receivers (such as Leica, etc.).

Positional accuracy can be affected by several factors which mapping-grade GPS units can track and to some extent, compensate for. Table 1 lists these functions, their definitions, and the standard settings.

Table 1 Minimum GPS Receiver Settings Standards

Name	Definition	Standard
Almanac	GPS unit collects data containing estimated position of satellites, time corrections, and atmospheric delay parameters.	The unit will automatically collect the almanac. Acquire within 10 days prior to data collection or navigating, download to computer.
Altitude reference	Ellipsoid model	Height Above Ellipsoid (HAE)
Antenna heights	GPS unit height above the ground (average).	1.0 – 1.5 meters
Coordinate System	A reference system consisting of a set of points, lines, and/or surfaces, and a set of rules, used to define the positions of points in space in either two or three dimensions.	Universal Transverse Mercator (UTM)
Datum	Geodetic model designed to fit a point on the earth's surface to the ellipsoid.	NAD 1983 (Conus)
Elevation mask	The minimum angle at which a GPS receiver will track satellite vehicles.	15 degrees
Logging intervals	Time interval between positions gathered.	Point: 1 second Line and Polygon: 5 seconds
Minimum number of positions for a point feature	Number of positions received then averaged to create a point feature.	10 - 20
Mode	2-Dimensional or 3-Dimensional	3-Dimensional (4 satellites)
PDOP Mask	Positional Dilution of Precision is a measurement of the geometry of the satellites.	6.0 or less
Satellite vehicles	Number of satellites, currently a constellation of 28 DOD satellites.	4

Name	Definition	Standard
SNR Mask	Signal-to-Noise Ratio is a measure of the strength of the satellite signal relative to background noise.	4.0
Unit of Measure	Units of measure.	Meters
Zone	In UTM coordinate system, the globe is divided into 60 north-south zones.	Zone 12 North (N)* *Black Canyon & Curecanti are Zone 13 N

1.3 Data Dictionary

A data dictionary should be utilized to facilitate field data navigation and collection. The minimum elements necessary for the Big Rivers data dictionary are shown below. Once the project manager has given the GIS technician all (RTKed) data for a given park, those points are then imported with the Big Rivers data dictionary (using Pathfinder Office), creating a data file for use in the field (*PARK*_BigRiv.imp). All point features in the Big River Data Dictionary should have the default feature settings of:

Logging Interval	Time = 1 second
Minimum Positions	3
Accuracy	Code
Label 1	ReachID

The following data dictionary digital files (.ddf) can be obtained by contacting the NCPN Data Management staff. Since each park with Big River monitoring has slightly different SOPs, each park has a unique data dictionary, although there are many same features throughout all data dictionaries.

Black Canyon of the Gunnison National Park Big Rivers Data Dictionary

Before each field hitch, the following data dictionary, populated with existing data of the 2 sentinel sites, will be loaded onto several GPS units. The data is primarily to help the field crew locate existing (established) locations, not to collect new locations, as the survey team will do the spatial data collection. If a spatial feature is collected via GPS (such as a photo point), allow the point to collect 10+ satellites hits, fill in the appropriate attributes, then save the feature. Given the terrain in Black Canyon, marking the location on a paper map as well is encouraged.

ControlPt Feature – This feature identifies locations where the tripod or RTK base are located within the sentinel site.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
POINTID	Unique ID	Entry permitted in the field	Numeric
Site	Sentinel site name	Entry permitted in the field	Text - Optional

PT_TYPE	• Control point • Occupy point • Base setup point • Temp base setup • Future control • Other	Entry permitted in the field	Menu
Comments	Any comments regarding the control point	Entry permitted in the field	Text – Optional
Headpin Feature – This feature delineates where the headpins for each transect within the feature are located.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
ID	Coded unique identifier. Feature Letter, Transect number, Right or Left HeadPin, number. Example: "G2RHP203" is Feature G, Transect 2, Right head pin, 203.	Entry permitted in the field	Text – Optional
Descriptio	Description	Entry permitted in the field	Text – Optional
SiteName	Name of the sentinel site	Entry permitted in the field	Text – Optional
Comments	Any comments/notes regarding this headpin	Entry permitted in the field	Text – Optional
Orientation Feature - This feature delineates where the orientation pin is located within the feature. Once an observer has found the head pin and the orientation pin, the transect can be established.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
ID	Coded unique identifier. Feature Letter, Transect number, Distance from headpin to orientation pin, Pin number. Example "G2D6P203" is Feature G, Transect 2, Distance 6 meters from headpin 203.	Entry permitted in the field	Text – Optional
Descriptio	Description	Entry permitted in the field	Text – Optional
SiteName	Name of the sentinel site	Entry permitted in the field	Text – Optional
Notes	Any comments/notes regarding this orientation pin	Entry permitted in the field	Text – Optional
Transducer Feature - This feature locates where transducers were placed, both water and air transducers.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
ID	Unique identifier of the transducer. Site name, Air or Water, number. Example: "EPW6" is East Portal, Water, #6.	Entry permitted in the field	Text – Optional
Transducer	Transducer type: • Air • Water • Other	Entry permitted in the field	Menu
River	Side of river: • Right • Left • NA	Entry permitted in the field	Menu
Comment	Any comments/notes regarding this transducer	Entry permitted in the field	Text – Optional

LocationNotes	Specific notes about the location. Example: "btn D1 & D2"	Entry permitted in the field	Text – Optional
PhotoPt Feature - This feature maps the location where repeat overview photographs are taken.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
SiteName	Name of sentinel site	Entry permitted in the field	Text – Optional
PhotoNum	Unique photo number	Entry permitted in the field	Text – Optional
LocationNotes	Specific notes about the location of the photo point	Entry permitted in the field	Text – Optional
Comment	Any comments/notes regarding this photo point	Entry permitted in the field	Text – Optional
Other Feature – This feature is for incidental observations, such as a gear cache or invasive plant location or some other item for which a location is helpful.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the other feature point	Entry permitted in the field	Text – Optional
Notes	Any additional notes about the other feature point		
Route Feature – This feature creates a line, or route, should such a feature be helpful. Generally, use this feature on the way back from the sentinel site or geomorphic feature.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the route feature		
Notes	Any additional notes about the route feature		

Canyonlands National Park Big Rivers Data Dictionary

Prior to the field hitch, the following data dictionary, populated with existing data, will be loaded onto several GPS units. The data is primarily to help the field crew locate existing (established) locations, not to collect new locations, as the survey team will do the spatial data collection. If a spatial feature is collected via GPS (such as an invasive point), allow the point to collect 10+ satellites hits, fill in the appropriate attributes, then save the feature.

BaseLocation Feature – This feature identifies locations where the RTK base stations are located within the sentinel site.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
POINTID	Unique ID	Entry permitted in the field	Numeric
PT_TYPE	• Control point • Occupy point • Base setup point • Temp base setup • Future control • Other	Entry permitted in the field	Menu
SiteName	Name of the sentinel site	Entry permitted in the field	Text – Optional

Comment	Any comments regarding the control point	Entry permitted in the field	Text – Optional
Transducer Feature - This feature locates where transducers were placed, both water and air transducers.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
SiteName	Name of the sentinel site	Entry permitted in the field	Text – Optional
ID	Unique identifier of the transducer. Site name, Location (upstream or downstream). Example: "HCUS" is Holeman Canyon, (Water), upstream.	Entry permitted in the field	Text – Optional
Transducer	Transducer type: • Air • Water • Other	Entry permitted in the field	Menu
River	Side of river: • Right • Left • NA	Entry permitted in the field	Menu
Comment	Any comments/notes regarding this transducer	Entry permitted in the field	Text – Optional
Notes	Any other notes/comments about the transducer	Entry permitted in the field	Text – Optional
PhotoLocation Feature - This feature maps the location where repeat photographs are taken.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
PhotoNum	Photo number by site	Entry permitted in the field	Text – Optional
Type	• Overview photo • Transect photo • Feature photo • Other	Entry permitted in the field	Text – Optional
SiteName	Name of sentinel site	Entry permitted in the field	Text – Optional
Comment	Comment about photo location point	Entry permitted in the field	Text – Optional
Notes	Any comments/notes regarding this photo point	Entry permitted in the field	Text – Optional
Other Feature – This feature is for incidental observations, such as a gear cache or invasive plant location or some other item for which a location is helpful.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the other feature point	Entry permitted in the field	Text – Optional
Notes	Any additional notes about the other feature point	Entry permitted in the field	Text – Optional
Invasive Feature – This feature is to note any populations of invasive (trees) noted along the river.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Species	• Russian olive • Elm • Catalpa • Tree of heaven	Entry permitted in the field	Text – Optional

	• Other		
Notes	Any comments/notes regarding the invasive point taken.	Entry permitted in the field	Text – Optional
Route Feature – This feature creates a line, or route, should such a feature be helpful. Generally, use this feature on the way back from the sentinel site or geomorphic feature.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the route feature	Entry permitted in the field	Text – Optional
Notes	Any additional notes about the route feature	Entry permitted in the field	Text – Optional

Dinosaur National Monument Big Rivers Data Dictionary

Before each field hitch, the following data dictionary, populated with existing data, will be loaded onto several GPS units. The data is primarily to help the field crew locate existing (established) locations, not to collect new locations, as the survey team will do the spatial data collection. If a spatial feature is collected via GPS (such as a photo point), allow the point to collect 10+ satellites hits, fill in the appropriate attributes, then save the feature.

ControlPt Feature – This feature identifies locations where the tripod or RTK base are located within the sentinel site.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
POINTID	Unique ID	Entry permitted in the field	Text – Optional
PT_TYPE	• Control point • Occupy point • Base setup point • Temp base setup • O'Brien • Other	Entry permitted in the field	Menu
Site	Name of the sentinel site	Entry permitted in the field	Text – Optional
Comment	Any comments regarding the control point from years past.	Entry permitted in the field	Text – Optional
NewNotes	Any comments/notes noted during this field visit	Entry permitted in the field	Text – Optional
Transducer Feature - This feature locates where transducers were placed, both water and air transducers.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
SiteName	Name of the sentinel site	Entry permitted in the field	Text – Optional
ID	Unique identifier of the transducer. Site name, Location (upstream or downstream), # if applicable. Example: "IPUS1" is Island Park, (Water), upstream, #1.	Entry permitted in the field	Text – Optional
Transducer	Transducer type: • Water • Air • Other	Entry permitted in the field	Text – Optional

River	Side of river: • Right • Left • NA	Entry permitted in the field	Menu
Comment	Any comments/notes regarding this transducer	Entry permitted in the field	Text – Optional
Notes	Any other notes/comments about the transducer	Entry permitted in the field	Text – Optional
PhotoPt Feature - This feature maps the location where repeat sentinel site overview photographs are taken.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
SentinelSi	Sentinel site name: • Deerlodge • Laddie Park • Browns Park • Seacliff • Winnies • Other • Harding Hole • Echo Park • Limestone • Island Park • New (name in Notes)	Entry permitted in the field	Menu
PhotoNum	Photo number by site	Entry permitted in the field	Text – Optional
Comment	Comment about photo location point	Entry permitted in the field	Text – Optional
Notes	Any comments/notes regarding this photo point	Entry permitted in the field	Text – Optional
PhotoSynth Feature – This feature contains the location where photo synth photos were/are taken.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
SentSite	Sentinel site name: • Deerlodge • Laddie Park • Browns Park • Seacliff • Winnies • Other • Harding Hole • Echo Park • Limestone • Island Park • New (name in Notes)	Entry permitted in the field	Menu
Code	Identifier of Photosynth location	Entry permitted in the field	Text – Optional
Year	The year the point was established	Entry permitted in the field	Text – Optional
Notes	Any additional notes about the photosynth feature point	Entry permitted in the field	Text – Optional
Route Feature – This feature creates a line, or route, should such a feature be helpful. Generally, use this feature on the way back from the sentinel site or geomorphic feature.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the route feature	Entry permitted in the field	Text – Optional

1.4 Collecting data

Once you've arrived to the sentinel site, it's time to collect the GPS locations necessary. Appendix A contains detailed instructions for use with the big river data dictionary and various

files. Open the necessary file, and begin logging the point and any required data. Each point collected should be allowed to receive 10 positions before ending data collection and moving onto collecting another type of point.

1.5 Downloading

When data collection is finished, the GPS data need to be downloaded. The NCPN GIS technician downloads the data from the GPS unit(s) after each field excursion, and then differentially corrects the data, using the appropriate (closest) base station. The corrected GPS files are then exported to a GIS data format. Table 2 indicates the attributes to capture while exporting the corrected GPS data into a GIS data format (i.e., "turn on" in Pathfinder Office).

Table 2. GPS Auto-generated attributes to capture.

PDOP	Update Status	Height
Correction Status	Data File Name	Vertical Precision
Receiver Type	Total Positions	Horizontal Precision
Date Recorded	Filtered Positions	Standard Deviation
Time Recorded	Data Dictionary Name	Position

Data should be exported using the same coordinate system used in the field (UTM, NAD83 Conus, Zone 12 or 13, meters).

1.6 Uploading to the master Big River Database

Generally any collected GPS data will serve as a placeholder until the location can be obtained from survey data. When a GPS location, such as a photo point, is to be placed in the Big Rivers database, it first needs to be validated and verified (GPS points given a visual review and attributes verified) in ArcGIS. The GPS data is then exported from ArcMap into an Excel spreadsheet for importing into the Big Rivers Database.

Appendix A

File explanations:

Existing Data Files on GPSes:

- *1PARK_BigRiver* – This file will contain all the surveyed features for each feature in the park. There will be two files, 1PARK_BigRiver and 2PARK_BigRiver in case one file times out while in the field. The two files are identical.

Background Layers (Files):

- *PARK*_Roads – This file contains the roads for the park.
- *PARK_Trails* – This file contains the trails for the park.
- *PARK_bnd* – This file contains the park boundary.
- *PARK_Drainages* – This file contains the "streams" (hydrography) for the park.
-

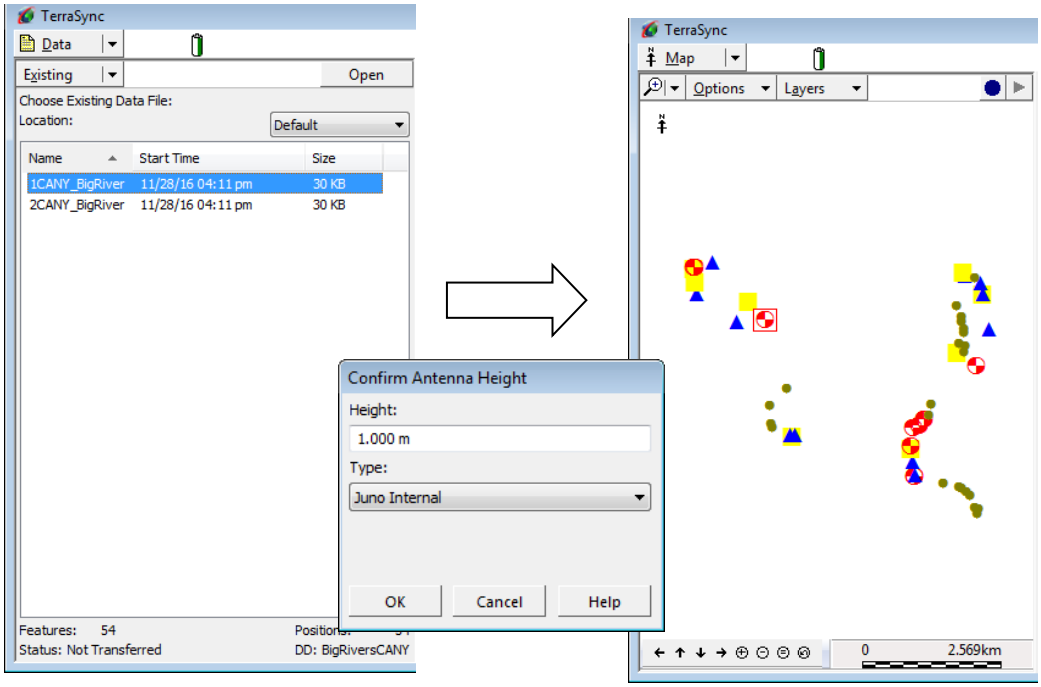
Basic instructions:



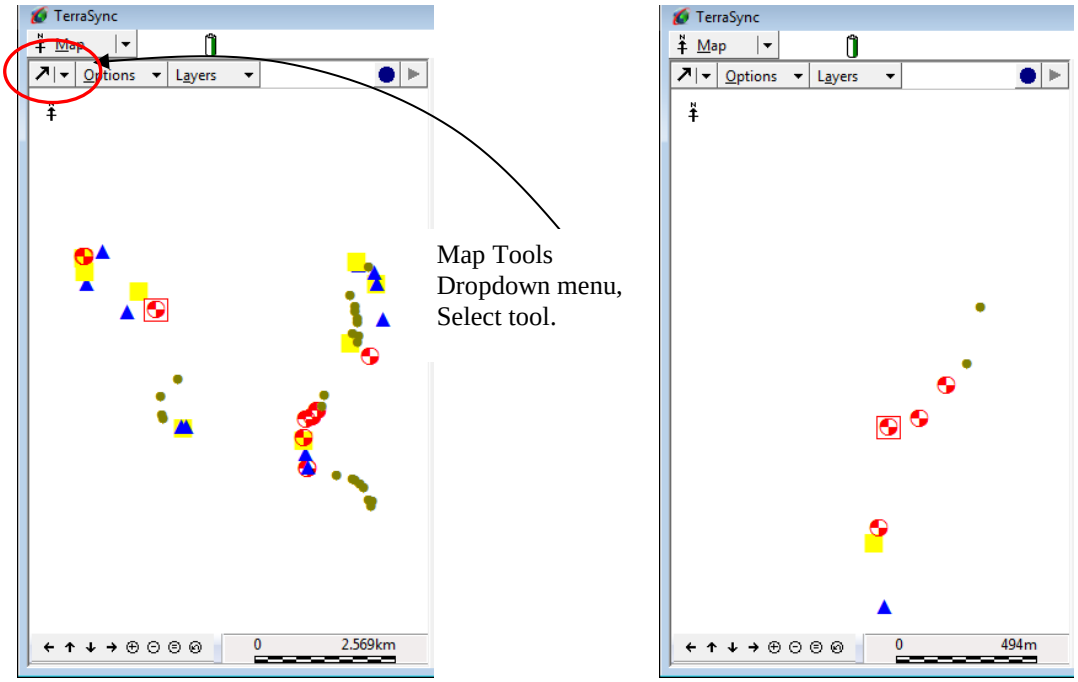
The following instructions are based on using a Trimble GPS unit with TerraSync Professional GPS software loaded. The directions below demonstrate one way of recording and navigating through the screens and options in TerraSync, not the only way to GPS data needed for monitoring points. Big River monitoring does not require much, if any, collecting of new GPS data, rather, the data provided in the files is primarily there to assist the field crew in finding general location of features.

Navigation:

To navigate to a point, open the file which contains the point you want to update. Change the screen to the Map View (tap on the Data drop down, and choose Map).

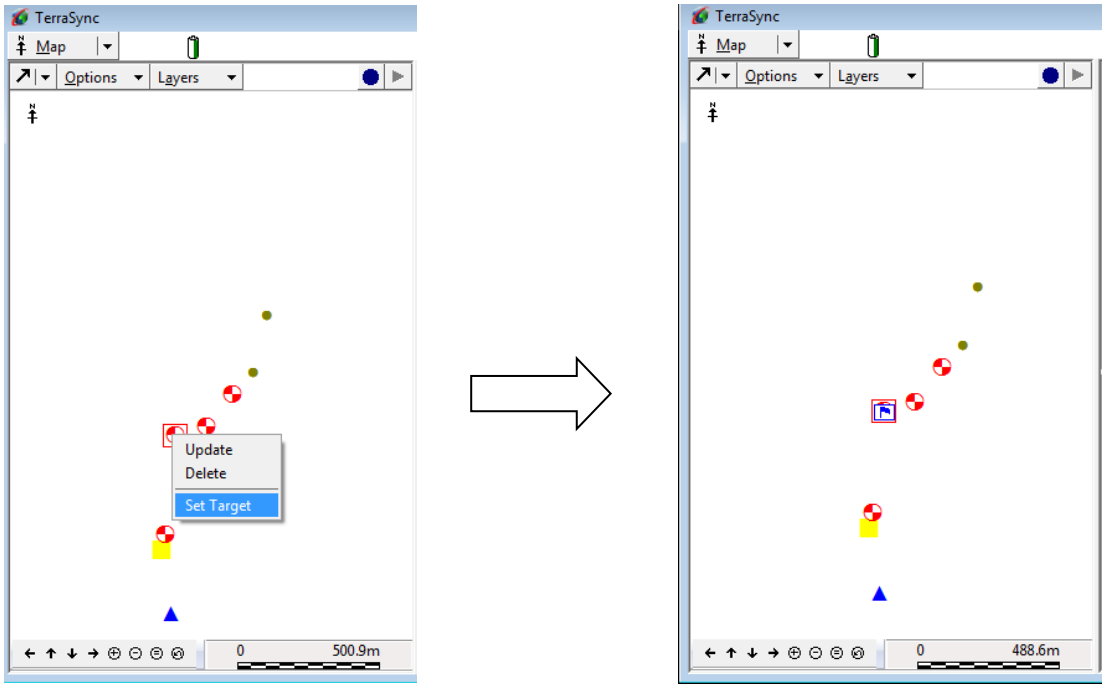


Using the Map Tools (the drop down menu directly underneath Map), use the Select tool to select the point to which you wish to navigate. A box will display around the point.



Map Tools Dropdown menu, Select tool.

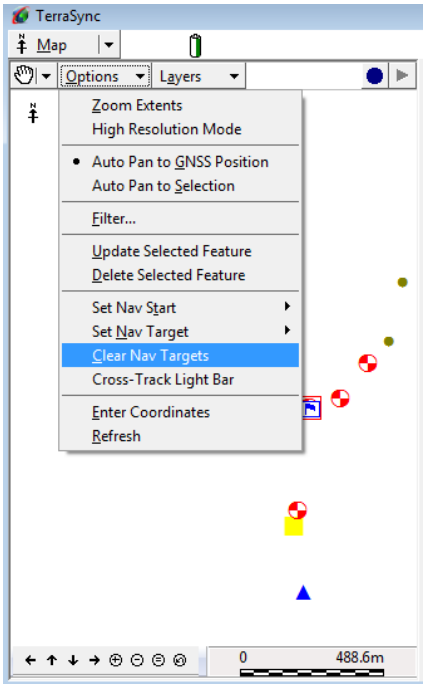
Tap and hold on the point to which you would like to navigate, and a popup menu will popup, choose Set Target. A navigation symbol will appear over your point.



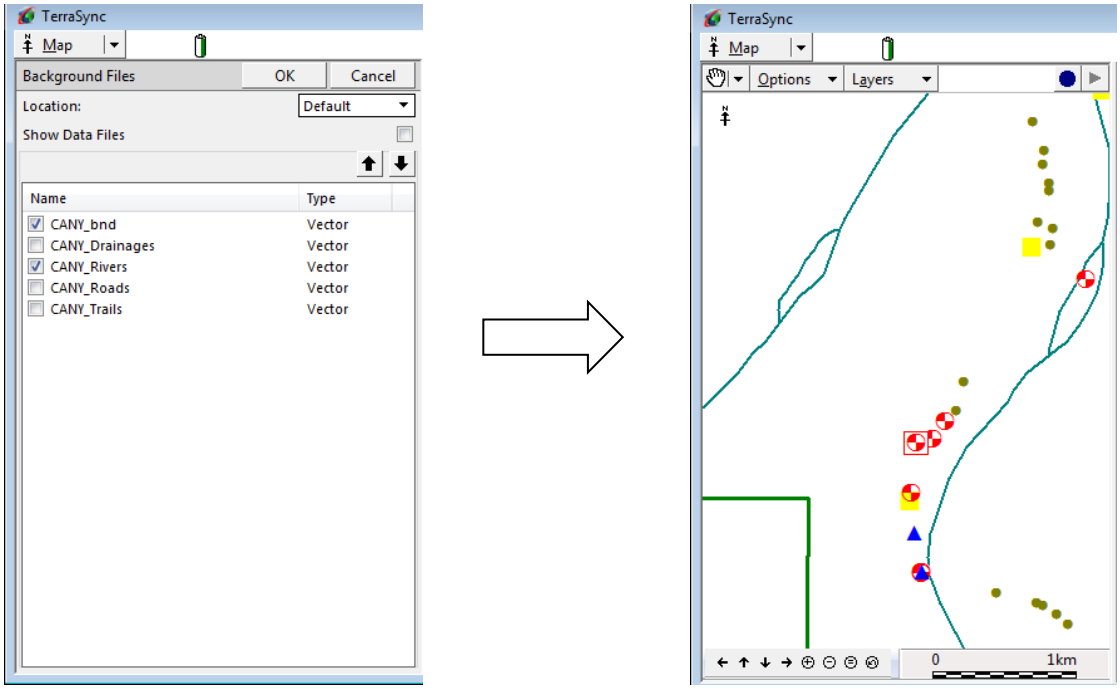
Open the Navigation section (click on Map and choose Navigation). This will open the navigation screen. As you move, this screen will display the information needed to navigate to the point.



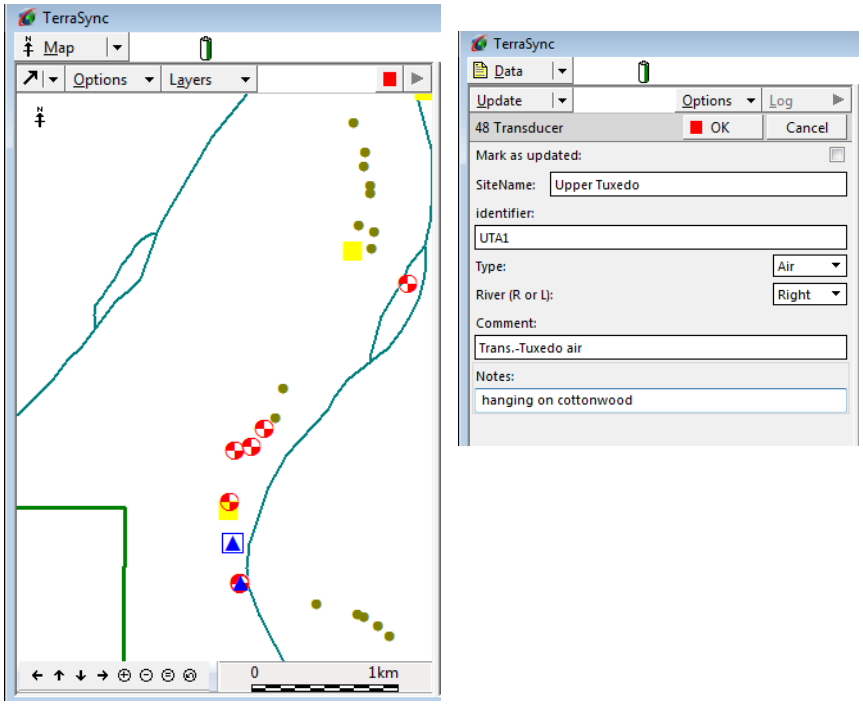
When you've reached your point and/or no longer need to navigate, select the Map screen, then go to Options and select Clear Nav Targets.



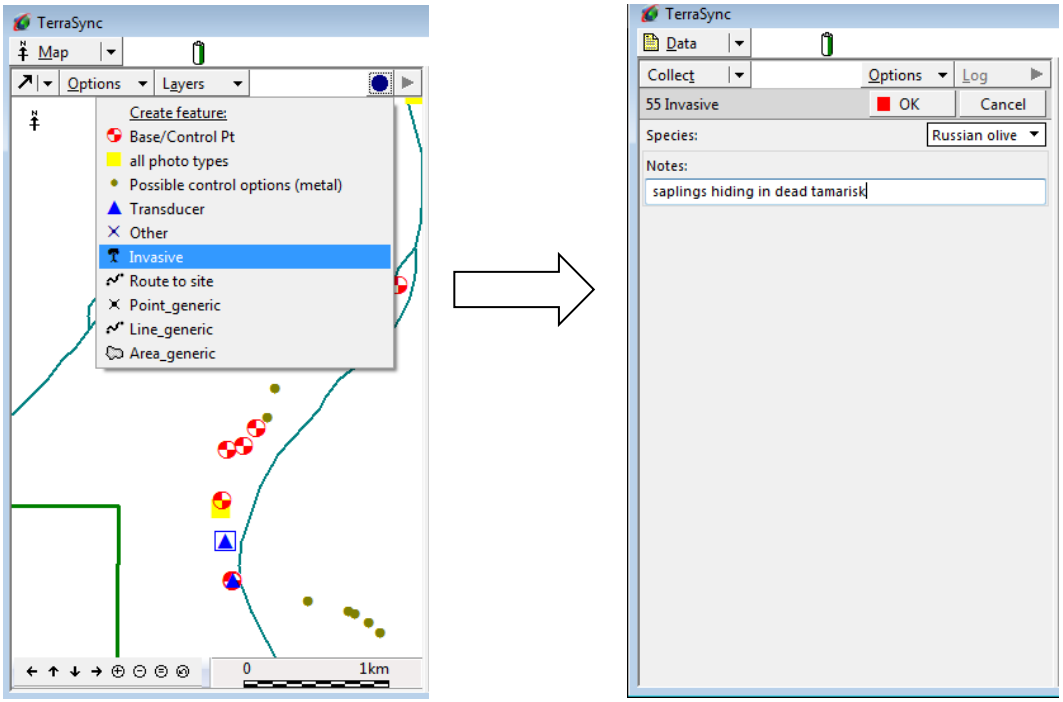
To bring in some background layers, tap the Layers button, then choose Background Files. You can select one or more to display on the Map view (be aware all background files will display as one color). Tap OK.



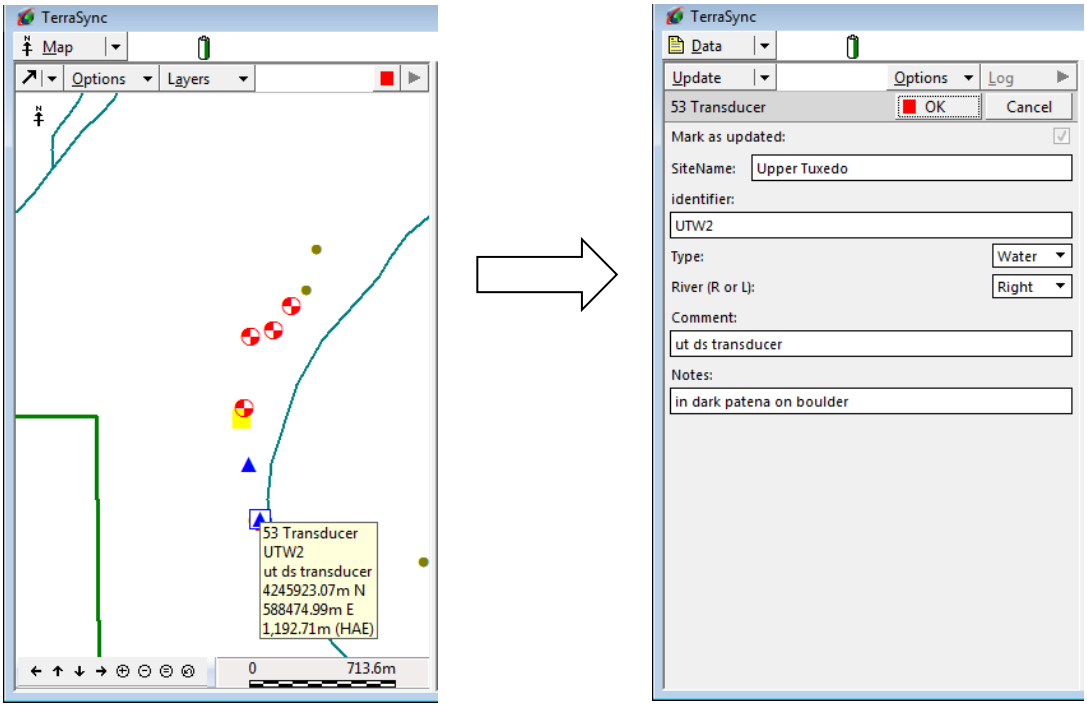
To GPS (locationally update) any of the points within the open TerraSync file, merely double tap the point from the map screen, and the data dictionary fields for the point will open (Transducer displayed). Add any attributes necessary, add just let the GPS unit obtain 10 or so "hits" from the satellites, and tap OK.



If you need to GPS a new point, the data dictionary can be accessed using the little blue dot in the upper right of the map screen. Merely tap it, and choose the feature type you'd like to GPS, fill in any attribute information, let the unit collect 10 satellite "hits", and save and close the feature.

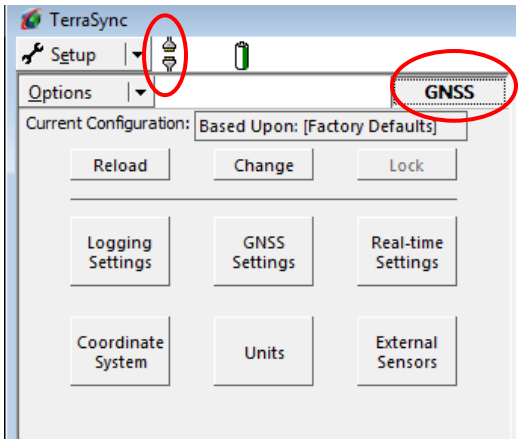


You can select (tap) a feature from the Map Screen and limited data will display in the Identity box. However, you can display more data about each feature by double-tapping to access the data dictionary attributes in their entirety. If necessary, you may update both the location and attributes.



Hints for Trimble units:

- Log a point for a minimum of 10 (to 20) "hits" (about 10 seconds).
- To re-boot the Junos, there is a little hole on the bottom left side (nestled in with the various buttons). Push that with the tip of the stylus to re-boot the Juno.
- To conserve on battery life (generally 8 hours on XMs and 4+ hours on Junos), turn the unit off if you aren't using it to navigate. It is recommended that TerraSync be closed *prior* to turning off the unit.
- While carrying extra batteries in the soft GPS cases, face the GPS unit screen to the opposite of the battery to prevent cracked screens.
- If the GPS gets disconnected, go to the Setup screen and tap the GNSS button on the upper right side. A little connecting icon will appear as the unit reconnects to the GPS. A satellite icon will replace the connecting icon when TerraSync is reconnected to the GPS.



- The NCPN has a copy of the TerraSync Users Guide, which goes into more detail about the many functions of TerraSync. Please contact the GIS technician if you would like to take a look at it.
- Report any idiosyncrasies with the Trimble GPSes to the NCPN data management staff.

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

Standard Operating Procedure (SOP) #4

Sentinel Site Set-Up (BLCA/CANY/DINO)

Version 3.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
Varied	1/2016	D. Perkins	SOPs from DINO, BLCA, CURE, and CANY were combined. See SOPs from each park from 2015 for previous changes.	Combine into one SOP for easier organization	3.00
3.00	2/2018	D. Perkins	Editorial	Peer review comments	3.01

This SOP describes the methods for establishing a new monitoring sentinel site, setting up and relocating transects for vegetation monitoring and geomorphic surveying, conducting vegetation monitoring at sentinel and rapid sites, taking photos, and mapping facies. A list of necessary equipment for these procedures can be found in SOP #1.

I - BLACK CANYON OF THE GUNNISON NP

1. Sentinel Site Establishment

Sentinel Site Establishment

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 Establishing a monitoring feature and vegetation transects

Geomorphic features are classified using a lettering system from downstream to upstream (i.e. Feature A, B, C…A being the furthest downstream) (Figure 1). Three to four one-bank stub transects are placed on each feature for vegetation sampling purposes (Figure 2). 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, at Red Rocks they are on both sides of the river.

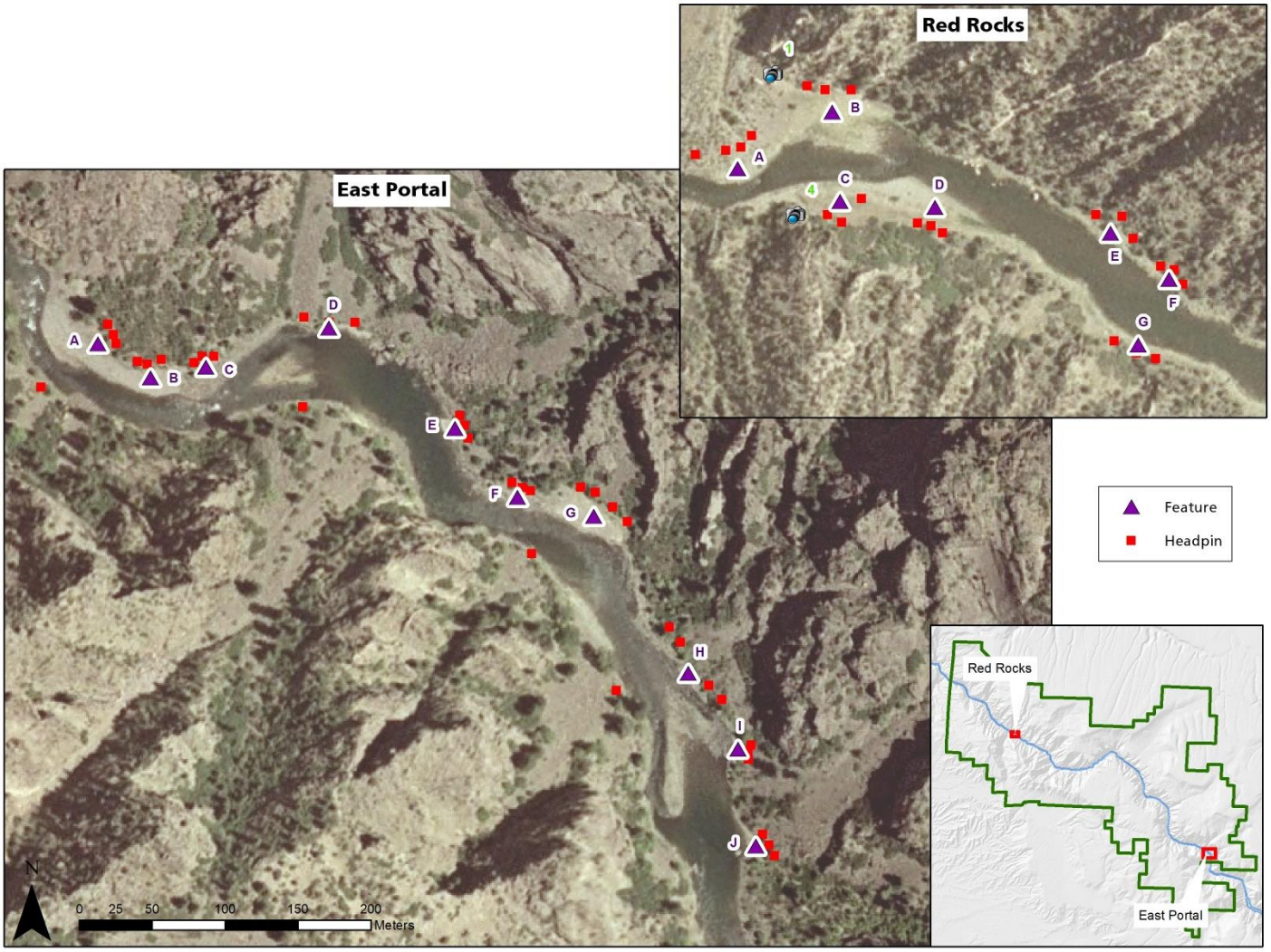


Figure 1. Location of sentinel monitoring sites at Black Canyon of the Gunnison National Park. Flow is from right to left of the figure. The headpins represent the transects on each feature which are labeled A-J at East Portal and A-G at Red Rocks.

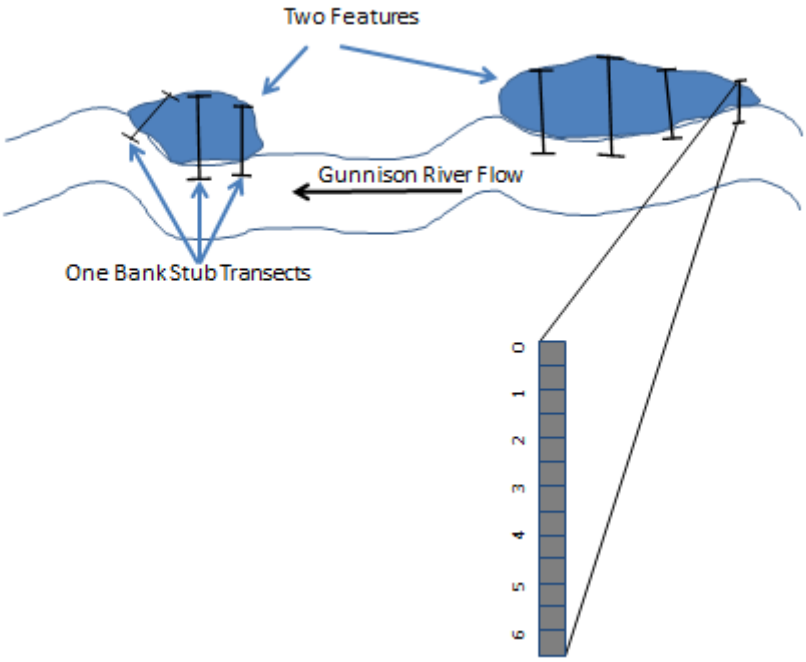


Figure 2. Two features and associated one bank stub transects with plot layout along continuous belt transect.

A. Establish three survey control points that are permanent and physically 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 section of rebar (at least 45 cm in length) 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 orientation pins are found by attaching a measuring tape using a cam strap and stake to a location such that the 0 mark is over the rebar (but not attached to the rebar so that it does not move the rebar). The measuring tape is then stretched to the known distance of the orientation pin in a direction that is perpendicular to the flow of the river. A metal detector may aid in finding the orientation pin. If it cannot be found, it can be staked out from the total station. 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 Section 4 below).
    e. Photograph the control points using the same methods.

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 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).
    - 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.

II - CANYONLANDS NP

1. Sentinel Site Selection and Transects Information, Establishment and Set-Up

1.1 Sentinel Site Selection

Six geomorphic features were selected along the lower Green River as sentinel sites (also called features). These sites were chosen via analysis of change through aerial images and discussion with experts: Millard Canyon, Queen Anne Bottom, Bonita Bend, Holeman Canyon, Sphinx, and Upper Tuxedo (Figure 3). Future sites will be established in a similar manner.

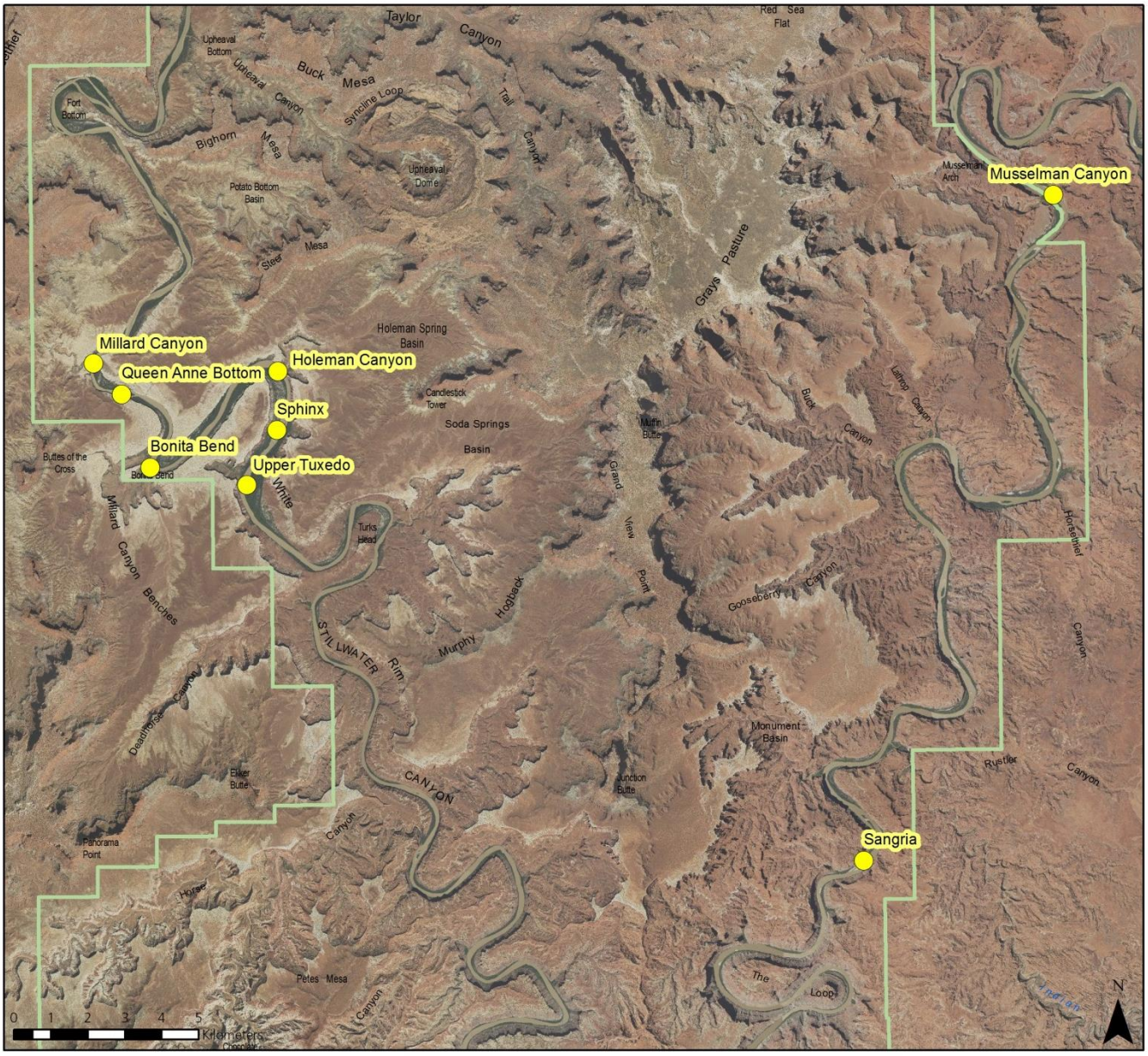


Figure 3. Location of sentinel monitoring sites in Canyonlands National Park. Flow is from top to bottom of the figure.

1.2 General Transect Information and Establishment

Three to twelve one-bank stub transects are placed on each sentinel site for monitoring purposes. 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.

A. Transects are permanent, but do not have any permanent rebar, headpins, or markers. Transects will be relocated using real-time kinetic (RTK) surveying based on established control points (using stakeout functions; see Surveying SOP #8).
B. Permanent transect locations and plots have been established. Transects are perpendicular to the valley floor and may not be perpendicular to flow as the channel changes.
C. Transects are numbered in sequential order, from upstream to downstream (i.e. 1 is the most upstream transect).
D. Transects are spaced equidistant throughout the feature. The total feature length is measured via pacing and the transects are spaced out according to the number of features. For example if we have a 100 m sentinel site and want 4 transects on it, we would divide the total feature length (100 m) by 5 (1 more than the number of transects) to get transect spacing of 20 m.
E. The number of transects may change from year to year, based on erosion or deposition of the sentinel site. Transects may be added or eliminated in future years.
F. Transect length may change from year to year, depending on the movement of the active floodplain, water level, and safety while wading.
G. Plots are permanent and are placed every 3 m along each transect. The surveyor will establish the plots to be recorded. The surveyor will extend plots to a safe wading distance (waist deep in slow water, less deep in faster water) and will extend the plots into the inactive floodplain. At CANY the AF boundary is generally noted by a change to dense (>75%) vegetation, often dominated by *Salix*, and fine sediment, while the inactive floodplain is usually on a higher bench often dominated by mature or large dead tamarisk.
H. Transects will be set up differently depending on type of geomorphic feature (i.e. attached bar or island sentinel sites) and amount of active floodplain. The same feature may change from year to year. For example Holeman Canyon was an island attached bar in 2013, but was an island in 2014. The surfaces on the sentinel site may consist of the following:
    1. AC = active channel
    2. AFP = active floodplain
    3. IFP = inactive floodplain
    4. UP = uplands

1.3 Attached Bar Sentinel Sites

1.3.1 Transect Establishment, Set-Up, & Revist on Attached Bar Sentinel Sites

Attached bar sentinel sites are geomorphic features attached to a bank of the river and there is no water flowing between the bar and main channel during low flow (Figure 4). All transects are continuous. In 2014 on the lower Green River the attached bar sentinel sites were Upper Tuxedo, the lower part of Millard Canyon and lower part Holeman Canyon. However it is possible that the upper parts of Millard Canyon and Holeman Canyon as well as Sphinx and Bonita Bend could become attached bars at lower flow.

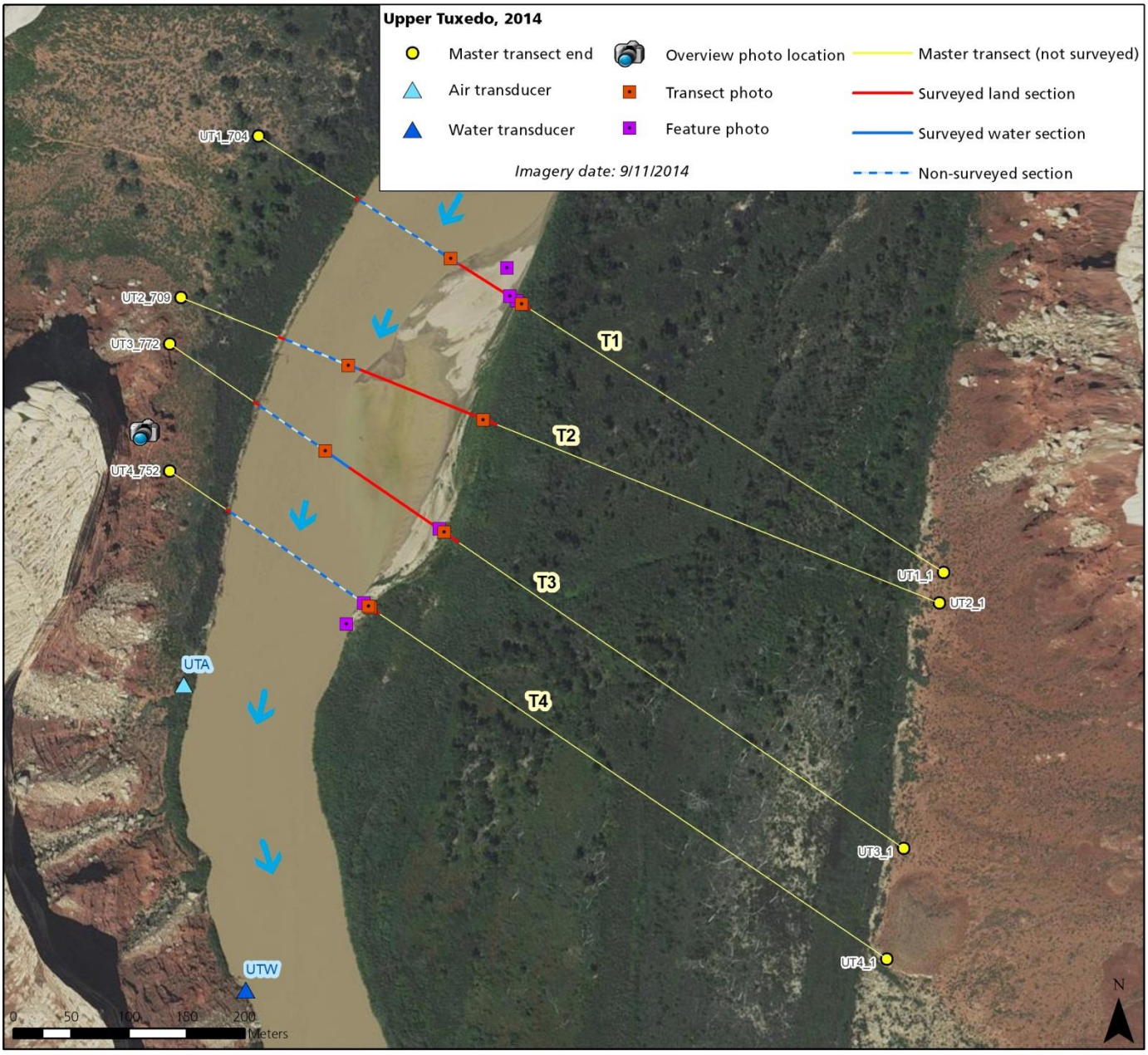


Figure 4. Transect layout at Upper Tuxedo site. Flow is from the top of the page to the bottom. This is an attached bar feature. Note that all transects are continuous transects that go from the inactive flood plain out to a safe wadeable distance in the river channel. The transect was also surveyed at the edge on the river right side by extending the transect with an RTK to note any future bank trimming or aggradation, no photos or vegetation work was done on this far river right side.

1.4 Island Sentinel Sites or Locations with Extensive Active Floodplain in the Middle of Transect

Island features have a back channel separate from the main channel. Water flows on both sides of these types of features. Island features can be exceedingly dynamic and these transects will reflect that. Most likely, the transects will vary from year to year, due to size of the sentinel site and water depth in the back channel (Figure 5).

For the lower Green River in 2014, island sentinel sites include the upper portion of Millard Canyon, Queen Anne Bottom, Bonita Bend, the upper portion of Holeman Canyon, and Sphinx.

Transects may be continuous or discontinuous, depending on two separate or combined factors:

- if the back channel is safe to wade across,
- how much active floodplain (and/or inactive floodplain and uplands) the island has (Figure 5).

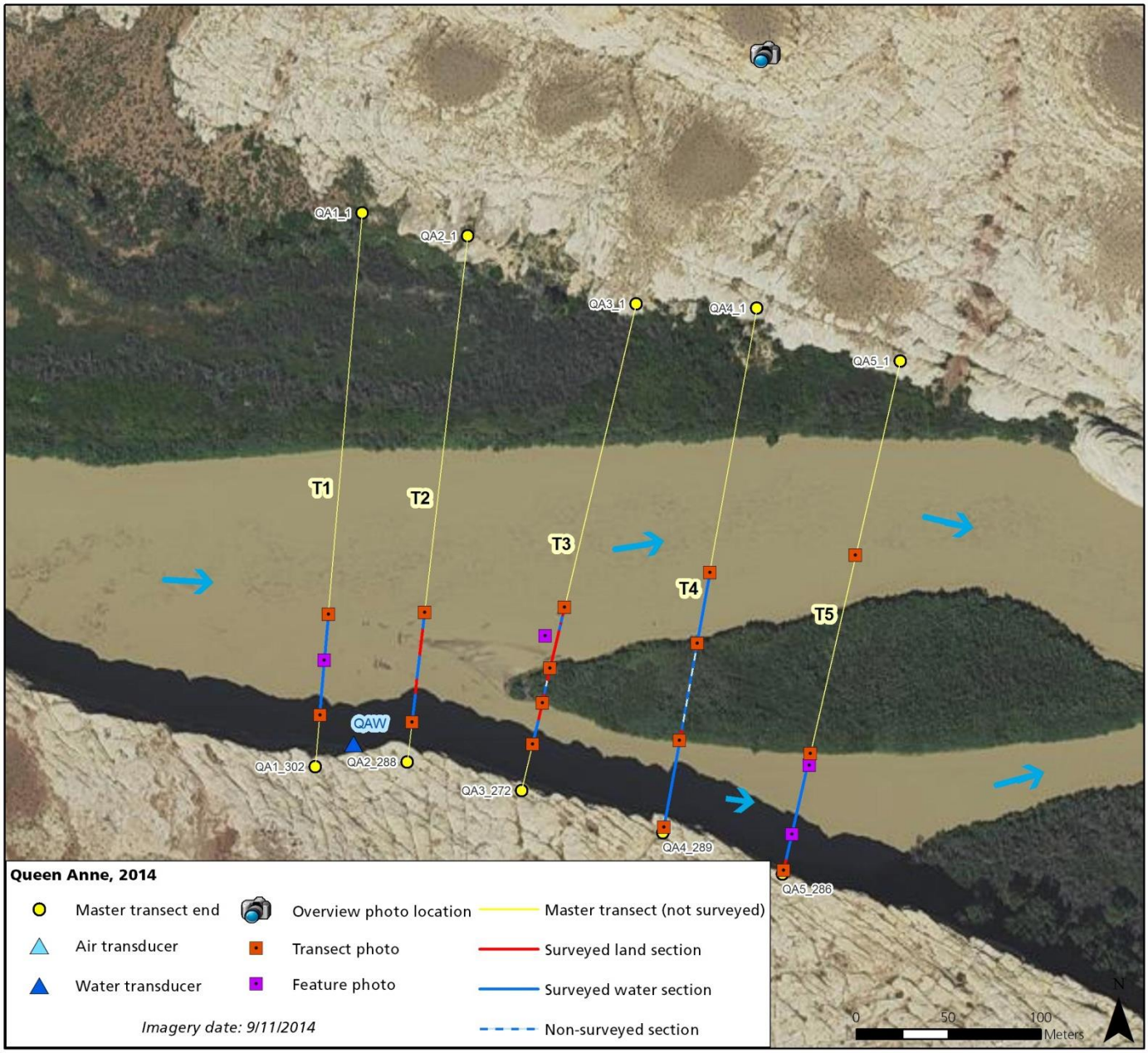


Figure 5. Transect layout at Queen Anne site. Flow is from the left to right. This is an island feature. Blue denotes that the transect was in the water, while red notes that the transect was on land. Note that three upstream most transects extend from a safe wadeable spot in the back channel to a safe wadeable spot in the main channel, while the downstream most transects extend all the way across the back channel. The downstream most three transects also stop when the transect goes into the active and inactive floodplain on the island. The downstream most transect had no safe wadeable portion of the transect on the main channel side of the island.

III – DINOSAUR NM

1. Sentinel Site Establishment

Sentinel Site Establishment

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 (Figure 6).

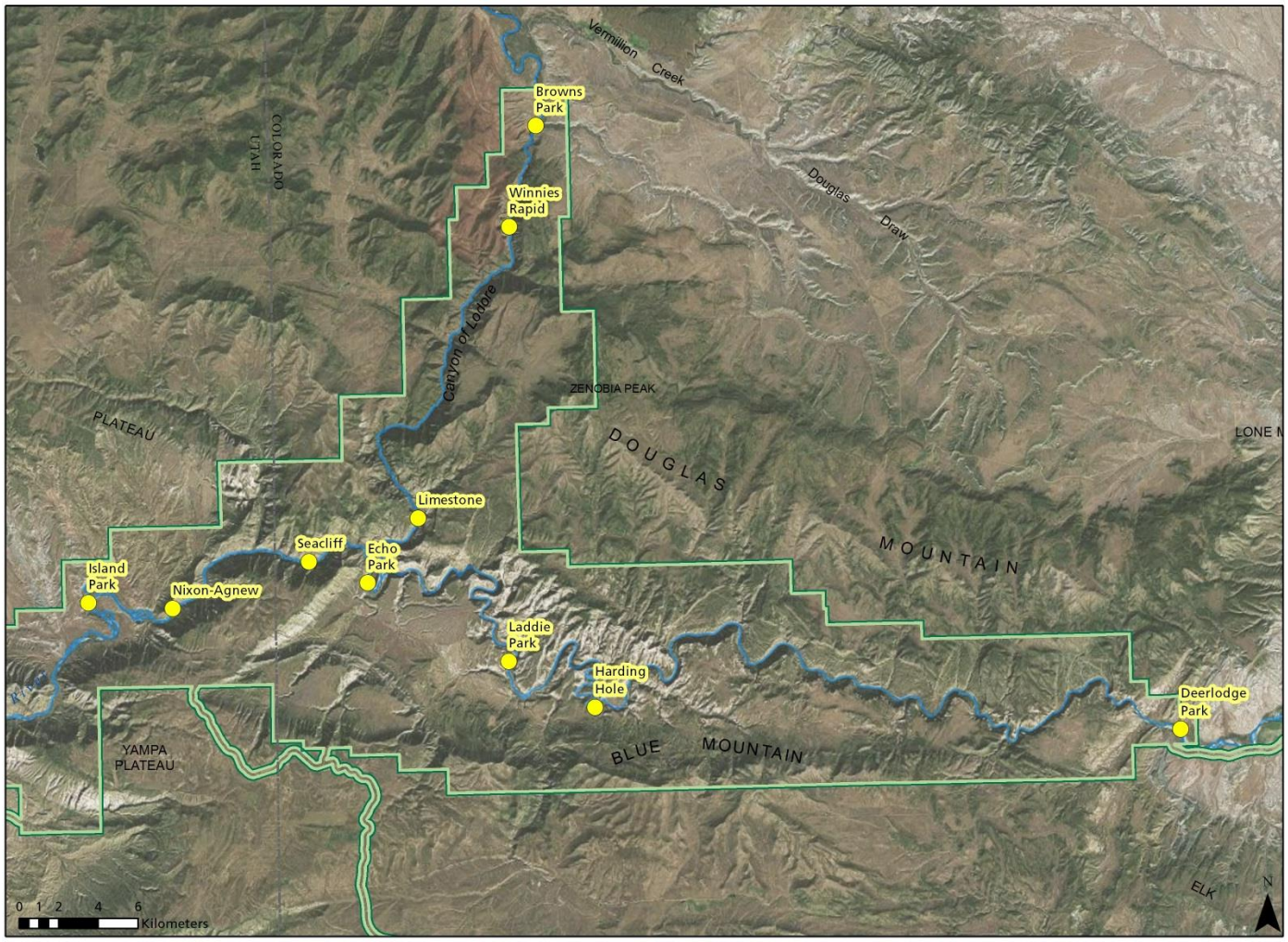


Figure 6. Location of sentinel monitoring sites at Dinosaur National Monument. Flow is from right to left of the figure.

1.1 Establishing Survey Control

Beginning in 2015 on the Green River and 2016 on the Yampa River, there are now a permanent set of "master" plots based on the 2011 plots plus the "extension" of plots that was possible in 2012 due to lower water levels. The extension using the 2012 plots was done by looking at the spatial extent that was completed in 2012, but placing the extent in line with the 2011 transects. If a site was not done in 2011, 2012-13 was used as the master set of plots, whichever was earlier. Prior to 2015 on the Green and 2016 on the Yampa, there are no permanent vegetation (or "veg") plots or transects. There are permanent control plots at all sites.

A. Establish at least three control points that are permanent and physically stable. 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 below Section 4).

1.2 Establishing Transects & Vegetation Plots

A. The goal is to place 50-100 vegetation randomly placed at each site. Pace (in meters) the sentinel site along the length of the approximate center of sentinel site.

B. There should be 7-10 transects per sentinel site depending on the size. Determine how many evenly-spaced transects would be necessary with an average number of plots per transect to achieve 50-100 plots (Figure 1). Also, determine the transect spacing necessary.

D. The transect originates in the IF or UP 5 m from the boundary of the AF and IF/UP. Determine the proportion of each riverine zone in each transects and how many plots will be necessary in each zone along the transect.

E. Use a random number table for pacing steps to determine the locations of the veg plots. The goal is to place plots roughly proportionate to the width of the sentinel site at the different transect spacing numbers. There may also be a few plots in the AC/AF transition. Pace steps are determined from the transect origination or from the zone boundary.

F. Label a pin flag in the center of the plot with a unique plot number in sequential order, starting upstream and closest to the water's edge.

G. While laying out plots, create a cheatsheet that has the list of transects and the plots that are on each transect for the veg and survey crew to ensure data completeness and efficiency. For example, transect 1 has plots 1-13, transect 2 has plots 13-25, etc.

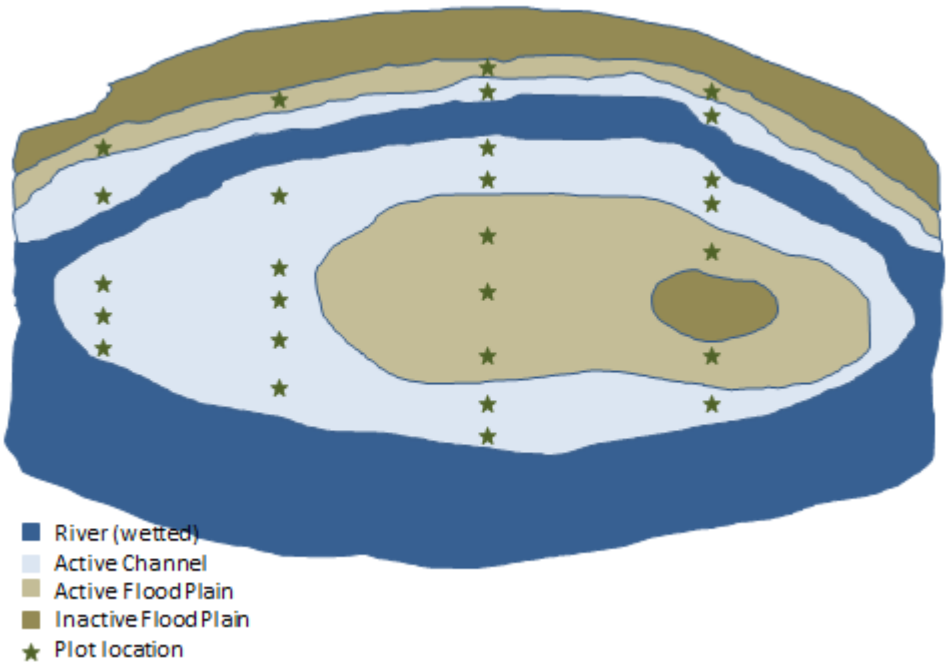


Figure 3. One sentinel site feature with the riverine zones and plot locations (actual sentinel site would have more plots).

2. Revisiting a Sentinel Site

A. Locate all survey control points using GPS units, survey equipment, and reference photographs and mark with highly visible pin flag(s) or flagging.
- If the rebar is missing, use the information provided by the sources above to relocate and replace 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.), document this and establish a new control point with a new name.
- Document the new control point using the guidelines in Section 1.1 above.

B. The master set of plots will be pre-loaded on to the RTK survey gear for each site.

C. A surveyor and an assistant will use the RTK equipment to re-locate each plot.

D. Upon locating a plot, the center of the plot will be marked with a temporary pin flag and plot number.

E. For plots that are completely submerged, the surveyor will tell the assistant that the plot is completely submerged and will note the modal particle size (see SOP 6 for details).

F. Based on geomorphic and vegetative characteristics, the surveyor will also note whether the geomorphic surface of the plot (active channel [AC], active floodplain [AF], inactive floodplain [IF], uplands [UP]) has

changed from the previous designation. The surveyor can also note a transitional plot, for example AC/AF. If there is no one qualified to make this designation on a trip, it is acceptable to skip this step.

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

Standard Operating Procedure (SOP) #5

Photographs (BLCA/CANY/DINO)

Version 3.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	12/17/15	D. Perkins	Minor wordsmithing and renumbering. SOPs for BLCA, CANY, and DINO were combined into one SOP.	Clarity, new SOP numbers	3.00
3.00	2/2018	D. Perkins	Editorial	Peer review comments	3.01

This SOP provides instructions for taking photographs at sentinel sites. Four types of photographs are taken at each sentinel site: transect, feature, overview, and reference. Reference photographs are used solely for future crews to locate things and may not be taken each year. All other photograph types are considered repeat photographs for monitoring changes to the sentinel site and will be taken every year. Photographs can be one of the most effective methods of showing long-term change at a site. This SOP covers Black Canyon of the Gunnison National Park, Canyonlands National Park, and Dinosaur National Monument from the start of monitoring in 2011 to present.

I - BLACK CANYON OF THE GUNNISON NP

One photograph data sheet (Appendix 1) can be filled out for all photograph types. Fill out the top portion of the data sheet:

Site ID: Circle RR (Red Rocks) or EP (East Portal).
Date: mm/dd/yyyy
Camera date/time checked: Go to the settings and date on the camera to ensure that the date on the camera matches today's date. Check the box after doing so.

1.1 Transect Photographs

Take transect photographs from each end of each stub transect while the meter tape and/or tagline is stretched out along the transect (Figure 1).

A. Place pin flags at the ends of all transects. For the part of the inundated portion of the transect, place the pinflag at the water's edge along the transect at a designated meter mark from last year's photograph.

B. Label the chalkboard with the information below and lean it next to the rebar marking the end of a transect.

Feature and Transect # – The feature letter (e.g. A, B, C…etc.), #1-4
Direction Facing – RR⇨RL would mean the photographer is looking from RR to RL, US⇨DS would mean the photographer is looking from upstream to downstream
Date – mm/dd/yyyy, e.g., 08/22/2010
Site – Park code and Site ID number (e.g., BLCA-EP)

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 photographs. 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 photograph.

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 photograph. If a transect ends in the water, take photograph from the temporary rebar location in the water with the chalkboard propped on the downstream side of the transect.

F. Take a photograph and record the photograph information on the Photograph data sheet:
Photo type – Circle "T" for transect

Direction (facing) – Circle the photographer is looking, either RR for river right or RL for river left for transect photographs
Photographer location - Record the location of the photographer, i.e. A1 at RHP (right head pin) (0 m), A1 at 25m
Subject location – Record what the photograph was centered on, i.e. A1RHP (right head pin), G1LP (left pin)
Photographer – use first name initial and full last name
Photo # - see directions below
Close-Up and Replacement Boxes - not recorded for transect photographs
Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
Comment – Record any comments unique to that photograph

Recording the Digital File Name

a. While the camera is in "play" mode, you will be able to view the number assigned to the photograph. *Do not record this number.* This number changes when the photographs 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 photograph number.
c. The template for the number you will record is P*mdd9999*, where P=photographs, *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 photograph. For example, photograph 0300 taken on October 1 would be recorded as PA010300.

1.2 Feature Photos

These photographs are to monitor the overall geomorphic feature (Figure 2).

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. Photograph 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 photograph.

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 (Figure 2). Orient the camera so that it takes a horizontal (landscape) format photograph.

D. Record the photograph information on the Photograph data sheet:

Site ID – Circle EP or RR for East Portal or Red Rocks
Date – Date(s) of photographs
Camera Date/Time Checked – check box after ensuring that you have gone into the camera settings and ensured that the date and time matches reality
Photo type – Circle "F" for feature
Direction (facing) – Circle the photographer is looking, either US for upstream or DS for downstream for feature photographs
Photographer location - Record the location of the photographer, i.e. A1 at 15 m,
Subject location – Record what the photograph was centered on, i.e. A3 at 25 m
Photographer – use first name initial and full last name
Photo # - see directions below
Close-Up and Replacement Boxes - not recorded for feature photographs
Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
Comment – Record any comments unique to that photograph

Recording the Digital File Name

a. While the camera is in "play" mode, you will be able to view the number assigned to the photograph. *Do not record this number.* This number changes when the photographs 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 photograph number.
c. The template for the number you will record is P*mdd9999*, where P=photographs, *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 photograph. For example, photograph 0300 taken on October 1 would be recorded as PA010300.

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.

1.3 Overview Photographs

These photographs are taken from above the feature Figure 3.

1. Initial Visit - The observer selects points where multiple features can be seen from one picture.
2. Take photograph and GPS photograph location, this is the photopoint. More than one overview photograph can be taken from a single photopoint.
3. Take reference photographs (see section 4.4 below) of the photopoint where the photographer was located.
4. Repeat visits. Print out the overall feature photographs as well as the reference photographs that showed the photopoints. Use the GPS and reference photographs to get to the location.

5. Use the previous year's photograph to center the photograph on the same place. When possible the same time of day is desired.
6. Record the information below on the photograph data sheet

Site ID – Circle EP or RR for East Portal or Red Rocks
Date – Date(s) of photographs
Camera Date/Time Checked – check box after ensuring that you have gone into the camera settings and ensured that the date and time matches reality
Photo type – Circle "O" for overview
Direction (facing) – Circle the photographer is looking, US for upstream, DS for downstream, RR for river right, RL for river left. More than thing can be circled, if US and RR was circled it would meant that the photographer was looking upstream and river right.
Photographer location - Record the photograph point location, i.e. PP1, PP3
Subject location – Record the overview number, followed by the feature(s) that the photograph captures (i.e., O3-A, O3-B, O4-B, O5-BCD)
Photographer – use first name initial and full last name
Photo # - see directions below
Close-Up and Replacement Boxes - not recorded for overview photographs
Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
Comment – Record any comments unique to that photograph

Recording the Digital File Name

a. While the camera is in "play" mode, you will be able to view the number assigned to the photograph. *Do not record this number.* This number changes when the photographs 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 photograph number.
c. The template for the number you will record is P*mdd9999*, where P=photographs, *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 photograph. For example, photograph 0300 taken on October 1 would be recorded as PA010300.

1.4 Reference Photographs

Take reference photographs to document locations of all survey control, headpins, orientation pins, or other specific features or items that need to be located in the future (Figure 4). Include the cliff line, surrounding perennial vegetation, and/or other recognizable landmarks in the background to help the returning field crew relocate these points.

1. 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.

2. Place the chalkboard in a location where it will be easy to read in the photograph.
3. 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 photograph. Unlike repeat photographs, you may include anything in reference photographs that may assist with re-locating the point (i.e., crew members, bright-colored flagging, etc.).
4. Take a photograph and check the quality. If the photograph is blurry or otherwise not acceptable, delete it and take another one.
5. Record the information below on the Photograph data sheet.

   Site ID – Circle EP or RR for East Portal or Red Rocks
   Date – Date(s) of photographs
   Camera Date/Time Checked – check box after ensuring that you have gone into the camera settings and ensured that the date and time matches reality
   Photo type – Cirlce "R" for reference
   Direction (facing) – Circle the photographer is looking, US for upstream, DS for downstream, RR for river right, RL for river left. More than thing can be circled, if US and RR was circled it would meant that the photographer was looking upstream and river right.
   Photographer location - Record the photographer location, i.e. 10 m upstream of EP water transducer 7
   Subject location – Record what the photograph captures, i.e. A1RHP, EP water transducer 7
   Photographer – use first name initial and full last name
   Photo # - see directions below
   Close-Up and Replacement Boxes - Check the box if it is a close-up photograph or replaces a previous reference photograph
   Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
   Comment – Record any comments unique to that photograph

   Recording the Digital File Name

   a. While the camera is in "play" mode, you will be able to view the number assigned to the photograph. *Do not record this number.* This number changes when the photographs 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 photograph number.
   c. The template for the number you will record is P*mdd9999*, where P=photographs, *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 photograph. For example, photograph 0300 taken on October 1 would be recorded as PA010300.



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



Figure 2. Example feature photograph 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 photograph.



Figure 3. Example overview photograph taken from a location above the sentinel site.



Figure 4. Example reference photograph of a headpin.

1.5 Other Photographs

Crew members are encouraged to take other photographs to document specific aspects of a reach or to provide scenic or fieldwork photographs for publications or Facebook. Fill in the category, photographer, photograph# and description on the bottom of the photograph data sheet.

II - CANYONLANDS NP

One photograph data sheet (Appendix 1) can be filled out for all photograph types. Fill out the top portion of the data sheet:

Park Code: Use the standard 4-letter code to indicate the park unit (e.g., CANY).
River: Use Green, CAC (Colorado Above Confluence), or CBC (Colorado Below Confluence)
Feature: Use two-letter abbreviations for the feature sentinel sites.
Date: mm/dd/yyyy
Camera date/time checked: Go to the settings and date on the camera to ensure that the date on the camera matches today's date. Check the box after doing so.

1.1 Transect Photographs

The goal is to capture the entire transect within the context of the sentinel site. Transect photographs are only taken in two directions, river right and river left (Figures 5, 6). At minimum there will be a picture taken from both ends of the transect, if the transect is heavily vegetated, additional photographs may be placed along the tagline at vegetated/unvegetated boundaries. The complete set of transect photographs are taken in the initial year. In subsequent years, transect photographs only need to be taken if there are dramatic changes, for example a sand bar disappears or appears, and island is ripped out. Transect photographs should be re-taken every 5 years if they are not taken more frequently.

For Establishment:

A. Go to transect photograph location flags established by the survey crew.

B. Check that the date/time is correct in the camera.

C. Label the chalkboard with the information below and lean it against the transect end rebar:

> **Site**: park code (e.g., CANY)
> **Sentinel Site ID and Transect End:** transect end where photographer is standing. Use transect end label (e.g., MC2RHP, see Section 1.2.J).
> **Direction Facing:** The photographer was standing with an arrow to direction facing (e.g., RR→RL which means the person was standing river right and facing river left.
> **Date** – mm/dd/yyyy, e.g., 08/22/2010

D. 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 photographs. You can also hang the chalkboard on vegetation.

- Take transect photographs from each end of the transect with the tagline is stretched out along the transect. Stand directly over the transect end. Camera should be approximately 1.5m in height and pointed down the transect, centering on the opposite transect end with the tagline in the middle of the frame.

- If dense vegetation is blocking the headpin photograph, take the photograph on the other side of the vegetation along the transect.
- If the transect is heavily vegetated, additional photographs may be placed along the tagline at vegetated/unvegetated boundaries, which can be looking either direction. The goal is to have photograph documentation of all of entire transect (Figures 8 & 9).
- Stand in the water for the river pin location photograph.

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

F. Check to ensure that the chalkboard is visible at the bottom of the field of view.

For Transect Photograph Revisits:
During a revisit, follow the above guidelines for taking transect photographs with these few specifics:

- The previous transect photograph location will be marked with a flag by the surveyor. Use the 2014 photographs to do your best to match the photograph. If vegetation has grown so that the photograph no longer captures the transect, take the photograph, and then establish a new transect photograph location at a more suitable location. Explain why it was necessary in the comment section of the data sheet,
- It is possible that the river pin will not be at the same location due to erosion or accretion of sediment and differing water levels, but the observer should still take the picture at the same x, y, location.

G. Record the photograph information on the Photograph data sheet:

Photo Type – Circle "T"
Direction Facing – Circle the direction the photographer is facing. RL (river left), RR (river right), US (upstream), DS (downstream). In some cases it is appropriate to circle two abbreviations.
Photographer Location – Location of photographer. The surveyor will have pre-labeled flags, using the following naming convention T2-1, T3-1, where the number after the T corresponds to the transect where the photograph is taken. Numbers generally go from lowest on river left to highest on river right.
Subject Location – Leave blank for transect photographs.
Photographer – use first name initial and full last name
Photo # - Digital file name (see instructions below; e.g., P7251234**)**
Close Up? – Check this box if it is a close-up photograph and a direction cannot be noted. Usually only used for reference mark or rebar photographs.
Replacement – Check this box if the photograph is to replace a previously taken photograph. This is usually only used for reference photographs
Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
Comment - Any useful comments

Recording the Digital File Name

d. While the camera is in "play" mode, you will be able to view the number assigned to the photograph. *Do not record this number*. This number changes when the photographs are downloaded from the camera. Instead, use the following instructions to record the digital file name on the data sheet.
e. The last 4 digits of the number displayed on the camera (those following the dash) represent a unique photograph number.
f. The template for the number you will record is P*mdd9999*, where P=photographs, *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 photograph. For example, photograph 0300 taken on October 1 would be recorded as PA010300 and photograph 1234 taken on July 25 would be recorded as P7251234.



Figure 5. Transect photographs from transect 7 at Holeman Canyon. On left, photograph from headpin taken at the 8 m (due to dense vegetation in front of headpin) facing river left. On right, photograph from river pin at 42 m facing river right. Total transect length was 42 m.

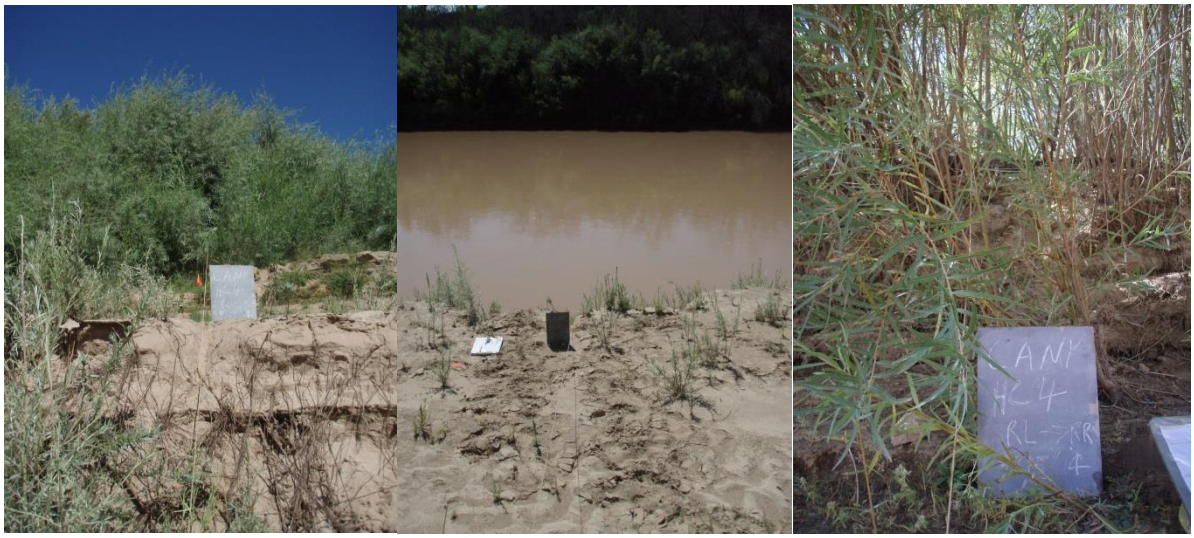


Figure 6. Transect 4 at Holeman Canyon required three photographs to document the transect as the transect went through a dense willow island. Pictures were taken at the 100 m (RP start of transect) mark facing river left, 108 m mark (middle of transect at dense willow vegetation) facing river right, and 120 m (LP end of transect) mark facing river right.

3.2 Feature Photographs

These photographs are to monitor the overall geomorphic feature (Figures 7, 8). Feature photographs are only taken in two directions, upstream and downstream. Feature photographs are taken every year.

A. **For Establishment:**Set up target pin flags at both ends of the upstream most and downstream most transects so that two flags are on each transect. These flags could be placed at 2 of the following locations near the ends of the transect: a meter mark closest to the water's edge (without being in the water); with flagging tied around the RP/LP in the river or back channel, at the RHP/LHP, or at the dense vegetation line closest to the upland end of the transect. Alternatively if the transect is not the best place to capture the feature, choose another location on the feature for the feature photograph. Choose whichever locations best show the feature.

B. Walk to the furthest downstream transect of the sentinel site. Stand at the target pin flag.

C. Label the chalkboard with the information below and lean it against a chaining pin for support. Keep the chalkboard a short enough distance from the photographer to be legible in the photograph:

Park: Park code (e.g., CANY)
Sentinel Site ID: Two-letter abbreviation for sentinel site
Direction Facing: direction the photographer is facing. US = upstream, DS=downstream
Date – mm/dd/yyyy, e.g., 08/22/2014

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 photographs. You can also hang the chalkboard on vegetation.

D. Looking upstream, center the camera on the target pinflag at the most upstream transect. Photograph should be taken with the camera at approximately 1.5m height.

E. Orient the camera so that it takes a horizontal (landscape) format photograph and take photograph.

F. Walk to the other target pin flag on the downstream transect and take the photograph as in D looking US

G. Repeat steps B-F so that photographs are taken from the upstream transect looking downstream.

H. For larger features, there are two methods to capture the entire sentinel site. Use one or both of them:
    1. If the sentinel site is very long, additional photographs can be taken from the middle of the feature. Place more target pinflags in the middle of the feature. Continue to use target the same target pin flag located on the most upstream or downstream transect and take upstream and downstream photographs from the middle transect (Figure 8).
    2. If the sentinel site is very wide, photographs can be taken from multiple locations across the feature (e.g., if BB1 is 50 m long, stand at 10 m and 40 m). Use multiple target pin flags to maintain an upstream-downstream orientation (e.g., for the first photograph, the photographing will be standing at BB1 at 10m photographing pinflag at BB5 at 15m; the second photograph will be the photographer standing at BB1 at 45m photographing pinflag at BB5 at 47m).

I. Record the photograph information on the Photographs data sheet:
Photo Type – Circle "F" for feature photograph
Direction Facing – Circle the direction the photographer is facing. US (upstream), DS (downstream). In some cases it is appropriate to circle two abbreviations.
Photographer Location – Location of photographer. The surveyor will have pre-labeled flags, using the following naming convention F2-1, F3-1.
Subject Location – Leave blank for feature photographs.
Photographer – use first name initial and full last name
Photo # - Digital file name (see instructions below; e.g., P7251234**)**
Close Up? – Check this box if it is a close-up photograph and a direction cannot be noted. Usually only used for reference mark or rebar photographs.
Replacement – Check this box if the photograph is to replace a previously taken photograph. This is usually only used for reference photographs
Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping

photograph in the comment field
Comment - Any useful comments

For Feature Photograph Revisits:
During a revisit, follow the above guidelines for taking feature photographs with these few specifics:

- The previous transect photograph location will be marked with a flag by the surveyor. Stand at the same location of previous year's meter mark to ensure repeatability. Use 2014 photographs to match the photographs. If vegetation has grown so that the location no longer effectively captures the feature, take the photograph, and then establish a new feature location that has a better view of the feature. Explain why it was necessary in the comment section of the data sheet,
- Consult revisit sheet to see if middle transects or multiple locations along the transect were used.



Figure 7. Examples of upstream-facing feature photographs from Transect 7 at Holeman Canyon, a very long sentinel site, using middle transects to capture the feature. In the left photograph, the photographer was standing at the 10 m on Transect 7 and photographed a pin flag at the 15 m on Transect 5. In the right photograph, the photographer then moved to 47 m on Transect 7 and photographed a pin flag at the 42 m on Transect 5



Figure 8. Examples of downstream-facing feature photographs from Transect 5 at Holeman Canyon, a very long sentinel site, using middle transects to capture the feature. In the left photograph, the photographer was standing at the 15 m on Transect 5 and photographed a pin flag at 10 m on Transect 7. In the right photograph, the photographer was standing at 41 m on Transect 5 and photographed on a pin flag at 47 m on Transect 7.

3.3 Overview Photographs

Overview photographs are taken from above the sentinel site from "photo point" (PP) locations and will be used to monitor changes (Figure 9). Overview photographs are taken every year.

For Establishment:

7. Select 1+ photo point(s) where all or most of the sentinel site can be seen from one location. Usually a high point across the river from the sentinel site offers the best vantage. Pick a place with unique characteristics for future crews to easily locate (e.g., high point of large boulder, unusual rock outcropping, etc.). Sometimes multiple photo points may need necessary. Photo points are the location. Multiple overview photographs can be taken from one photopoint.
8. Do not use a chalkboard for these photographs.
9. Take photograph(s) that capture the sentinel site. If possible one photograph should be taken with the sentinel site in the center of the frame. Ideally orient the camera in horizontal (landscape) view, however, sometimes vertical (portrait) orientation works better. If multiple photographs are needed, overlap the photographs with at least 50% of the frame (see Figure 11).
10. Record on the Photographs datasheet:

    Photo Type – Circle "O" for overview photograph
    Direction Facing – Circle the direction the photographer is facing. RL (river left), RR (river right), US (upstream), DS (downstream). In some cases it is appropriate to circle two abbreviations.
    Photographer Location – Location of photographer, PP1, PP2, etc. Use digits and not the transect end label. Record to nearest whole m) (e.g., 54 m).
    Subject Location – record what the photograph is of, O1, O2, O3.
    Photographer – use first name initial and full last name
    Photo # - Digital file name (see instructions below; e.g., P7251234)
    Close Up? – Check this box if it is a close-up photograph and a direction cannot be noted. Usually only used for reference mark or rebar photographs.
    Replacement – Check this box if the photograph is to replace a previously taken photograph. This is usually only used for reference photographs
    Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
    Comment - Any useful comments

11. GPS the photograph point location.

12. Take reference photographs of the location where the photographer was located (see Section 3.4).

For Revisits:

A. Before leaving the office, print out previous year's overview photographs and reference photographs of the photo point(s).

B. Use the GPS and reference photographs to get to the location.

C. Use the previous year's photograph to center the photograph on the exact same place. When possible the same time of day is desired.



Figure 9. Example of overview photographs for the Holeman Canyon.. Three photographs were necessary to capture the entire sentinel site. Note the overlap of the photograph frames.

3.4 Reference Photographs

Reference photographs are to document locations of all survey control, headpins, or other specific items that need to be located in the future. These are solely used for future crews and not used for monitoring purposes (Figure 10).

6. Label a chalkboard with the following information:

   Park: Park code (e.g., CANY)
   Sentinel Site ID: Two letter abbreviation for sentinel site (e.g., HC)
   Item: description of subject of photograph (e.g., CP1, CP2, etc.)
   Direction Facing: The photographer was standing with an arrow to direction facing (e.g., RR→RL which means the person was standing river right and facing river left.

   Date: mm/dd/yyyy, e.g., 08/22/2014

7. Place the chalkboard in a location where it will be easy to read in the photograph and the item is clearly visible (e.g., not against rebar if rebar is the item being photographed).

8. 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 ground at the point or held above the point where they will be visible in the photograph. Unlike repeat photographs, you may include anything in reference photographs that may assist with re-locating the point (i.e., crew members, bright-colored flagging, etc.).

9. Take a far-away photograph and check the quality. If the photograph is blurry or otherwise not acceptable, delete it and take another one. Include the cliff line, surrounding perennial vegetation, and/or other recognizable landmarks in the background to help the returning field crew relocate these points. Camera orientation does not matter. Multiple photographs from different perspectives can be taken to help with future finding.
10. Take a close-up photograph of the item, including any perennial vegetation nearby or distinctive rocks.
11. Take any intermediate distance photographs or photographs from another direction – i.e. upstream and downstream locations.
12. Record this data on a Reference Photographs datasheet.

Photo Type – Circle "R" for reference photograph
Direction Facing – Circle the direction the photographer is facing. RL (river left), RR (river right), US (upstream), DS (downstream). In some cases it is appropriate to circle two abbreviations.
Photographer Location – Location of photographer. These will not be any set location, but would be in reference to the subject of the photograph, i.e located 10 m upstream of Upper Tuxedo water transducer.
Subject Location – this is what the photographer is taking a photograph of (e.g., CP1, RM2, etc.)
Photographer – use first name initial and full last name
Photo # - Digital file name (see instructions below; e.g., P7251234**)**
Close Up? – Check this box if it is a close-up photograph and a direction cannot be noted. Usually only used for reference mark or rebar photographs.
Replacement – Check this box if the photograph is to replace a previously taken photograph. This is usually only used for reference photographs
Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field
Comment - Any useful comments



Figure 10. Example of reference photographs of the location of Holeman Canyon Photopoint #1. The left photograph is a close-up photograph accompanied with notes that state the photo point is at the tip of the rock, while the right photograph is the same rock with the photograph taken at a downstream location looking upstream.

3.5 Other Photographs

Crew members are encouraged to take other photographs to document specific aspects of a reach or to provide scenic or fieldwork photographs for publications or Facebook. Photograph number, photographer, and a description can be filled out on the bottom margin of the Photograph data sheet.

III - DINOSAUR NM

Four types of photographs are taken for each sentinel site:

1. Overview repeat photographs taken from Photo Point locations. Record on *DINO Photographs* data sheet (Appendix 1). Mandatory.
2. Reference photographs, which are for anything necessary for future crews to find. Record on *DINO Photographs* data sheet. Optional.
3. Other photographs. Record on *DINO Photographs* data sheet. Optional.
4. Photosynth photographs, taken on the iPad. No paper data sheet is used for Photosynth. Mandatory.

1.1 For Overview, Reference, and Other Photographs

A. Fill out the top portion of *DINO Photographs* data sheet:

River: Circle either Green or Yampa.
Sentinel Site: Record the pre-assigned, 2-letter code for each sentinel site
DL=Deerlodge
HH=Harding Hole
LP=Laddie Park
BP=Brown's Park
WN=Winnie's
LS=Limestone
EP=Echo Park
SC=Seacliff
IP=Island Park
Date: mm/dd/yyyy
Camera date/time checked?: check this box after the correct date and time have been set in the camera.

Photo #: This is necessary for all photographs and is *not* intuitive. Please follow directions carefully:

1. While the camera is in "play" mode, you will be able to view the number assigned to the photograph. *Do not record this number*. This number changes when the photographs are downloaded from the camera. Instead, use the following instructions to record the digital file name on the data sheet.
2. The last 4 digits of the number displayed on the camera (those following the dash) represent a unique photograph number.
3. The template for the number you will record is P*mdd9999*, where P = photographs, *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 photograph. For example, photograph 0300 taken on October 1 would be recorded as PA010300.

B. Overview Photographs

Overview photographs are repeat photographs that are taken from Photo Point locations which are generally high locations above the sentinel site with good visibility. Record this photograph data on the *DINO Photographs* datasheet, direction in Section 4.3.

1. Establishment:
    a. Select a best time of day that minimizes shadows on the sentinel site.
    b. The observer selects Photo Point location where the entire sentinel site can be seen.
    c. Take repeat photograph(s) of sentinel site
    d. GPS Photo Point location
    e. Take reference photographs (see section 4.2 below) of the location where the photographer was located.
2. Revisits:
    a. Use the Revisit sheet for total Photo Point locations, total number of photographs, and best times of day needed to repeat photographs.
    b. Use maps, GPS units, and reference photographs to get to the Photo Point location.
    c. Carefully repeat the photographs using the Repeat Photos binder to match photographs in the field. When possible, use the same time of day or best times when shadows are minimized.
3. Fill out the remaining *DINO Photographs* data sheet with the following:

Photo Type: circle O for overview
Direction Facing: circle US for upstream, DS for downstream, RR for river right, or RL for river left for the direction the photographer is facing. One or more directions can be circled.
Photographer Location: record the Photo Point location (e.g., PP1, PP2, etc.).
Subject Location: this is what the photographer is taking a photograph of. If establishing

overview photographs, use O1, O2, O3, etc. If repeating overview photographs, use the same nomenclature as the original photograph (e.g., O1, O2, O3, etc).

Photographer: record the first initial and full last name of the photographer

Photo number: Record the Digital File Name using the above procedures (e.g., P7241234, P8176789)

Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field

Comments: Record any pertinent comments for the photograph.

C. Reference Photographs

Take reference photographs 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. Record this photograph data on the *DINO Photographs* datasheet, direction in Section 4.3.

1. 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.
2. Place the chalkboard in a location where it will be easy to read in the photograph.
3. 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 photograph. Unlike repeat photographs, you may include anything in reference photographs that may assist with re-locating the point (i.e., crew members, bright-colored flagging, etc.).
4. Take a photograph and check the quality. If the photograph is blurry or otherwise not acceptable, delete it and take another one.
5. Fill out the remaining *DINO Photographs* data sheet with the following:

Photo Type: circle R for reference

Direction Facing: circle US for upstream, DS for downstream, RR for river right, or RL for river left for the direction the photographer is facing. One or more directions can be circled.

Photographer Location: record a general description (e.g., from the river, 10 m upstream from HHCP1, etc.).

Subject Location: this is what the photographer is taking a photograph of (e.g., CP1, RM2, etc.)

Photographer: record the first initial and full last name of the photographer

Photo number: Record the Digital File Name using the above procedures (e.g., P7241234, P8176789)

Close Up?: check only for a Reference Photograph that is a close-up.

Replacement?: check only if the Reference photograph being taken is to replace an already existing reference photograph. This should help make it easy to update reference photographs in the office afterwards.

Skipped Box – Check if photograph deliberately not taken and enter a reason for skipping photograph in the comment field

Comments: Record any pertinent comments for the photograph.

D. Other Photographs

Crew members are encouraged to take other photographs to document specific aspects of a reach or to provide scenic or fieldwork photographs for publications or Facebook.

A. Fill out the remaining *DINO Photographs* data sheet with the following:

Category: circle one

Photographer: record the first initial and full last name of the photographer

Photo #: Record the Digital File Name using the above procedures (e.g., P7241234, P8176789)

Description: record a short description of the photograph

1.2 Photosynth

Photosynth is taken with the iPad and nothing is recorded on paper data sheets. Photosynth software stitches together photographs to form a complete picture. Directions can be found at www.photosynth.net (last accessed 12/14/2011) and are modified for our needs here.

A. GPS a location that gets a good view of the feature and label as Photosynth on iPad. Sometimes 2 or 3 locations may be necessary to adequately capture the feature.
B. Standing at the Photosynth location, use the iPad to spin around, taking overlapping shots as you go. Make sure successive photographs are overlapped by at least 50%. Depending on how wide your lens goes, you'll probably need to take 15-30 photographs to go all the way around (Figure 11).

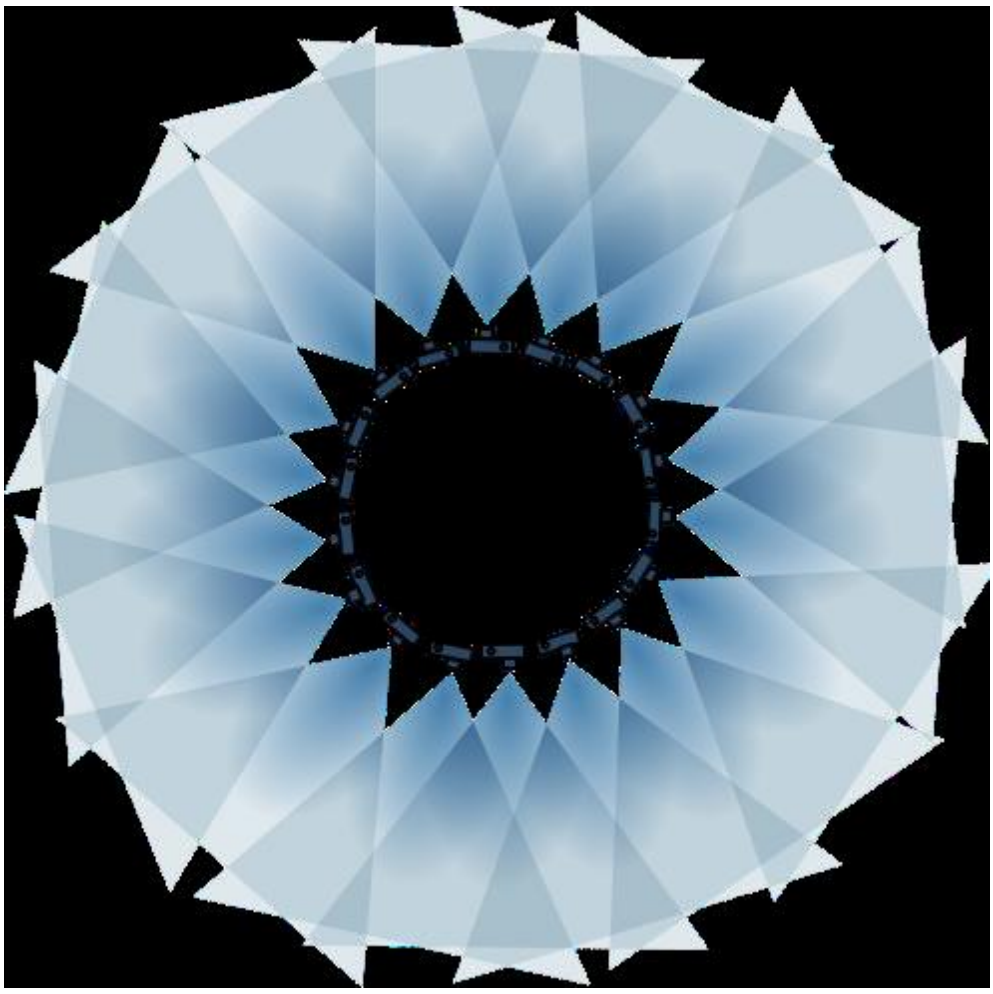


Figure 11. Pictures taken from the center of the feature.

Appendix 1. Data Sheets

BLCA Photos | Photos downloaded by: | Date downloaded: ___/___/___ | Data entered by: | Date entered: ___/___/___ | Data verified by: | Date verified: ___/___/___ | Page ___ of ___

NCPN Big River Monitoring | Big River Monitoring - SOP #5 - Version 3.01 - Feb 2018

River (circle): Gunnison **Sentinel Site:** **Date:** ___/___/___ **Camera date/time checked?** ☐

LOCATION	F → Feature letter transect#(s) @ tagline distance (m or ft) (J1@20)	T → Feature letter transect# - tagline dist. (m or ft) (G1LHP, G1LP@26)
PHOTOGRAPHER	O → PP1, PP2, PP3	R → from river, 10m upstream, etc.
SUBJECT Location being photographed	F → Feature letter transect#(s) @ tagline distance (m or ft) (J1@20)	T → Feature letter transect# - tagline dist. (m or ft) (G1LHP, G1LP@26)
	O → O #- feature(s) O1-GH	R → CP1, RM2, etc.

KEY	T	F	O	R
Photo Type	Transect	Feature	Overview	Reference
Direction Facing	RR | RL	US | DS	US | DS RR | RL	US | DS RR | RL

PA010300 (① ② ③)

❶ Jan-Sep = 1-9, Oct-Dec = A-C
❷ 01-31
❸ 4-digit Camera Photo Sequence #

Photo Type	ALL	ALL	O R	ALL	ALL	R		ALL
Photo Type (circle one)	**Direction facing** (circle)	**Photographer**  **Location**	**Subject Location**	**Photographer** (first initial, last name)	**Photo #**	**Close Up?**	**Replacement?**	**Comments** **Skipped?** *(if so, give reason)*
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐

OTHER PHOTOS:

Category (select one)	Photographer	Photo #	Description
Animals Cultural Disturbance Field Work Plants Scenic Weather Other			
Animals Cultural Disturbance Field Work Plants Scenic Weather Other			

CANY Photos | Photos downloaded by: | Date downloaded: ___/___/___ | Data entered by: | Date entered: ___/___/___ | Data verified by: | Date verified: ___/___/___ | Page ___ of ___

NCPN Big River Monitoring | Big River Monitoring - SOP #5 - Version 3.01 - Feb2018

River (circle): Green CAbvC CBlwC **Sentinel Site:** **Date:** ___/___/___ **Camera date/time checked?** ☐

LOCATION		
PHOTOGRAPHER	F → F transect #(s)-order # (F3/4-2)	T → T transect #- order # (T2-1)
	O → PP1, PP2, PP3	R → from river, 10m upstream, etc.
SUBJECT Location being photographed	F → N/A	T → N/A
	O → O1, O2, O3	R → CP1, RM2, etc.

KEY	T	F	O	R
Photo Type	Transect	Feature	Overview	Reference
Direction Facing	RR | RL	US | DS	US | DS RR | RL	US | DS RR | RL

PA01 0300
① ② ③

❶ Jan-Sep = 1-9, Oct-Dec = A-C
❷ 01-31
❸ 4-digit Camera Photo Sequence #

Photo Type	ALL	ALL	O R	ALL	ALL	R		ALL
Photo Type (circle one)	**Direction facing** (circle)	**Photographer**  **Location**	**Subject Location**	**Photographer** (first initial, last name)	**Photo #**	**Close Up?**	**Replacement?**	**Comments** **Skipped?** *(if so, give reason)*
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐

OTHER PHOTOS:

Category (select one)	Photographer	Photo #	Description
Animals Cultural Disturbance Field Work Plants Scenic Weather Other			
Animals Cultural Disturbance Field Work Plants Scenic Weather Other			

DINO Photos

Photos downloaded by: Date downloaded: ___/___/___

Data entered by: Date entered: ___/___/___

Data verified by: Date verified: ___/___/___

Page ___ of ___

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River (circle): GAbvC GBlwC Yampa **Sentinel Site:** **Date:** ___/___/___ **Camera date/time checked?** ☐

LOCATION			
	PHOTOGRAPHER	F → N/A	T → N/A
		O → PP1, PP2, PP3	R → from river, 10m upstream, etc.
	SUBJECT Location being photographed	F → N/A	T → N/A
		O → O1, O2, O3	R → CP1, RM2, etc.

KEY	O	R
Photo Type	Overview	Reference
Direction Facing	US | DS RR | RL	US | DS RR | RL

PA01 0300
① ② ③

❶ Jan-Sep = 1-9, Oct-Dec = A-C
❷ 01-31
❸ 4-digit Camera Photo Sequence #

Photo Type	ALL	ALL	O R	ALL	ALL	R		ALL
Photo Type (circle one)	**Direction facing** (circle)	**Photographer**  **Location**	**Subject Location**	**Photographer** (first initial, last name)	**Photo #**	**Close Up?**	**Replacement?**	**Comments** **Skipped?** *(if so, give reason)*
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐
T F O R	US DS RR RL					☐	☐	☐

OTHER PHOTOS:

Category (select one)	Photographer	Photo #	Description
Animals Cultural Disturbance Field Work Plants Scenic Weather Other			
Animals Cultural Disturbance Field Work Plants Scenic Weather Other			

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

Standard Operating Procedure (SOP) #6

Measuring Vegetation (BLCA/CANY/DINO)

Version 3.21 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
Varies	1/4/16	D. Perkins	Combine BLCA, CANY, and DINO veg into one SOP	Clarity, organization	3.00
3.00	11/7/17	L. Gommermann	Clarifying vegetation plot parameters used during field season, making structure and wording of SOP consistent between park units	Organization and clarity of data collected during previous field season	3.10
3.10	12/11/17	L. Gommermann	Updating vegetation plot parameters for upcoming field season	SOP Updates	3.20
3.20	2/2018	D. Perkins	Editorial	Peer review comments	3.21

This SOP describes the methods for conducting vegetation monitoring at sentinel sites. A list of necessary equipment for these procedures can be found in SOP #1.

I - BLACK CANYON OF THE GUNNISON NP

1. Measuring Vegetation

Vegetation sampling consists of a plant walk to develop a species list of the sentinel site and observations of modal sediment size, inundation, litter, woody debris, woody canopy cover, and indicator species within 2 x 0.5 m plots along permanent, repeated cross-sections.

When filling out datasheets (Appendix 1), do not erase mistakes. If a mistake is made, draw a line through the erroneous information, write in the correct information, and annotate with your initials and date.

1.1 Plant Walk

Using the plant walk datasheet, record all plant species observed at the sentinel site by feature (e.g., East Portal, Feature E), extending upslope to transect headpins. The objective of the plant walk is to record as many species as possible. Record date and approximate time spent looking (there is no minimum or maximum time to spend on this). Consider conducting an initial plant walk before vegetation quadrat monitoring as a means of vegetation team calibration. Alternatively, the plant walk can be done in increments as the work schedule allows. If time is running short, the plant walk may be skipped.

A. Fill out BLCA Veg Walk datasheet header information:

River: Circle Gunnison
Sentinel Site/Feature: Record the 2-letter code for each sentinel site and 1-letter code for each site feature.
EP: East Portal (Features A-I)
RR: Red Rocks (Features A-G)
Date: Record date of observations (mm/dd/yyyy)
Observer: Record the name of the person(s) calling out the data
Recorder: Record the name of the person(s) recording the data
Page ____of_____: This will be completed once all datasheets are collected

B. Species Found: Place a check mark next to any species found that is listed on the data sheet. If a species is found and not listed, record the full Latin name at the end of the list.

1.2 Vegetation Quadrats

After transect and plot establishment, vegetation sampling can generally be done by one person in an equivalent time to conduct 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 2 x 0.5m plot that is centered on the tagline. 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 subtracting the open spaces within the polygon. Imagine if the sun were directly overhead, what percentage is shaded. Stand over the plot to get a proper view of the species within a plot (Figure 1).



a. b. c.

Figure 1. To estimate percent cover, a) view the plot from above, b) visualize open vs. covered space by plants that are within the plot, and c) lump all covered space to one side of the plot in your mind.

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.

On a daily basis before quadrat sampling, documented calibration of at least 3 plots by all vegetation observers should be conducted. Ideally, plots to be observed during sampling should not be used for calibration. Find calibration plots with representative and varied characteristics (e.g., vegetative cover and composition, sediment sizes, etc.) with respect to the site to be monitored. Calibration plots should be labeled with a "C" followed by plot numbers not in use at any site across a park during that season (e.g. C901 can be used once at each of BLCA, CANY, and DINO during a single field season). During calibration, each vegetation observer should independently observe and record their individual estimations of plot all parameters on a datasheet. Once all observers have finished, discussion of individual observations should take place by all observers. During this discussion, do not change recorded observations as written on datasheets. Since crews lack known values of parameters within plots to compare to, the focus of this discussion should work towards collectively minimizing variability among observers for all parameters.

Use the following guidelines to determine if calibration has been meet after 3 calibration plots or if more calibration is needed before individual sampling is conducted:

- All observers are within 2% for covers that compose 0-5% of the plot
- All observers are within 4% for covers that compose 6-10% of the plot
- All observers are within 7% for covers that compose 11-25% of the plot

- All observers are within 10% for covers that compose 26-50% of the plot
- All observers are within 20% for covers that compose 51-100% of the plot

A. Fill out BLCA Veg Plot datasheet header information:

River: Circle Gunnison
Sentinel Site: Record the 2-letter code for each sentinel site
EP: East Portal
RR: Red Rocks
Observer: Record the name of the person(s) calling out the data
Recorder: Record the name of the person(s) recording the data
Date: Record date of observations (mm/dd/yyyy)
Page ____of_____: This will be completed once all datasheets are collected

B. If not being measured by surveyors, fill out the Tag Line Measurements table in the upper right corner of the data sheet. These measurements are used in the case that the line hits rocks or vegetation and to determine the true distance from the headpin:

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

b. **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).

c. **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.

d. **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. Place Plot Frame and Record Plot Feature, Transect, and Location: Record plot feature letter (EP = Features A – I, RR = Features A-G) and transect number (1-4, numbered from downstream to upstream). The 2-m belt transect is surveyed in a series of 2 x 0.5 m plots centered on the transect and oriented with the long axis of the quadrat perpendicular to the tagline. Starting in uplands at the headpin (0 m), center the plot frame on the tagline. Record the location of the plot by documenting the starting line

distance along the transect tagline. For example, a plot located between the 10 and 10.5 m mark would be recorded as 10 on the Plot Location row of the datasheet

D. % Inundation (Water) (0.5-100): Record to the nearest 1% the amount of that plot that is inundated (covered) by water.

E. Class and % Modal Particle Size: Record the class and percent cover of the modal particle size(s) using the modified-Wentworth scale (see Appendix 2) by visually estimating a plan view projection of substrate within the plot. Look at the diameter of the intermediate axis of the particles. Do not include litter, woody debris, or plant bases. For example, if a plot's surface is characterized by 30% tamarisk bole and 70% sand, record this plot as 100% sand. If necessary, first record Percent Litter and Woody Debris and then physically remove organic matter from the plot to determine percent cover of modal particle size.

For unsaturated sediment finer than sand, conduct the surface soil texture test. Collect a small amount of soil in your hand and slowly add water. Mix the water and soil in your hand and use the key in Figure 1 in Appendix 2 to determine the soil texture. If you have never textured soil, practice this technique with the guidance of an experienced co-worker before the beginning of field sampling. The texture triangle (Figure 2 in Appendix 2) is also helpful for understanding the relationship between different soil particle sizes in determining soil texture. Soil texture tests do not need to be done in every plot, but should be done when the modal sediment size makes an observable change.

If you cannot see ground surface (due to turbid water), use your hand to feel the bottom of plot to determine dominant particle size. If necessary, randomly select and measure several particles to determine a dominant measurement. For saturated sediment finer than sand, record "F" for fines. If there is a veneer of fines <1 cm thick over another substrate, for example, cobbles, record the modal particle size as "cobbles". Only record fines (including clay, clay/loam, or loam) if you cannot recognize the substrate underneath (i.e., more than a veneer) or if the veneer is >1 cm thick.

F. % Sand or Finer (0.5-100): Record the percent cover to the nearest 1% of the plot that is sand (<2 mm) or less. Do not include litter, woody debris, or plant bases. For example, a plot that is 50% sand & finer, 25% plant base, and 25% boulder should be characterized as 67% sand & finer.

G. % Litter (0.5-100): Record the amount of the plot that is covered by litter (< 2.5 cm in diameter) to the nearest 1%. Only include litter that is on the ground. Do not include suspended or aerial litter.

H. % Woody Debris (0.5-100): Record the amount of the plot that is covered by woody debris (≥2.5 cm in diameter), each to the nearest 1%. Only include debris that is lying on the ground. Do not include suspended or aerial woody debris.

I. % Filamentous Algae (0.5-100): Record the amount of the plot that is covered by filamentous algae (FA) (long enough to move with current, about ½ cm) to the nearest 1%.

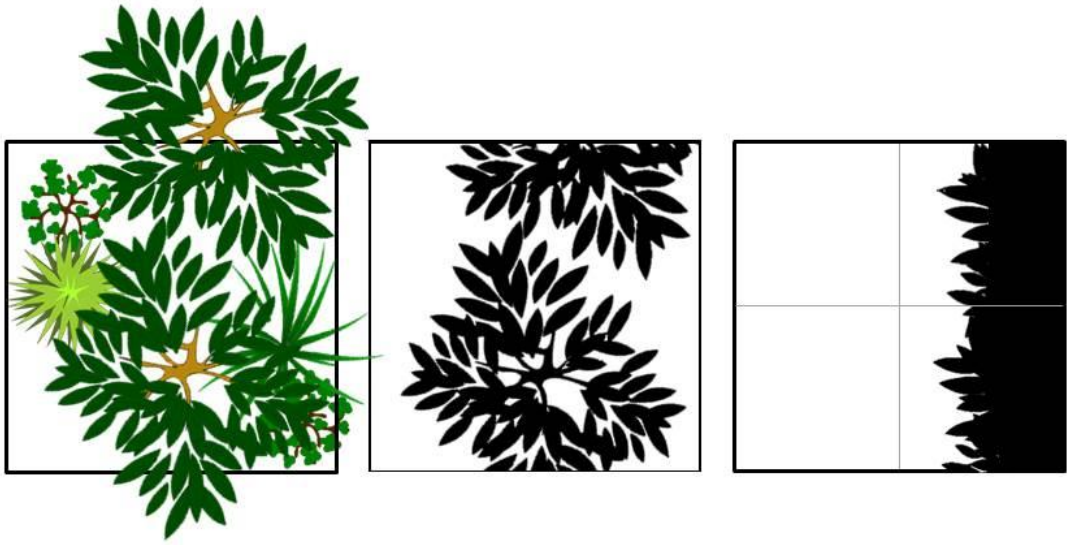
J. % Social Trails: Record the percent cover of social trail present in the plot to the nearest 1%. Record a "T" for trace percentage (<0.5%).

K. Beaver Browse Activity Checkbox: If recent (i.e., having occurred during the current growing season) beaver browsing is observed on vegetation rooted within the plot, check this checkbox with a clear, well-defined "X" for that plot.

L. Plot Density: Record the fraction of plots sampled (1/4, 1/2, 1/1). Changing plot densities along a transect are conducted to avoid bias in the sample size of vegetation plots that experience inundation under a range of flow rates. 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.

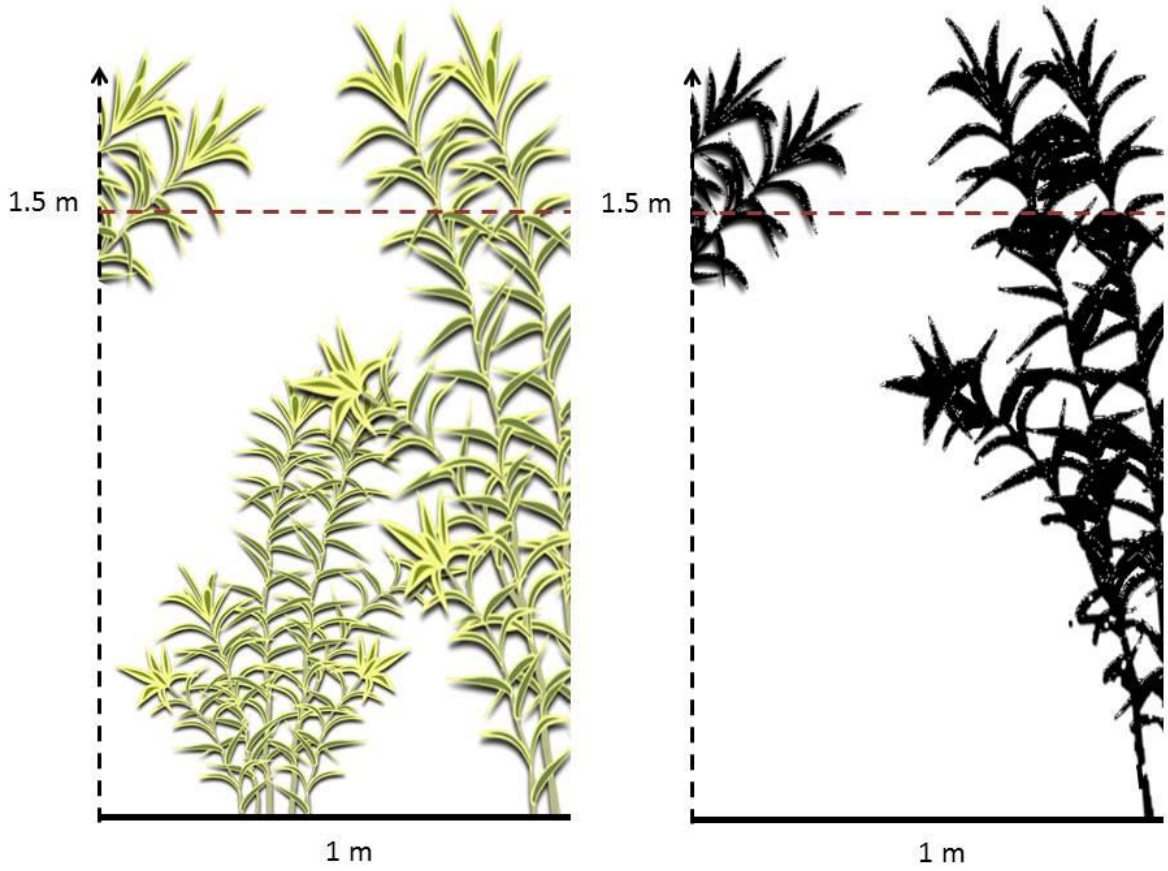
M. No Woody Canopy Checkbox: If there is no live woody (trees and shrubs) canopy cover (>1.5 m height, rooted in and outside of the plot) present over the plot, check this checkbox with a clear, well-defined "X" for that plot.

N. % Woody Canopy Cover (WCC) (0.5-100): Visually estimate the total percentage of live woody canopy cover and the percentage of live woody canopy cover by species in the plot (Figures 2, 3). The vegetation can be rooted inside or outside of the plot. Be sure to look overhead for tall vegetation that might be present. Woody canopy cover includes low branches less than 1.5 m in height of plants whose tallest dead braches are over 1.5 m in height. Therefore, observers need to look at the entire plant and decide first if the entire plant counts as woody canopy or not (i.e., if any living part of the plant is over 1.5 m in height). If it is woody canopy, then all parts of the plant are included in woody canopy cover. Woody canopy cover does not include plants that are longer than 1.5 m but are leaning such that no part of the living plant is 1.5 m above the ground. Visualize the plan view projection of outline polygon of plant within the plot, regardless of where plant is rooted. 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). Record to the nearest 1%. Record a "T" for trace percentage (<0.5%). Record by 6-letter code for the species on data form (writing in the margin the full Latin name for each first encounter).



a. b. c.

Figure 2. To estimate woody canopy cover, a) visualize the plot from above, b) visualize how much space above the plot is covered by live, woody plants over 1.5 m in height regardless of where they are rooted, and c) in your mind, lump all covered space to one side of the plot.



a. b.

Figure 3. When estimating woody canopy cover, include any portions of plants (of individuals over 1.5 m in height) that fall directly over the plot regardless of where they are rooted. In this diagram, a) illustrates all plants in the plot and b) illustrates the plants that would be included in woody canopy cover.

O. % Standing Dead (0.5-100): Record the percentage of any dead, woody canopy cover (plants greater than 1.5 m in height directly over and rooted within or outside of the plot) of shrubs and trees to the nearest 1%. Record a "T" for trace percentage (<0.5%). Standing dead material may be attached to living plants. Standing dead includes low dead branches less than 1.5 m in height of plants whose tallest dead braches are over 1.5 m in height. Therefore, observers need to look at an entire plant and decide first if any of the plant counts as standing dead canopy or not (i.e., if any dead part of the plant is over 1.5 m in height). Standing dead cover does not include plants that are longer than 1.5 m but are leaning such that no part of the living plant is 1.5 m above the ground. Visually estimate the plan view projection of the outline polygon of each plant species.

P. % Understory Rooted Total Plant Cover (0.5-100): Record the percentage of total understory (any species ≤1.5 m in height) plant cover rooted in the plot to the nearest 1%. Record a "T" for trace percentage (<0.5%). Visually estimate a plan view projection from 1.5 m down of outline polygons of plants. Cover includes plants that are alive or were alive earlier this year. Do not double-count overlapping areas of cover below 1.5 m (i.e., 100% is max overall plot cover below 1.5 m). Leave and count plants as you found them (i.e., if a plant is rooted and lying on its side, don't stand it up) (Figure 1). Roots and exposed rhizomes do not count as canopy cover. This measurement will continue into the inundated channel by recording total plant cover of rooted or attached macrophytes.

Q. No Indicator Species Checkbox: If there are no indicator species present in the plot, check this checkbox with a clear, well-defined "X" for that plot.

R. % Understory Rooted Indicator Species Cover and Trails (0.5-100): Record the percent cover of understory (≤1.5 m in height) indicator species rooted in the plot less than or equal to 1.5 m in height to the nearest 1%. Check "***None"*** if there are no understory indicator species rooted within the plot.

The following indicator species are measured:

Acer negundo
Agrostis stolonifera
Apocynum cannabinum
Artemisia ludoviciana
Circium arvense
Eleocharis palustris
Elymus repens
Epilobium ciliatum
Equisetum hyemale-laevigatum
Euthamia occidentals
Heterotheca zionensis
Melilotus sp.

Phalaris arundinaceae
Populus angustifolia
Rhus aromatic
Salix exigua
Verbena bracteata
Veronica anagallis-aquatica
Verbascum thapsus

S. Conduct Plot Replicates: Following completion of vegetation monitoring plots, 5-10% of plots should be replicated at each site/feature by a different observer. Plots used as replicates should be documented on datasheets by noting "R" followed by the plot number. Replicate plots should also be conducted across the various facies present at a site and contain at least a trace (ideally 5% or more) of vegetative plant cover.

T. Review Datasheets: Visually inspect datasheets for completeness. Common errors include incomplete header information and missing (blank) values.

1.3 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 site and use existing unknown names whenever possible.

A. 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).

If an identifiable specimen cannot be found, create a unique name using the following code: **Unknown Code =** unk + 4 LETTER PARK CODE + SITE CODE + feature letter + -your initials + collection number for the feature (e.g., unkBLCARRb-ST1). Notify team members of this plant and unknown code.

b. 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. Try to get good images of floral parts, fruits, foliage and the whole 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.).

B. 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. Collecting multiple individuals can be useful as destruction of flowers and fruits may be necessary during keying of plants.

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 information.

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 while fresh, preserve the bag in a cooler as soon as possible or keep it in the plant press. Make sure the specimen does not get wet. If the species cannot be determined during the field visit, press the plant. If it is identified and there is no specimen in the herbarium then press the plant, if it is identified and a voucher specimen is already present, discard the species in the field.

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.

C. Unknown Plant Datasheets: When filling out the datasheet (Appendix 1), 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:

a. Unknown Code: unk + 4 LETTER PARK CODE + SITE CODE + feature letter + -your initials + collection number for the feature (e.g., unkBLCARRb-ST1)

b. Plant Type and General Description: Circle the appropriate categories and provide a succinct description of the overall appearance (e.g., tiny *Eleocharis*).

c. Most Salient Feature: A unique characteristic that identifies the plant from others.

d. Leaf Characteristics (optional): Describe the leaf type, leaf margin, leaf surface, petiole, etc.

e. Stem Characteristics (optional): Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.

f. Flower Characteristics (optional): Describe the floral structure (i.e., number and arrangement of bracts, calyx, corolla, androecium, and gynoecium),

location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.

g. **Microhabitat Characteristics:** Describe the microhabitat in which it was found if unique on the plot (e.g., wash bottom, limestone outcrop, etc.).
h. **Collected:** Circle yes or no, whether a specimen was collected.
i. **Best Guess:** Preliminary guess about species in field.

D. 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.

II - CANYONLANDS NP

1. Measuring Vegetation

Vegetation sampling consists of a plant walk to develop a species list of the sentinel site and observations of modal sediment size, inundation, litter, woody debris, woody canopy cover, and indicator species within 1 x 1 m plots along permanent, repeated transects.

When filling out datasheets (Appendix 1), do not erase mistakes. If a mistake is made, draw a line through the erroneous information, write in the correct information, and annotate with your initials and date.

1.1 Plant Walk

Using the plant walk datasheet, conduct a plant walk by recording all plant species observed in and around the sentinel site (e.g., Holeman Canyon), extending upslope to transect headpins. Record date and approximate time spent looking (there is no minimum or maximum time to spend on this). Consider conducting an initial plant walk before vegetation quadrat monitoring as a means of vegetation team calibration. Alternatively, the plant walk can be done in increments as the work schedule allows. If time is running short, the plant walk may be skipped.

A. Fill out CANY Veg Walk datasheet header information:

River: Green = Green
CAC = Colorado above confluence
CBC = Colorado below confluence

Sentinel Site: Use two-letter abbreviations for the sentinel sites.
MC = Millard Canyon
QA = Queen Anne
BB = Bonita Bend
HC = Holeman Canyon
SP = Sphinx
UT = Upper Tuxedo
SG = Sangria
MM = Musselman

Observer: Record the name of the person(s) calling out the data
Recorder: Record the name of the person(s) recording the data
Date: mm/dd/yyyy
Page ____of_____: This will be completed once all datasheets are collected

B. Species Found: Place a check mark next to any species found that is listed on the data sheet. If a species is found and not listed, record the full Latin name at the end of the list.

1.2 Vegetation Plots

Vegetation sampling includes cover of species in 1 m^2 plots placed every 3 m along the transect. The plots are permanent locations but all plots at a site may not be surveyed every year. Transects will extend from at least one plot in the inactive floodplain to a safe wading distance into the water (waist deep in slow water, less deep as the current increases). Plots will be loaded into the RTK units and will be laid out by the surveyors. Plots where the water is too deep to place a pin flag will be recorded by the surveyors.

Species cover is visually quantified. Crew members should be trained on visual estimation techniques before collecting data. Visual estimation is based on a plan view projection of outline polygon of plant subtracting the open spaces within the polygon (Figure 4). If the sun were directly overhead, imagine what percentage would be shaded. Stand over the plot to get a proper view of the species within a plot.



a. b. c.

Figure 4. To estimate percent cover, a) view the plot from above, b) visualize open vs. covered space by plants that are within the plot, and c) in your mind, lump all covered space to one side of the plot.

For all vegetation data documentation, record the full Latin name of each species the first time it is encountered at a reach. This can be done in the margin of the paper data sheet. Any additional times the species is encountered, use the six-letter code composed of the first three letters of the genus and specific epithet.

On a daily basis before quadrat sampling, documented calibration of at least 3 plots by all vegetation observers should be conducted. Ideally, plots to be observed during sampling should not be used for calibration. Find calibration plots with representative and varied characteristics (e.g., vegetative cover and composition, sediment sizes, etc.) with respect to the site to be monitored. Calibration plots should be labeled with a "C" followed by plot numbers not in use at any site across a park during that season (e.g. C901 can be used once at each of BLCA, CANY, and DINO during a single field season). During calibration, each vegetation observer should independently observe and record their individual estimations of plot all parameters on a datasheet. Once all observers have finished, discussion of individual observations should take place by all observers. During this discussion, do not change recorded observations as written on datasheets. Since crews lack known values of parameters within plots to compare to, the focus of

this discussion should work towards collectively minimizing variability among observers for all parameters.

Use the following guidelines to determine if calibration has been meet after 3 calibration plots or if more calibration is needed before individual sampling is conducted:

- All observers are within 2% for covers that compose 0-5% of the plot
- All observers are within 4% for covers that compose 6-10% of the plot
- All observers are within 7% for covers that compose 11-25% of the plot
- All observers are within 10% for covers that compose 26-50% of the plot
- All observers are within 20% for covers that compose 51-100% of the plot

A. Fill out CANY Veg Plot datasheet header information:

River: Green = Green
CAC = Colorado above confluence
CBC = Colorado below confluence

Sentinel Site: Use two-letter abbrevations for the sentinel sites.
MC = Millard Canyon
QA = Queen Anne
BB = Bonita Bend
HC = Holeman Canyon
SP = Sphinx
UT = Upper Tuxedo
MM = Musselman Canyon
SG = Sangria
LC = Lockhart Canyon

Observer: Record the name of the person(s) calling out the data
Recorder: Record the name of the person(s) recording the data
Date: mm/dd/yyyy
Page ____of_____: This will be completed once all datasheets are collected

B. Place the Plot Frame and Record Transect and Plot Location: The surveyors mark the center of the plot, so the plot should be laid out centered on the flag with two sides perpendicular to the flow of the main river. Record the transect number and plot number written on the pin flag laid out by the surveyors.

C. % Inundation (Water) (0.5-100): Record to the nearest 1% the amount of that plot that is inundated (covered) by water.

D. Class and % Modal Particle Size: Record the class and percent cover of the modal particle size(s) using the modified-Wentworth scale (see Appendix 2) by visually estimating a plan view projection of substrate within the plot. Look at the diameter of the intermediate axis of the particles. Do not include litter, woody debris, or plant bases. For example, if a plot's surface is characterized by 30% tamarisk sp. bole and 70% sand, record this plot as 100% sand. If necessary, first record Percent Litter and

Woody Debris and then physically remove organic matter from the plot to determine percent cover of modal particle size.

For unsaturated sediment finer than sand, conduct the surface soil texture test. Collect a small amount of soil in your hand and slowly add water. Mix the water and soil in your hand and use the key in Figure 1 in Appendix 2 to determine the soil texture. If you have never textured soil, practice this technique with the guidance of an experienced co-worker before the beginning of field sampling. The texture triangle (Figure 2 in Appendix 2) is also helpful for understanding the relationship between different soil particle sizes in determining soil texture. Soil texture tests do not need to be done in every plot, but should be done when the modal sediment size makes an observable change.

If you cannot see ground surface (due to turbid water), use your hand to feel the bottom of plot to determine dominant particle size. If necessary, randomly select and measure several particles to determine a dominant measurement. For saturated sediment finer than sand, record "F" for fines. If there is a veneer of fines <1 cm thick over another substrate, for example, cobbles, record the modal particle size as "cobbles". Only record fines (including clay, clay/loam, or loam) if you cannot recognize the substrate underneath (i.e., more than a veneer) or if the veneer is >1 cm thick.

E. % Sand or Finer (0.5-100): Visually estimate the percent cover of the plot that is characterized by particles that are sand (<2 mm) or smaller to the nearest 1%. Do not include litter, woody debris, or plant bases. For example, a plot that is 50% sand & finer, 25% plant base, and 25% boulder should be characterized as 67% sand & finer.

F. % Litter (0.5-100): Record the amount of the plot that is covered by litter (< 2.5 cm in diameter) to the nearest 1%. Only include litter that is on the ground. Do not include suspended or aerial litter.

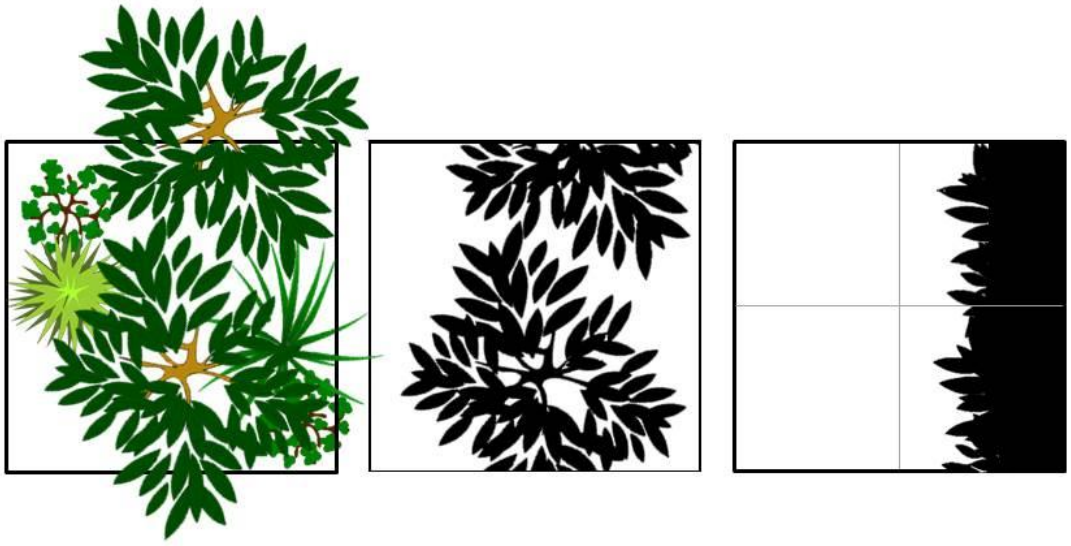
G. % Woody Debris (0.5-100): Record the amount of the plot that is covered by woody debris (≥2.5 cm in diameter), each to the nearest 1%. Only include debris that is lying on the. Do not include suspended or aerial debris.

H. % Filamentous Algae (0.5-100): Record the amount of the plot that is covered by filamentous algae (FA) (long enough to move with current, about ½ cm) to the nearest 1%.

I. Beaver Browse Activity Checkbox: If recent (i.e., having occurred during the current growing season) beaver browsing is observed on vegetation rooted within the plot, check this checkbox with a clear, well-defined "X" for that plot.

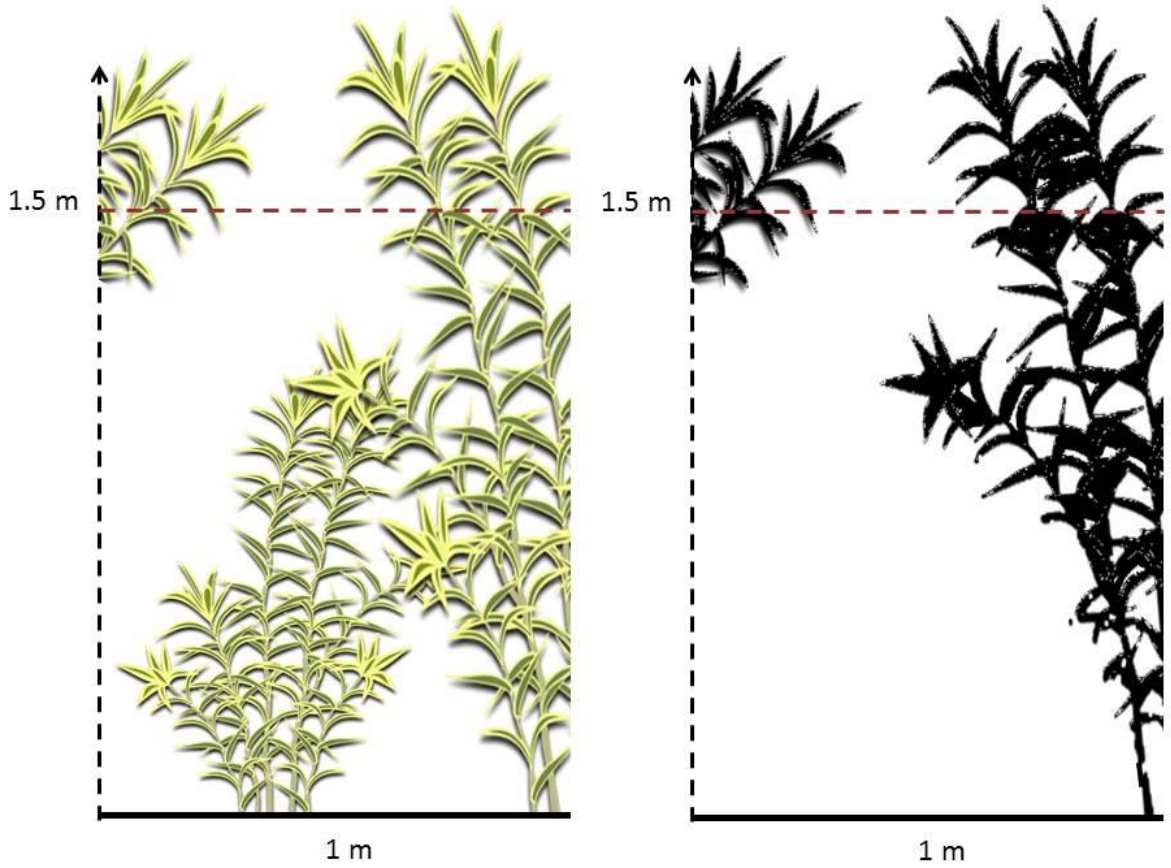
J. No Woody Canopy Checkbox: If there is no live woody (trees and shrubs) canopy cover (>1.5 m height, rooted in and outside of the plot) present over the plot, check this checkbox with a clear, well-defined "X" for that plot.

K. % Woody Canopy Cover (WCC) (0.5-100): Visually estimate the total percentage of live woody canopy cover and the percentage of live woody canopy cover by species in the plot (Figures 5, 6). The vegetation can be rooted inside or outside of the plot. Be sure to look overhead for tall vegetation that might be present. Woody canopy cover includes low branches less than 1.5 m in height of plants whose tallest, live braches are over 1.5 m in height. Therefore, observers need to look at the entire plant and decide first if the entire plant counts as woody canopy or not (i.e., if any living part of the plant is over 1.5 m in height). If it is woody canopy, then all parts of the plant are included in woody canopy cover. Woody canopy cover does not include plants that are longer than 1.5 m but are leaning such that no part of the living plant is 1.5 m above the ground. Visualize the plan view projection of outline polygon of plant within the plot, regardless of where plant is rooted. 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). Record to the nearest 1%. Record a "T" for trace percentage (<0.5%). Record by 6-letter code for the species on data form (writing in the margin the full Latin name for each first encounter).



a. b. c.

Figure 5. To estimate woody canopy cover, a) visualize the plot from above, b) visualize how much vertical space above the plot is covered by plants that are over 1.5 m in height, regardless of where they are rooted, and c) in your mind, lump all covered space to one side of the plot.



a. b.

Figure 6. When estimating woody canopy cover, include any portions of plants (of individuals over 1.5 m in height) that fall directly over the plot regardless of where they are rooted. In this diagram, a) illustrates all plants in the plot and b) illustrates the plants that would be included in woody canopy cover.

L. % Standing Dead (0.5-100): Record the percentage of any dead, woody canopy cover (plants greater than 1.5 m in height directly over and rooted within or outside of the plot) of shrubs and trees to the nearest 1%. Record a "T" for trace percentage (<0.5%). Standing dead material may be attached to living plants. Standing dead includes low dead branches less than 1.5 m in height of plants whose tallest dead braches are over 1.5 m in height. Therefore, observers need to look at an entire plant and decide first if any of the plant counts as standing dead canopy or not (i.e., if any dead part of the plant is over 1.5 m in height). Standing dead cover does not include plants that are longer than 1.5 m but are leaning such that no part of the living plant is 1.5 m above the ground. Visually estimate the plan view projection of the outline polygon of each plant species.

M. No Rooted Veg Checkbox: Check this box with a clear, well-defined "X" for that plot if the plot does not contain any rooted vegetation.

N. Total Rooted Plant % Cover (0.5-100): Visually estimate the percentage of live plant cover of any height rooted in the plot to the nearest 1% (Figure 4). Record a "T" for trace percentage (<0.5%). Cover includes plants that are alive or were alive earlier this year. Do not double-count overlapping areas of cover (i.e., 100% is max overall plot cover). Leave and count plants as you found them (i.e., if a plant is rooted and lying on its side, don't stand it up). Roots and exposed rhizomes do not count as canopy cover. This measurement will continue into the inundated channel by recording total plant cover of rooted or attached macrophytes.

O. Total Rooted Plant % Cover by Species (0.5-100): Visually estimate a plan view projection of outline polygons of each plant species rooted in the plot (Figure 4). Cover includes plants that are alive and that were alive earlier this year. Do not double-count overlapping areas of cover (i.e., 100% is max overall plot cover). Leave and count plants as you found them (i.e., if a plant is rooted and lying on its side, don't stand it up). Roots and exposed rhizomes do not count as canopy cover.

Record the 6-letter code for each species on data sheet (writing in the bottom of the sheet the full Latin name for each first encounter on each transect). Record the percentage of each unique species plant species cover to nearest 1%. Record a "T" for trace percentage (<0.5%). This measurement will continue into the inundated channel recording plant cover of rooted or attached macrophytes.

Separate rooted woody seedlings (≤1.5m tall) from adults (>1.5m tall) for *Acer negundo*, *Celtis reticulata*, *Forestiera pubescens*, *Pluchea sericea*, *Populus* sp., *Salix* sp., and *Tamarix* sp. species. If a plant is longer than 1.5 m in length, but no part of plant is above 1.5 m in height (i.e. the plant is leaning), then the plant is recorded a seedling (i.e. *Salix* sp. seedling). If a rooted woody plant is >1.5 m tall, it gets recorded as the species name (*Salix* sp.).

P. Conduct Plot Replicates: Following completion of vegetation monitoring plots, 5-10% of plots should be replicated at each site/feature by a different observer. Plots used as replicates should be documented on datasheets by noting "R" followed by the plot number. Replicate plots should also be conducted across the various facies present at a site and contain at least a trace (ideally 5% or more) of vegetative plant cover.

Q. Review Datasheets: Visually inspect datasheets for completeness. Common errors include incomplete header information and missing (blank) values.

1.3 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 site and use existing unknown names whenever possible.

A. 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).

If an identifiable specimen cannot be found, create a unique name using the following code: **Unknown Code =** unk + 4 LETTER PARK CODE + SITE CODE + -your initials + collection number for the feature (e.g., unkCANYLC-ST1). Notify team members of this plant and unknown code.

b. 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. Try to get good images of floral parts, fruits, foliage and the whole 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.).

B. 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 information.

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 while fresh, preserve the bag in a cooler as soon as possible or keep it in the plant press. Make sure the specimen does not get wet. If the species cannot be determined during the field visit, press the plant. If it is identified and there is no specimen in the

herbarium then press the plant, if it is identified and a voucher specimen is already present, discard the species in the field.

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.

C. Unknown Plant Datasheets: When filling out the datasheet (Appendix 1), 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:

a. Unknown Code = unk + 4 LETTER PARK CODE + SITE CODE + -your initials + collection number for the feature (e.g., unkCANYLC-ST1).
b. Plant Type and General Description: Circle the appropriate categories and provide a succinct description of the overall appearance (e.g., tiny *Eleocharis*).
c. Most Salient Feature: A unique characteristic that identifies the plant from others.
d. Leaf Characteristics (optional): Describe the leaf type, leaf margin, leaf surface, petiole, etc.
e. Stem Characteristics (optional): Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.
f. Flower Characteristics (optional): Describe the floral structure (i.e., number and arrangement of bracts, calyx, corolla, androecium, and gynoecium), location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.
g. Microhabitat Characteristics: Describe the microhabitat in which it was found if unique on the plot (e.g., wash bottom, limestone outcrop, etc.).
h. Collected: Circle yes or no, whether a specimen was collected.
i. Best Guess: Preliminary guess about species in field.

D. 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.

III - DINOSAUR NM

1. Measuring Vegetation

Vegetation sampling consists of a plant walk to develop a species list of the sentinel site and observations of modal sediment size, inundation, litter, woody debris, woody canopy cover, and indicator species within a 1 x 1 m plots along permanent, repeated transects.

When filling out datasheets (Appendix 1), do not erase mistakes. If a mistake is made, draw a line through the erroneous information, write in the correct information, and annotate with your initials and date.

1.1 Veg Walk

Using the plant walk datasheet, conduct a plant walk by recording all plant species observed in and around the sentinel site (e.g., Laddie Park), extending upslope to transect headpins. Record date and approximate time spent looking (there is no minimum or maximum time to spend on this). Consider conducting an initial plant walk before vegetation quadrat monitoring as a means of vegetation team calibration. Alternatively, the plant walk can be done in increments as the work schedule allows. If time is running short, the plant walk may be skipped.

A. Fill out the DINO Veg Walk datasheet header information:

River: Yampa = Yampa
GabvC = Green above confluence
GblwC = Green below confluence

Sentinel Site: Use two-letter abbreviations for the sentinel sites.
DL = Deerlodge
HH = Harding Hole
LP = Laddie Park
EP = Echo Park
BP = Browns Park
WR = Winnies Rapid
LS = Limestone
SC = Seacliff
IP = Island Park

Date: mm/dd/yyyy
Observer: Record the name of the person(s) calling out the data
Recorder: Record the name of the person(s) recording the data, if applicable
Page ____of_____: This will be completed once all datasheets are collected

B. Record species found: Place a check mark next to any species found that is listed on the data sheet. If a species is found and not listed, record the full Latin name at the end of the list.

1.2 Vegetation Plots

Vegetation surveying will consist of relocating previous plots (originally randomly located along systematic transects). There are 50 to 150 permanent 1x1 m plots at each site. Transects will extend from at least one plot in the inactive floodplain to a safe wading distance into the water (waist deep in slow water, less deep as the current increases). Plots will be loaded into the RTK units and will be laid out by the surveyors. Plots where the water is too deep to place a pin flag will be recorded by the surveyors.

Veg plots will be marked with pinflags that are put out by the surveyors. Pinflags will be labeled with a unique number (e.g., 1, 2, 3, 4, etc.) and placed in the center of the plot. Care needs to be taken to ensure that plots are not missed as the surveyors will take measurements at plots that are completely submerged.

Species cover is visually quantified. Crew members should be trained on visual estimation techniques before collecting data. Visual estimation is based on a plan view projection of outline polygon of plant subtracting the open spaces within the polygon (Figure 7). If the sun were directly overhead, imagine what percentage would be shaded. Stand over the plot to get a proper view of the species within a plot.



a. b. c.

Figure 7. To estimate percent cover, a) view the plot from above, b) visualize open vs. covered space by plants that are within the plot, and c) in your mind, lump all covered space to one side of the plot.

For all vegetation data documentation, record the full Latin name of each species the first time it is encountered at a reach. This can be done in the margin of the paper data sheet. Any additional times the species is encountered, use the six-letter code composed of the first three letters of the genus and specific epithet.

On a daily basis before quadrat sampling, documented calibration of at least 3 plots by all vegetation observers should be conducted. Ideally, plots to be observed during sampling should not be used for calibration. Find calibration plots with representative and varied characteristics (e.g., vegetative cover and composition, sediment sizes, etc.) with respect to the site to be monitored. Calibration plots should be labeled with a “C” followed by plot numbers not in use at any site across a park during that season (e.g. C901 can be used once at each of BLCA, CANY, and DINO during a single field season). During calibration, each vegetation observer should

independently observe and record their individual estimations of plot all parameters on a datasheet. Once all observers have finished, discussion of individual observations should take place by all observers. During this discussion, do not change recorded observations as written on datasheets. Since crews lack known values of parameters within plots to compare to, the focus of this discussion should work towards collectively minimizing variability among observers for all parameters.

Use the following guidelines to determine if calibration has been meet after 3 calibration plots or if more calibration is needed before individual sampling is conducted:

- All observers are within 2% for covers that compose 0-5% of the plot
- All observers are within 4% for covers that compose 6-10% of the plot
- All observers are within 7% for covers that compose 11-25% of the plot
- All observers are within 10% for covers that compose 26-50% of the plot
- All observers are within 20% for covers that compose 51-100% of the plot

A. Fill out DINO Veg Plot datasheet header information:

River: Yampa = Yampa
GabvC = Green above confluence
GblwC = Green below confluence

Sentinel Site: Record the pre-assigned, 2-letter code for each sentinel site:
DL = Deerlodge
HH = Harding Hole
LP = Laddie Park
EP = Echo Park
BP = Browns Park
WN = Winnies Rapid
LS = Limestone
SC = Seacliff
IP = Island Park

Observer: Record the name of the person calling out the plot data
Recorder: Record the name of the person recording the data
Date: mm/dd/yyyy

B. Place Plot and Record Plot Location: Place plot with the pin flag in the center of the plot with two sides of the plot aligned perpendicular to the river's flow. Record the veg plot number written on the pin flag (e.g., 1, 2, 3, etc.).

C. % Inundation (Water) (0.5-100): Record to the nearest 1% the amount of that plot that is inundated (covered) by water.

D. Class and % Modal Particle Size: Record the class and percent cover of the modal particle size(s) using the modified-Wentworth scale (see Appendix 2) by visually

estimating a plan view projection of substrate within the plot. Look at the diameter of the intermediate axis of the particles. Do not include litter, woody debris, or plant bases. For example, if a plot's surface is characterized by 30% tamarisk sp. bole and 70% sand, record this plot as 100% sand. If necessary, first record Percent Litter and Woody Debris and then physically remove organic matter from the plot to determine percent cover of modal particle size.

For unsaturated sediment finer than sand, conduct the surface soil texture test. Collect a small amount of soil in your hand and slowly add water. Mix the water and soil in your hand and use the key in Figure 1 in Appendix 2 to determine the soil texture. If you have never textured soil, practice this technique with the guidance of an experienced co-worker before the beginning of field sampling. The texture triangle (Figure 2 in Appendix 2) is also helpful for understanding the relationship between different soil particle sizes in determining soil texture. Soil texture tests do not need to be done in every plot, but should be done when the modal sediment size makes an observable change.

If you cannot see ground surface (due to turbid water), use your hand to feel the bottom of plot to determine dominant particle size. If necessary, randomly select and measure several particles to determine a dominant measurement. For saturated sediment finer than sand, record "F" for fines. If there is a veneer of fines <1 cm thick over another substrate, for example, cobbles, record the modal particle size as "cobbles". Only record fines (including clay, clay/loam, or loam) if you cannot recognize the substrate underneath (i.e., more than a veneer) or if the veneer is >1 cm thick.

E. % Sand & Finer (0.5-100): Visually estimate the percent cover of the plot that is characterized by particles that are sand (<2 mm) or smaller to the nearest 1%. Do not include litter, woody debris, or plant bases. For example, a plot that is 50% sand & finer, 25% plant base, and 25% boulder should be characterized as 67% sand & finer.

F. % Litter (0.5-100): Record the amount of the plot that is covered by litter (< 2.5 cm in diameter) to the nearest 1%. Only include litter that is on the ground or piled upon other litter on the ground. Do not include suspended or aerial litter.

G. % Woody Debris (0.5-100): Record the amount of the plot that is covered by woody debris (≥2.5 cm in diameter), each to the nearest 1%. Only include debris that is lying on the ground or piled upon other debris on the ground. Do not include suspended or aerial debris.

H. % Filamentous Algae (0.5-100): Record the amount of the plot that is covered by filamentous algae (FA) (long enough to move with current, about ½ cm) to the nearest 1%.

I. Beaver Browse Activity Checkbox: If recent (i.e., having occurred during the current growing season) beaver browsing is observed on vegetation rooted within the plot, check this checkbox with a clear, well-defined "X" for that plot.

J. % Standing Dead (0.5-100): Record the percentage of any dead, woody canopy cover (plants greater than 1.5 m in height directly over and rooted within or outside of the plot) of shrubs and trees to the nearest 1%. Record a "T" for trace percentage (<0.5%). Standing dead material may be attached to living plants. Standing dead includes low dead branches less than 1.5 m in height of plants whose tallest dead braches are over 1.5 m in height. Therefore, observers need to look at an entire plant and decide first if any of the plant counts as standing dead canopy or not (i.e., if any dead part of the plant is over 1.5 m in height). Standing dead cover does not include plants that are longer than 1.5 m but are leaning such that no part of the living plant is 1.5 m above the ground. Visually estimate the plan view projection of the outline polygon of each plant species.

K. No Rooted Veg Checkbox: Check this box with a clear, well-defined "X" for that plot if the plot does not contain any rooted vegetation.

L. Total Rooted Plant % Cover (0.5-100): Visually estimate the percentage of live plant cover of any height rooted in the plot to the nearest 1% (Figure 7). Record a "T" for trace percentage (<0.5%). Cover includes plants that are alive or were alive earlier this year. Do not double-count overlapping areas of cover (i.e., 100% is max overall plot cover). Leave and count plants as you found them (i.e., if a plant is rooted and lying on its side, don't stand it up). Roots and exposed rhizomes do not count as canopy cover. This measurement will continue into the inundated channel by recording total plant cover of rooted or attached macrophytes.

M. All Rooted % Cover by Species (0.5-100):

For each understory and overstory unique species, record the 6-letter species code composed of the first three letters of the genus and specific epithet vertically in the column. (For the first time a unique species is encountered at a sentinel site, record the full Latin name in addition to the 6-letter species code.) If a specific epitaph is not known, use the genus name as the code. Count only species rooted within the plot (Figure 7). Cover includes plants that are alive and that were alive earlier this year. Leave and count plants as you found them (i.e., if a plant is rooted and lying on its side, don't stand it up). Roots and exposed rhizomes do not count as canopy cover.

Visually estimate the percentage of each unique species' canopy cover rooted within a 1x1m plot to the nearest 1%. Record T if trace percentage (≤0.5%), 1% if 0.5-1%. Visual estimation is based on a plan view projection of outline polygon of plant subtracting the open spaces within the polygon. If the sun were directly overhead, imagine what percentage is shaded. Stand over the plot to get a proper view of the species within a plot.

Distinguish between adults (>1.5m tall) and seedlings (≤1.5m tall) for *Acer negundo, Celtis reticulata, Populus* sp., *Salix* sp., and *Tamarix* sp. Adult plant material includes low branches less than 1.5 m in height connected to plants whose tallest, live braches are over 1.5 m in height. Therefore, observers need to look at the entire plant and decide first if the entire plant counts as an adult or seedling (i.e., if any living part of the plant is over 1.5 m in height). If it is an adult, then all parts of the plant are measured as adult canopy cover. Adult cover does not include plants that are longer than 1.5 m but are leaning such

that no part of the living plant is 1.5 m above the ground. Place the seedling cover in the pre-populated seedling row, or if the species is not pre-populated, write "seedling" after the species name and record an asterisk (*) following the 6-letter code.

N. Conduct Plot Replicates: Following completion of vegetation monitoring plots, 5-10% of plots should be replicated at each site/feature by a different observer. Plots used as replicates should be documented on datasheets by noting "R" followed by the plot number. Replicate plots should also be conducted across the various facies present at a site and contain at least a trace (ideally 5% or more) of vegetative plant cover.

O. Review Datasheets: Visually inspect datasheets for completeness. Common errors include incomplete header information and missing (blank) values.

1.3 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 site and use existing unknown names whenever possible.

A. 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).

If an identifiable specimen cannot be found, create a unique name using the following code: **Unknown Code =** unk + 4 LETTER PARK CODE + SITE CODE + -your initials + collection number for the feature (e.g., unkDINOLC-ST1). Notify team members of this plant and unknown code.

b. 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. Try to get good images of floral parts, fruits, foliage and the whole 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.).

B. 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 information.

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 while fresh, preserve the bag in a cooler as soon as possible or keep it in the plant press. Make sure the specimen does not get wet. If the species cannot be determined during the field visit, press the plant. If it is identified and there is no specimen in the herbarium then press the plant, if it is identified and a voucher specimen is already present, discard the species in the field.

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.

C. Unknown Plant Datasheets: When filling out the datasheet (Appendix 1), 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:

a. Unknown Code = unk + 4 LETTER PARK CODE + SITE CODE + -your initials + collection number for the feature (e.g., unkDINOLP-ST1).
b. Plant Type and General Description: Circle the appropriate categories and provide a succinct description of the overall appearance (e.g., tiny *Eleocharis*).
c. Most Salient Feature: A unique characteristic that identifies the plant from others.
d. Leaf Characteristics (optional): Describe the leaf type, leaf margin, leaf surface, petiole, etc.
e. Stem Characteristics (optional): Describe the shape, pubescence, markings, and color of the stem, as well as the bud characteristics.
f. Flower Characteristics (optional): Describe the floral structure (i.e., number and arrangement of bracts, calyx, corolla, androecium, and gynoecium), location (axillary or terminal), habit (indeterminate or determinate), pubescence, and color.
g. Microhabitat Characteristics: Describe the microhabitat in which it was found if unique on the plot (e.g., wash bottom, limestone outcrop, etc.).
h. Collected: Circle yes or no, whether a specimen was collected.

i. **Best Guess:** Preliminary guess about species in field.

D. 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.

Appendix 1. Data Sheets

BLCA Veg Walk

Data entered by: Data verified by:

Date entered: ____/____/____ Date verified: ____/____/____

Page _____ of _____

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River: Gunnison Feature: _____ Sentinel Site: _____ Date: ___/____/____ Observer: Recorder:

✓	Species Found	
	Aceraceae	
	Acer negundo	ACENEG
	Acer negundo SEEDLING	ACENEG
	Anacardiaceae	
	Rhus aromatic	RHUARO
	Apocynaceae	
	Apocynum sp.	APOCYNUM
	Apocynum cannabinum	APOCAN
	Asteraceae	
	Ambrosia acanthicarpa	AMBACA
	Ambrosia tomentosa	AMBTOM
	Artemisia biennis	ARTBIE
	Artemisia dracunculus	ARTDRA
	Artemesia ludoviciana	ARTLUD
	Artemisia tridentata	ARTTRI
	Aster ascendens	ASTASCENDENS
	Carduus nutans	CARNUT
	Centaurea repens	ACRREP
	Chrysothamnus linifolius	CHRLIN
	Chysothamnus nauseosus	CHRNAU
	Chysopsis villosa	CHRVIL
	Cirsium arvense	CIRARV
	Cirsium undulatum	CIRUND
	Conyza Canadensis	CONCAN
	Euthamia occidentalis	EUTOCC
	Gaillardia sp.	GAILLARDIA
	Gnaphalium palustre	GNAPAL
	Grindelia squarrosa	GRISQU
	Gutierrezia sarothrae	GUTSAR
	Helenium autumnale	HELAUT
	Helianthus sp.	HELIANTHUS
	Iva axillaris	IVAAXI
	Solidago sp	SOLIDAGO
	Solidago missoriensis	SOLMIS
	Taraxacum officinale	TAROFF
	Tragopogon dubius	TRADUB
	Xanthium strumarium	XANSTR
	Brassicaceae	
	Alyssum desertorum	ALYDES
	Descurainia sp.	DESCURAINIA
	Lepidium densiflorum	LEPDEN
	Lepidium latifolium	LEPLAT
	Sisymbrium altissimum	SISALT

✓	Species Found	
	Capparaceae	
	Cleome lutea	CLELUT
	Cleome serrulata	CLESER
	Chenopodiaceae	
	Chemopodium fremontii	CHEFRE
	Chenopodium glaucum	CHEGLA
	Cycloloma atriplicifolia	CYCATR
	Salsola tragus	SALTRA
	Cupressaceae	
	Juniperus osteosperma	JUNOST
	Juniperus scopulorum	JUNSCO
	Cyperaceae	
	Carex sp.	CAREX
	Carex emoryi	CAREMO
	Eleocharis palustris	ELEPAL
	Scirpus pungens	SCIPUN
	Equisetaceae	
	Equisetum arvense	EQUARV
	Equisetum hyemale	EQUHYE
	Equisetum hyemale/laevigatum	EQUHYELAE
	Equisetum sp.	EQUISETUM
	Euphorbiaceae	
	Chamaesyce sp.	CHAMAESYCE
	Euphorbia esula	EUPESU
	Fabaceae	
	Astragalus sp.	ASTRAGALUS
	Astragalus mollissimus	ASTMOL
	Glycyrrihza lepidota	GLYLEP
	Melilotus officinalis	MELOFF
	Melilotus sp.	MELILOTUS
	Psoralidium lanceolatum	PSOLAN
	Fagaceae	
	Quercus gambelii	QUEGAM
	Hydrangeaceae	
	Philadelphus microphyllus	PHIMIC
	Juncaceae	
	Juncus arcticus	JUNARC
	Lamiaceae	
	Mentha arvensis	MENARV
	Oleaceae	
	Fraxinus anomala	FRAANO

✓	Species Found	
	Onagraceae	
	Epilobium ciliatum	EPICIL
	Oenothera biennis	OENBIE
	Oenothera elata	OENELA
	Oenothera pallida	OENPAL
	Pinaceae	
	Pseudotsuga menziesii	PSEMEN
	Poaceae	
	Agrostis stolonifera	AGRSTO
	Bromus inermis	BROINE
	Bromus japonicus	BROJAP
	Bromus tectorum	BROTEC
	Crypsis alopecuroides	CRYALO
	Distichlis spicata	DISSPI
	Elymus sp	ELYMUS
	Elymus canadensis	ELYCAN
	Elymus cinereus	ELYCIN
	Elymus elymoides	ELYELY
	Elymus lanceolatus	ELYLAN
	Elymus repens	ELYREP
	Elymus smithii	ELYSMI
	Elymus trachycaulus	ELYTRA
	Hordeum jubatum	HORJUB
	Muhlenbergia asperifolia	MUHASP
	Phalaris arundinacea	PHAARU
	Poa pratensis	POAPRA
	Poa secunda	POASEC
	Spartina pectinata	SPAPEC
	Sporobolus cryptandrus	SPOCRY
	Stipa comata	STICOM
	Stipa hymenoides	STIHYM
	Plantaginaceae	
	Plantago major	PLAMAJ
	Polygonaceae	
	Polygonum amphibium	POLAMP
	Polygonum lapathifolium	POLLAP
	Portulacaceae	
	Portulaca oleracea	POROLE
	Rosaceae	
	Amelanchier utahensis	AMEUTA
	Potentilla anserina	POTANS
	Rosa woodsii	ROSWOO

BLCA Veg Walk

Data entered by: Data verified by:

Date entered: ____/____/____ Date verified: ____/____/____

Page _____ of _____

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River: Gunnison **Feature:** _____ **Sentinel Site:** _____ **Date:** ___/____/____ **Observer:** **Recorder:**

KEY : **suspected** = * **species** = sp.

unknown = UNK + CODE
CODE = *park + site + 2 letter initials + 1 digit*

Example unknown: *UNK-DINO-BP-BG-3*

✓	Species Found	
	Salicaeae	
	Populus angustifolia	POPANG
	Populus angustifolia SEEDLING	POPANG
	Populus fremontii	POPFRE
	Populus fremontii SEEDLING	POPFRE
	Salix exigua	SALEXI
	Salix exigua SEEDLING	SALEXI
	Scrophulariaceae	
	Verbascum thapsus	VERTHA
	Veronica anagallis-aquatica	VERANA
	Tamaricaceae	
	Tamarix sp.	TAMARIX
	Tamarix sp. SEEDLING	TAMARIX
	Ulmaceae	
	Celtis reticulata	CELRET
	Ulmus pumila	ULMPUM
	Verbenaceae	
	Verbena bracteata	VERBRA

✓	Species Found

✓	Species Found	
	Unknowns	
	Unknown annual forb	UNKAF
	Unknown annual graminoid	UNKAG
	Unknown forb	UNKF
	Unknown graminoid	UNKG

BLCA Veg Plots

Data entered by: Data verified by: Page _____ of _____

Date entered: ___/___/___ Date verified: ___/___/___

NCPN Big River Monitoring — Big River Monitoring Protocol – SOP#6 – Version 3.21 – Feb 2018

River: Gunnison Site: _____ Feature: ____ Transect: _____ Observer: Recorder: Date: ___/____/____

NCPN Modified Wentworth Scale

Class Size	Code	Diameter (mm)	Class Size	Code	Diameter (mm)
Fines	F	See SOP definition	Gravel	GR	> 2 – 16
Clay	CL		Pebble	PE	> 16 – 64
Loam/Clay	LC		Cobble	CO	> 64 – 256
Loam	LO		Boulder	BL	> 256 – 512
Sand	SA	0.5µm — 2mm	Bedrock, Hardpan	BR	> 512

Tagline Measurements

DESCRIPTION	HEIGHT (cm)	LINE DISTANCE (m)
Above Headpin @ 0		0
Above Water @ RS		

Plot Location {m} *plot centered on transect*																	
% Inundation (Water)																	
Modal Particle Size {F CL LC LO SA GR PE CO BL BR}																	
% Modal Particle Size {nearest 1%}																	
% Sand & Finer {nearest 1%}																	
% Litter {nearest 1%}																	
% Woody Debris {nearest 1%}																	
% Filamentous Algae {nearest 1%}																	
Beaver Browse Activity	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
% Social Trails {nearest 1%}																	
Plot Density 1/x {1, 2, 4, or 8}																	

No double-counting overlapping areas of cover — Woody Canopy % Cover — Rooted & Unrooted • nearest 1% • Trace ≤ 0.5

No Canopy Veg?		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
% Total WCC - Live																	
% Standing Dead																	

Understory Rooted Plant % Cover

≤ 1.5m height • to nearest 5% • Trace ≤ 0.5 • No dead plants/parts • No double-counting overlapping areas of cover • max overall plot cover = 100%

Total Plot Cover % *(< 1.5m in height)*																	
Herbaceous Indicator Species		**≤ 1.5m • % Cover**															
No Rooted Veg?		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Acer negundo	ACENEG																
Agrostis stolenifera	AGRSTO																
Apocynum cannabinum	APOCAN																
Artemisia ludoviciana	ARTLUD																
Cirsium arvense	CIRARV																
Eleocharis palustris	ELEPAL																
Elymus repens	ELYREP																
Epilobium ciliatum	EPICIL																
Equisetum hyemale/laevigatum	EQUHYELAE																
Euthamia occidentalis	EUTOCC																
Heterotheca zionensis	CHRZIO																
Melilotus sp.	MELILOTUS																
Phalaris arundinacea	PHAARU																
Populus angustifolia	POPANG																
Rhus aromatica	RHUARO																
Salix exigua	SALEXI																
Verbascum thapsus	VERTHA																
Verbena bracteata	VERBRA																
Veronica anagallis-aquatica	VERANA																

Notes:

CANY Veg Walk

Data entered by: Data verified by:

Date entered: ____/____/____ Date verified: ____/____/____

Page _____ of _____

NCPN Big River Monitoring — Big River Monitoring Protocol – SOP#6 – Version 3.21 – Feb 2018

River (circle): **Green CAC CBC** **Sentinel Site:** _____ **Observer:** **Recorder:** **Date:** ___/____/____

✓	Species Found	
	Amaranthaceae	
	Amaranthus albus	AMAALB
	Anacardiaceae	
	Rhus aromatica	RHUARO
	Apocynaceae	
	Apocynum cannabinum	APOCAN
	Asclepiadaceae	
	Asclepias subverticillata	ASCSUB
	Asteraceae	
	Artemisia biennis	ARTBIE
	Artemisia dracunculus	ARTDRA
	Artemesia ludoviciana	ARTLUD
	Aster frondosus	ASTFRO
	Baccharis salicina	BACSAL
	Baccharis viminea	BACVIM
	Bidens cernua	BIDCER
	Bidens frondosa	BIDFRO
	Cirsium sp.	CIRSIUM
	Conyza canadensis	CONCAN
	Euthamia occidentalis	EUTOCC
	Gnaphalium palustre	GNAPAL
	Gnaphalium stramineum	GNASTR
	Helenium autumnale	HELAUT
	Sonchus asper	SONASP
	Viguiera multiflora	VIGMUL
	Xanthium strumarium	XANSTR
	Brassicaceae	
	Lepidium latifolium	LEPLAT
	Chenopodiaceae	
	Bassia sp.	BASSIA
	Chenopodium sp.	CHENOPODIUM
	Chenopodium fremontii	CHEFRE
	Chenopodium rubrum	CHERUB
	Salsola tragus	SALTRA
	Cyperaceae	
	Carex sp.	CAREX
	Cyperus erythrorhizos	CYPERY
	Eleocharis palustris	ELEPAL
	Equisetaceae	
	Equisetum hyemale/laevigatum	EQUHYELAE
	Euphorbiaceae	
	Chamaesyce glyptosperma	CHAGLY

✓	Species Found		
	Fabaceae		
	Astragalus sp.		ASTRAGALUS
	Melilotus officinalis		MELOFF
	Lamiaceae		
	Mentha arvensis		MENARV
	Onagraceae		
	Oenothera sp.		OENOTHERA
	Oenothera biennis		OENBIE
	Poaceae		
	Crypsis alopecuroides		CRYALO
	Distichlis spicata		DISSPI
	Echinochloa crus-galli		ECHCRU
	Eragrostis hypnoides		ERAHYP
	Leptochloa fascicularis		LEPFAS
	Panicum capillare		PANCAP
	Phragmites australis		PHRAUS
	Sporobolus cryptandrus		SPOCRY
	Plantaginaceae		
	Plantago major		PLAMAJ
	Polygonaceae		
	Polygonum lapathifolium		POLLAP
	Rumex maritumus		RUMMAR
	Portulacaceae		
	Portulaca oleracea		POROLE
	Ranunculaceae		
	Ranunculus cymbalaria		RANCYM
	Rosaceae		
	Potentilla sp.		POTENTILLA
	Salicaeae		
	Populus fremontii		POPFRE
	Populus fremontii	*SEEDLING*	POPFRE*
	Salix exigua		SALEXI
	Salix exigua	*SEEDLING*	SALEXI*
	Salix lucida		SALLUC
	Salix lucida	*SEEDLING*	SALLUC*
	Scrophulariaceae		
	Veronica anagallis-aquatica		VERANA
	Tamaricaceae		
	Tamarix sp.		TAMARIX
	Tamarix sp. SEEDLING		TAMARIX*
	Typhaceae		
	Typha sp.		TYPHA

✓	Species Found	
	Verbenaceae	
	Verbena bracteata	VERBRA
	Unknowns	
	Unknown annual forb	UNKAF
	Unknown annual graminoid	UNKAG
	Unknown forb	UNKF
	Unknown graminoid	UNKG

CANY Veg Walk

Data entered by:
Date entered: ____/____/____

Data verified by:
Date verified: ____/____/____

Page _____ of _____

NCPN Big River Monitoring | Big River Monitoring Protocol – SOP#6 – Version 3.21 – Feb 2018

River (circle): **Green CAC CBC** **Sentinel Site:** _____ **Date:** __/____/____ **Observer:** **Recorder:**

KEY : **suspected** = * **species** = sp.
unknown = UNK + CODE
CODE = *park + site + 2 letter initials + 1 digit*
Example unknown: *UNK-DINO-BP-BG-3*

✓	Species Found	✓	Species Found	✓	Species Found

CANY Veg Plots

Data entered by: Data verified by:

Date entered: ___/___/____ Date verified: ___/___/____

Page ______ of ______

NCPN Big River Monitoring — Big River Monitoring Protocol – SOP#6 – Version 3.21 – Feb 2018

River: Green CAC CBC **Site:** ________ **Observer:** **Recorder:** **Date:** ___/____/____

NCPN Modified Wentworth Scale

Class Size	Code	Diameter (mm)	Class Size	Code	Diameter (mm)
Fines	F	See SOP definition	Gravel	GR	> 2 – 16
Clay	CL		Pebble	PE	> 16 – 64
Loam/Clay	LC		Cobble	CO	> 64 – 256
Loam	LO		Boulder	BL	> 256 – 512
Sand	SA	0.5µm — 2mm	Bedrock, Hardpan	BR	> 512

Plot Density 1/3

Plot Dimensions			
Length (m)	1	Width (m)	1

Transect																	
Plot Location (m) *center of plot*																	
% Inundation (Water)																	
Modal Particle Size (F CL LC LO SA GR PE CO BL BR)																	
% Modal Particle Size (nearest 1%)																	
% Sand & Finer (nearest 1%)																	
% Litter (nearest 1%)																	
% Woody Debris (nearest 1%)																	
% Filamentous Algae (nearest 1%)																	
Beaver Browse Activity		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
No double-counting overlapping areas of cover		**Woody Canopy % Cover**								Rooted & Unrooted • nearest 1% • Trace ≤ 0.5							
No Canopy Veg?		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
% Total WCC - Live																	
% Standing Dead																	
Rooted Plant % Cover																	
to nearest 1% • Trace ≤ 0.5 • No dead plants/parts • No double-counting overlapping areas of cover • max overall plot cover = 100%																	
Total Plot Cover %	0 = No Veg, Max = 100%																
Herbaceous Indicator Species														**% Cover**			
No Rooted Veg?		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Salix exigua SEEDLING	*SALEXI**																
Salix exigua	*SALEXI*																

NOTES: *please be brief!*

DINO Veg Walk

Data entered by: Data verified by:

Date entered: ____/____/____ Date verified: ____/____/____

Page _____ of _____

NCPN Big River Monitoring — Big River Monitoring Protocol – SOP#6 – Version 3.21 – February 2018

River (circle): **GAC GBC Yampa** **Sentinel Site:** _____ **Observer:** **Recorder:** **Date:** ___/____/____

✓	Species Found	
	Aceraceae	
	Acer negundo	ACENEG
	Acer negundo SEEDLING	ACENEG
	Anacardiaceae	
	Rhus aromatica	RHUARO
	Apocynaceae	
	Apocynum sp.	APOCYNUM
	Apocynum cannabinum	APOCAN
	Asclepiadaceae	
	Asclepias sp.	ASCLEPIAS
	Asclepias speciosa	ASCSPE
	Asteraceae	
	Ambrosia acanthicarpa	AMBACA
	Ambrosia tomentosa	AMBTOM
	Artemisia biennis	ARTBIE
	Artemisia dracunculus	ARTDRA
	Artemesia ludoviciana	ARTLUD
	Artemisia tridentata	ARTTRI
	Aster ascendens	ASTASCENDENS
	Carduus nutans	CARNUT
	Centaurea repens	ACRREP
	Chrysothamnus linifolius	CHRLIN
	Chysothamnus nauseosus	CHRNAU
	Chysopsis villosa	CHRVIL
	Cirsium arvense	CIRARV
	Cirsium undulatum	CIRUND
	Conyza canadensis	CONCAN
	Euthamia occidentalis	EUTOCC
	Gaillardia sp.	GAILLARDIA
	Gnaphalium palustre	GNAPAL
	Grindelia squarrosa	GRISQU
	Gutierrezia sarothrae	GUTSAR
	Helenium autumnale	HELAUT
	Helianthus sp.	HELIANTHUS
	Iva axillaris	IVAAXI
	Solidago sp	SOLIDAGO
	Solidago missoriensis	SOLMIS
	Taraxacum officinale	TAROFF
	Tragopogon dubius	TRADUB
	Xanthium strumarium	XANSTR

✓	Species Found	
	Brassicaceae	
	Alyssum desertorum	ALYDES
	Descurainia sp.	DESCURAINIA
	Lepidium densiflorum	LEPDEN
	Lepidium latifolium	LEPLAT
	Sisymbrium altissimum	SISALT
	Capparaceae	
	Cleome lutea	CLELUT
	Cleome serrulata	CLESER
	Chenopodiaceae	
	Chenopodium fremontii	CHEFRE
	Chenopodium glaucum	CHEGLA
	Cycloloma atriplicifolia	CYCATR
	Salsola tragus	SALTRA
	Cupressaceae	
	Juniperus osteosperma	JUNOST
	Cyperaceae	
	Carex sp.	CAREX
	Carex emoryi	CAREMO
	Eleocharis palustris	ELEPAL
	Scirpus pungens	SCIPUN
	Equisetaceae	
	Equisetum arvense	EQUARV
	Equisetum hyemale	EQUHYE
	Equisetum hyemale/laevigatum	EQUHYELAE
	Euphorbiaceae	
	Chamaesyce sp.	CHAMAESYCE
	Euphorbia esula	EUPESU
	Fabaceae	
	Astragalus sp.	ASTRAGALUS
	Astragalus mollissimus	ASTMOL
	Glycyrrihza lepidota	GLYLEP
	Melilotus officinalis	MELOFF
	Psoralidium lanceolatum	PSOLAN
	Juncaceae	
	Juncus arcticus	JUNARC
	Lamiaceae	
	Mentha arvensis	MENARV
	Onagraceae	
	Oenothera biennis	OENBIE
	Oenothera elata	OENELA
	Oenothera pallida	OENPAL

✓	Species Found	
	Poaceae	
	Agrostis stolonifera	AGRSTO
	Bromus inermis	BROINE
	Bromus japonicus	BROJAP
	Bromus tectorum	BROTEC
	Crypsis alopecuroides	CRYALO
	Distichlis spicata	DISSPI
	Elymus sp	ELYMUS
	Elymus canadensis	ELYCAN
	Elymus cinereus	ELYCIN
	Elymus elymoides	ELYELY
	Elymus lanceolatus	ELYLAN
	Elymus repens	ELYREP
	Elymus smithii	ELYSMI
	Elymus trachycaulus	ELYTRA
	Hordeum jubatum	HORJUB
	Muhlenbergia asperifolia	MUHASP
	Phalaris arundinacea	PHAARU
	Poa pratensis	POAPRA
	Poa secunda	POASEC
	Spartina pectinata	SPAPEC
	Sporobolus cryptandrus	SPOCRY
	Stipa comata	STICOM
	Stipa hymenoides	STIHYM
	Plantaginaceae	
	Plantago major	PLAMAJ
	Polygonaceae	
	Polygonum amphibium	POLAMP
	Polygonum lapathifolium	POLLAP
	Portulacaceae	
	Portulaca oleracea	POROLE
	Rosaceae	
	Potentilla anserina	POTANS
	Rosa woodsii	ROSWOO
	Salicaeae	
	Populus fremontii	POPFRE
	Populus fremontii SEEDLING	POPFRE
	Salix exigua	SALEXI
	Salix exigua SEEDLING	SALEXI
	Scrophulariaceae	
	Verbascum thapsus	VERTHA
	Tamaricaceae	
	Tamarix sp.	TAMARIX
	Tamarix sp. SEEDLING	TAMARIX

DINO Veg Walk

Data entered by: Data verified by:

Date entered: ____/____/____ Date verified: ____/____/____

Page _____ of _____

NCPN Big River Monitoring | Big River Monitoring Protocol – SOP#6 – Version 3.21 – February 2018

River (circle): **GAC GBC Yampa** **Sentinel Site:** _____ **Date:** __/____/____ **Observer:** **Recorder:**

KEY : **suspected** = * **species** = sp.

unknown = UNK + CODE
CODE = *park + site + 2 letter initials + 1 digit*

Example unknown: *UNK-DINO-BP-BG-3*

✓	Species Found	
	Ulmaceae	
	Celtis reticulata	CELRET
	Verbenaceae	
	Verbena bracteata	VERBRA

✓	Species Found	

✓	Species Found	
	Unknowns	
	Unknown annual forb	UNKAF
	Unknown annual graminoid	UNKAG
	Unknown forb	UNKF
	Unknown graminoid	UNKG

Integrity

DINO Veg Plots

Data entered by:

Date entered: ___/___/___

Data verified by:

Date verified: ___/___/___

Page _____ of _____

NCPN Big River Monitoring — Big River Monitoring Protocol – SOP#6 – Version 3.21 – February 2018

River: GAC GBC Yampa   Sentinel Site: ________   Observer: Recorder: Date: ___/___/___

NCPN Modified Wentworth Scale

Class Size	Code	Diameter (mm)	Class Size	Code	Diameter (mm)
Fines	F	See SOP definition	Gravel	GR	> 2 – 16
Clay	CL		Pebble	PE	> 16 – 64
Loam/Clay	LC		Cobble	CO	> 64 – 256
Loam	LO		Boulder	BL	> 256 – 512
Sand	SA	0.5µm — 2mm	Bedrock, Hardpan	BR	> 512

Plot Dimensions

Length (m)	1	Width (m)	1

Plot #																	
% Inundation (Water)																	
Modal Particle Size (F CL LC LO SA GR PE CO BL BR)																	
% Modal Particle Size (nearest 1%)																	
% Sand & Finer (nearest 1%)																	
% Litter (nearest 1%)																	
% Woody Debris (nearest 1%)																	
% Filamentous Algae (nearest 1%)																	
Beaver Browse Activity		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
% Standing Dead (nearest 1%)																	
R = rooted in plot		**All Rooted Species % Cover**								Rooted & Unrooted > 1.5m • nearest 1% • Trace ≤ 0.5							
No Rooted Veg?		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Total Plot Cover %																	
Salix exigua	*SALEXI*																
Salix exigua SEEDLING	*SALEXI**																
Tamarix sp.	*TAMARIX*																
Tamarix sp. SEEDLING	*TAMARIX**																

Unknown Plant Species

Data entered by: Data verified by:

NCPN Big River Monitoring

Park Code: **Reach ID:** **Date:** **Recorder:**

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

Unknown species code (e.g., unkZION-P02-KL1): _____

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 structure)

Microhabitat Characteristics:

Collected: *Yes* *No* Collected by:

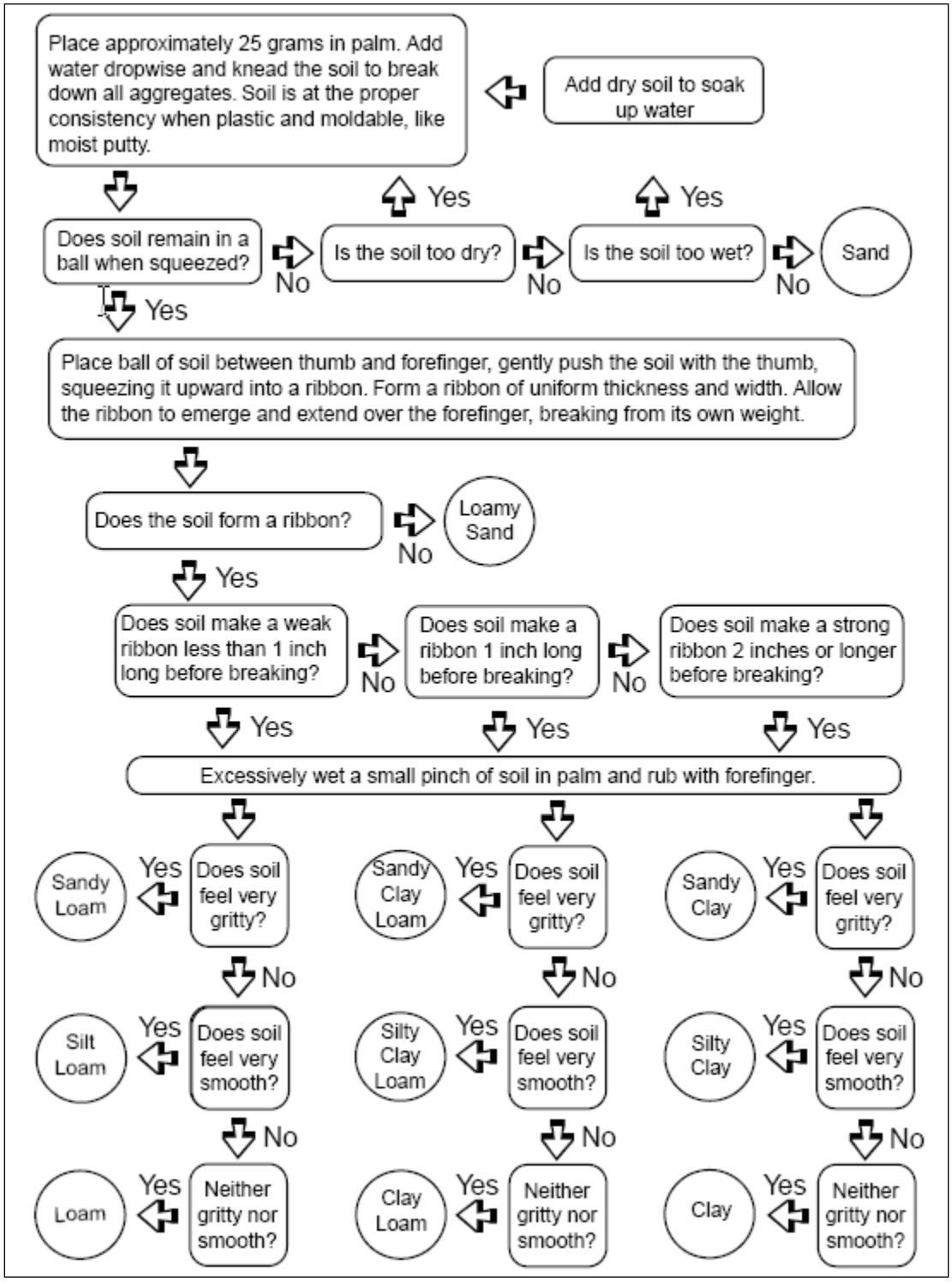
Best Guess:

Confirmed to be:

Identified by: Date:

Appendix 2. Modal sediment table and soil texture figures

Modified Wentworth Scale		
Class Size range	**Code**	**Diameter (mm)**
Fines	F	For classes finer than sand in saturated sediment, simply record as fines.
Clay (right most column in Figure 1)	CL	For classes finer than sand, please see Figures 1 and 2.
Loam/Clay (middle column in Figure 1)	LC	
Loam (left most column in Figure 1)	LO	
Sand	SA	0.5 micrometers to 2 milimeters
Gravel (medium, fine, and very fine gravel)	GR	>2 to 16
Pebble (course to very course gravel)	PE	>16 to 64
Cobble	CO	>64 to 256
Boulder	BL	>256 to 512
Bedrock, Hardpan	BR	>512



(Herrick et al. 2005)

Figure 1. Soil texture key. Begin in the top left corner and answer the yes/no questions to determine soil texture.

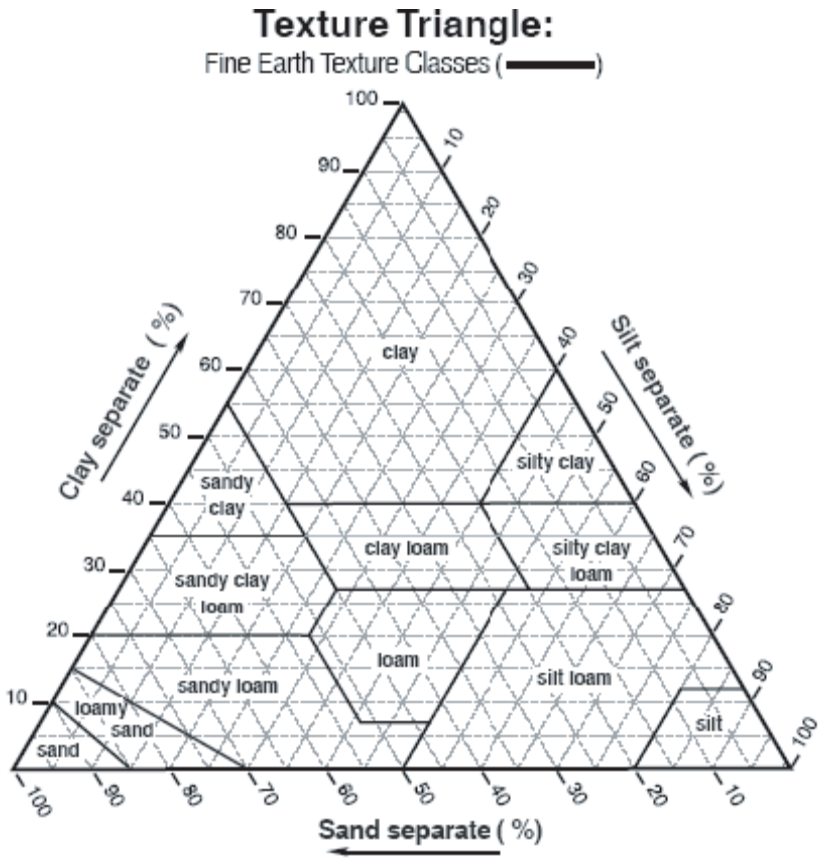


Figure 2. Soil texture triangle (Schoeneberger et al. 2002)

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

Standard Operating Procedure (SOP) #7

Transducers and Hydrologic Monitoring (BLCA/CANY/DINO)

Version 1.02 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	8/2015	D. Perkins	Added software instructions relevant to BLCA	BLCA was not in SOP before	1.01
1.01	2/2018	D. Perkins	Editorial comments	Peer Review	1.02

This SOP describes installation techniques, instrument set up, and monitoring measurements for transducers and describes field work done from 2013 to present. This SOP is relevant to Black Canyon of the Gunnison National Park, Canyonlands National Park, and Dinosaur National Monument. An equipment list is provided in SOP #1.

The initial site visit includes transducer installation; programming and installing dataloggers; and taking initial water level measurements. Monitoring revisits include water level measurements, downloading transducers, and casing and transducer maintenance, if needed.

A three-person team comprised of one installation specialist and two assistants is required to effectively complete the installation tasks described below. All crew members should have good physical endurance and be capable of heavy lifting. Revisits can be completed by one person.

1. Installation Procedure

1.1 Preparing transducers

There are two types of transducers, water transducers that are installed so that the slope of the water can be drawn across the sentinel sites and an atmospheric pressure transducer that is installed on land in the vicinity of the water transducers.

The settings on the pressure transducer need to be adjusted before it can be installed. These procedures are specific to the manufacturer and the type of logger used. For detailed instructions on settings, refer to the instrument's user manual (i.e., Solinst Levelogger User Manual or HOBOware User's Guide) and software (Solinst Levelogger 4.0.3 and Hoboware Pro).

A. Electronically label each pressure transducer with the site and upstream or downstream location, and any well-specific identification information, e.g. DINO_DL_us, DINO_DL_air, CANY_BB etc.
B. Set the logging interval to 60 minutes.
C. Change the units to centimeters, and adjust the site elevation so that they are at the testing elevation.
D. Synchronize the logger time to your computer's time. If needed, adjust the logger time to Mountain Standard Time, and set a future launch date and time.
E. Before employing transducers in the field, it is important to test them to insure they are accurately reading pressure. The easiest way to do this is to put them through an atmospheric pressure test. Gather the transducers to be installed at a park on the next monitoring visit. Keep the groups as large as possible to support as many "should be the same" comparisons as possible. The minimum number of transducers should be a set of three transducers that will be used at one site (two water and one atmospheric pressure). The transducers to be tested should be placed in a stable environment (office desk). Synchronize the time and program a common start time for all transducers. Let the transducers run for at least a 24 hour period and ideally for up to a week of exposing the transducers to an identical environment. This data will support identification of potential fixed offsets among transducers which will then be used in analysis or may show a transducer is no longer operational.
F. Stop the test and download the transducers using Solinst or Hobo Software (see Section 2.0 Return Visits below for information on how to download the transducers).
G. If the transducers atmospheric pressure tests are successful (<5 cm deviation, see Figure 1), store the test data on the X drive and reset the loggers using the elevation of the site where they are to be deployed. NOTE that when comparing data from barologgers (atmospheric pressure transducers) to leveloggers (water transducers) the barologgers must be multiplied by 1.01702 (as specified in the software specifications) for the graphing operations. It is fine to just keep them recording through transport and deployment.

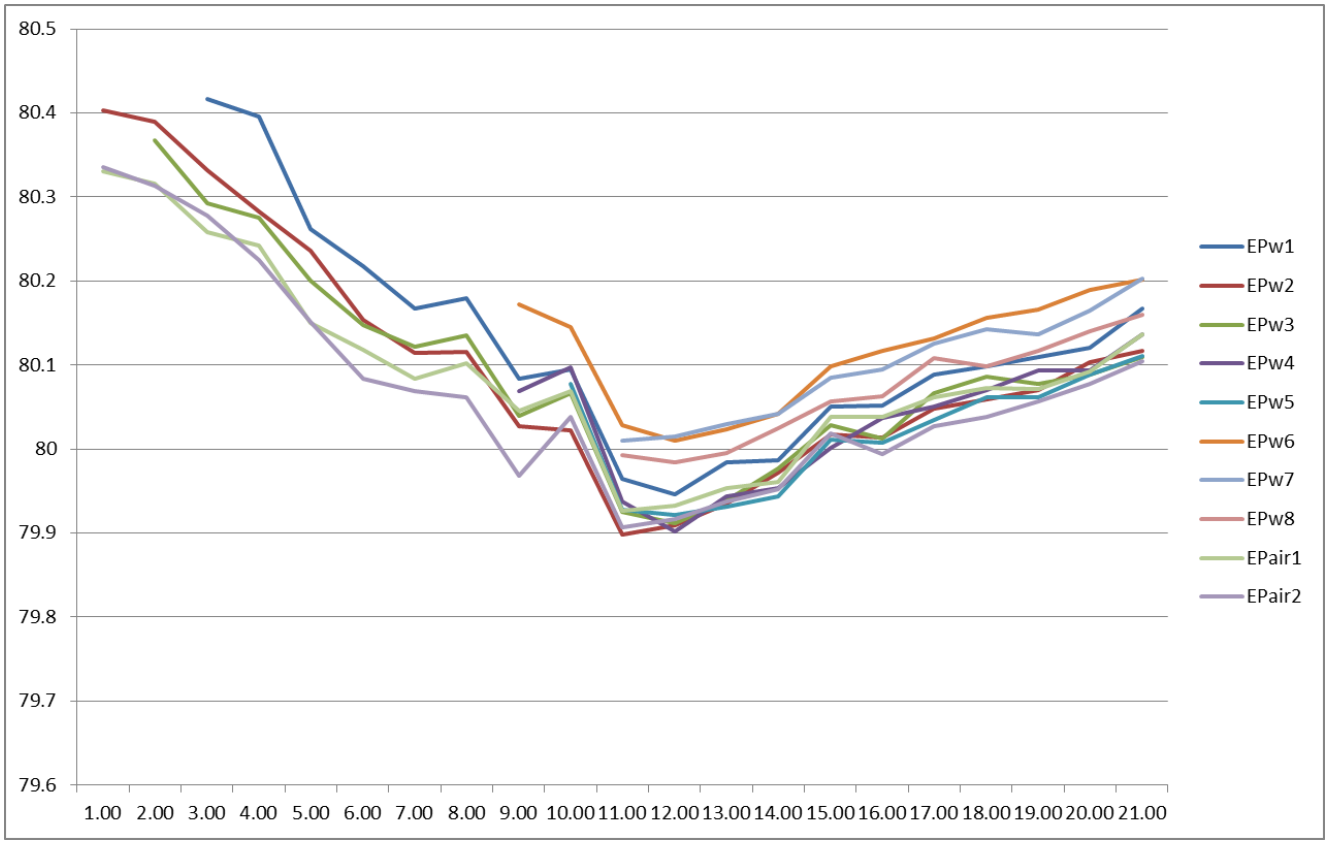


Figure 1. Example of a successful atmospheric pressure test.

1.2 Preparing the transducer casing

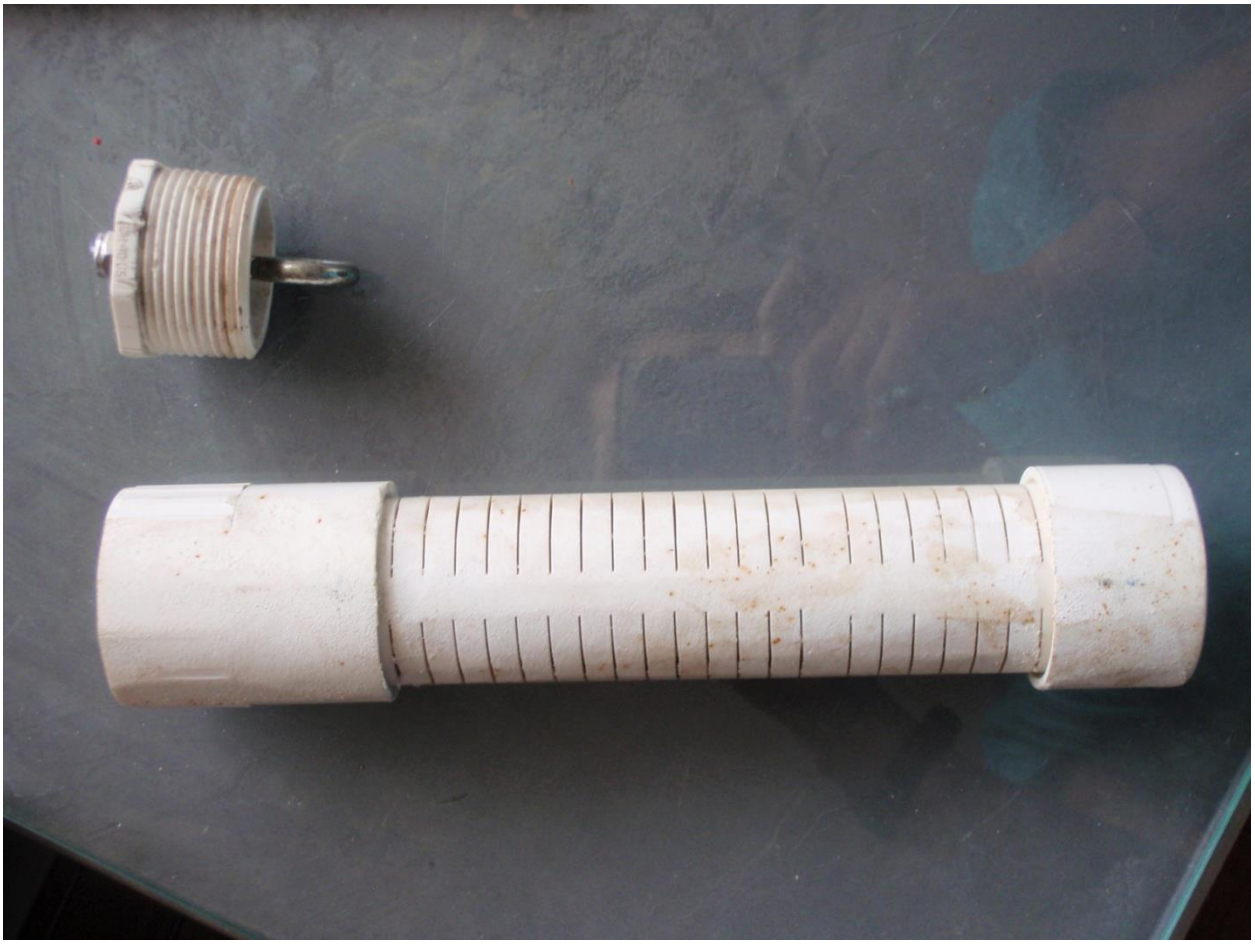


Figure 2. Example of an atmospheric pressure transducer casing. A water transducer casing would not have a cap on the bottom. Many of the water transducer casings will be considerably longer than shown.

A. Cut 1 1/4" inside diameter schedule 80 slotted PVC well casing (Eagle Pacific PVC 1120 SCH.80 ASTM is the current brand being used) into 5 foot lengths. This well casing is compatible with 1 ¼ PVC pipe.
B. Glue a threaded PVC sleeve to the top of the piece of casing using PVC glue (Fig. 2). Allow to dry.
C. Drill a hole in the threaded PVC cap for a 3/8" diameter eyebolt. Leaving space for the eyebolt to be assembled with a washer and nut, drill additional smaller holes in the cap to allow water and air to flow through the casing when assembled (Fig. 3).
D. Thread a nut and washer onto the eyebolt to the top of the threads. Put the eyebolt through the hole in the threaded PVC cap. Put another washer and nut on the eyebolt on the outside of the cap. Adjust the nuts and washers on both sides of the cap so that the very tip of the eyebolt is showing above the nut on the outside of the cap (Fig. 4). This will allow the surveyors to survey from the top of the eyebolt and know the elevation of the pressure transducer without opening the casing.
E. If the casing is for an atmospheric pressure transducer (deployed in the air), glue an unthreaded PVC cap to the bottom of the casing (Fig. 2). Drill several holes in the cap to vent the casing and allow rain to flow through. The holes should be small to deter insects from building a nest in the casing. If the casing is for a water transducer, leave the bottom uncapped.

F. The transducer needs to be attached to the eyebolt on a line that will not kink or change in length. The loggers are about 5 inches long, and they shouldn't be resting too close to the bottom of the casing or protruding out the bottom of the casing.
G. Atmospheric pressure transducer casings should be spray painted brown or green to blend into the trees where they will be mounted. Water transducer casings can remain unpainted, these will be painted on site to match the surrounding substrate.

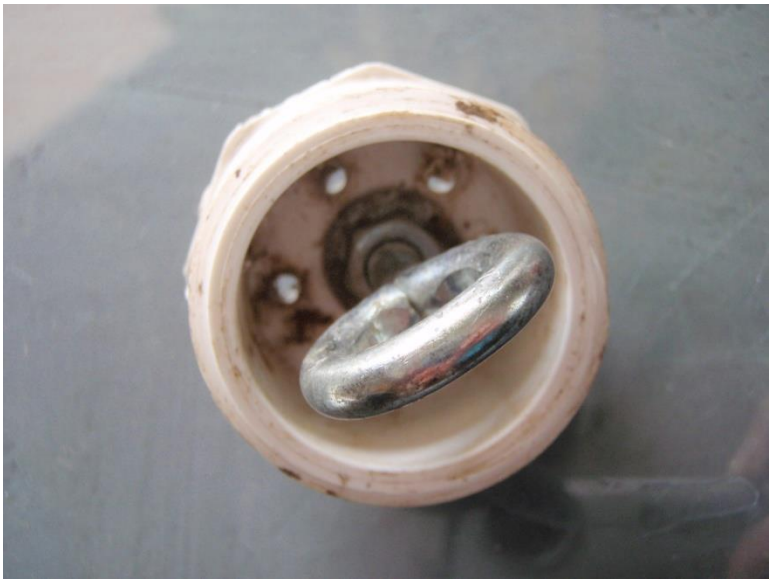


Figure 3. Ventilation holes drilled in cap with eyebolt.



Figure 4. Threaded cap with eyebolt and threaded sleeve.

1.3 Mounting atmospheric pressure transducers

A. Select a branch on a tree that is well above the high water line. Use two heavy duty zip ties or two hose clamps to mount the casing on the branch so that it hangs vertically (Figure 5).



Figure 5. Atmospheric pressure transducer attached to a tree.

1.4 Mounting water transducers

A. On a large boulder or cliff wall, select a location that should be inundated during higher flows and still can capture low base flows (Figure 6). Consideration should also be given to taking survey measurements with a rod (can a rod be placed straight up on the eyebolt and reference mark), protection of the transducers from debris, and effects that could result in water being higher at the transducer (circling eddy) than the rest of the river channel.
B. Hold the logger casing up to the rock, and put a ¾" wide, U-shaped pipe mounting bracket (Figure 7) snug against the lip of the threaded PVC sleeve on the casing. Mark where the bracket holes are on the rock. Drill a hole big enough for a 3/8" expansion bolt (Figure 8) in each desired spot.
C. Work the expansion bolt with the nut attached through the hole in the bracket into the drilled hole in the rock. Drive the pin and back off the nut.
D. Determine how long the casing should be to extend the transducer into the water at low base flows. Cut the casing appropriately.
E. Place the bracket on the bolt and casing, and deploy the expansion bolt by hitting the pin with a hammer. If necessary, before deploying the expansion bolt, use additional washers to make sure that the casing is held snugly to the rock.
F. Tie a piece of Kevlar cord to the transducer so that it is hanging approximately two inches below the bottom of the casing for maximum recording of the hydrograph.
G. Chisel/cut a Reference Mark (RM) or "x" directly, and at least 1 m above the eyebolt on the pressure transducer. IMAGINE extending the line/chord/wire suspending the transducer up through the casing

and eyebolt vertically to the RM (Figure 9). In some cases it may be necessary to have two reference marks, one for easy measurement at low flows and one that is higher for use during peak flows.

H. Then measure and record the vertical distance from the RM to the top of the eyebolt; and measure and record the distance from the RM to the water surface. These measurements will allow you to:
    1. During a subsequent visit determine if the logger has moved or shifted by simply measuring the distance from RM to eyebolt – no surveying required (Assumes the RM was scribed on a solid, immovable rock during install);
    2. During a subsequent visit – when the pressure transducer is under water – obtain a calibration stage measurement by measuring distance from RM to water surface. This measurement can be compared to the recorded stage reading from the transducer for that date/time.

I. For water and atmospheric pressure transducers, record a GPS waypoint for each site. If the GPS is not able to take an accurate point, measure distance and bearing from a reference point so that loggers can be re-located. Take reference photos that show the location of each set up and reference marks with distinctive landmarks such as large boulders or cliff lines. Make sure your landmarks will be visible during high water. Take whatever notes you can to help you relocate loggers and interpret data.



Figure 6. Water transducers attached to boulders and painted to match surroundings.

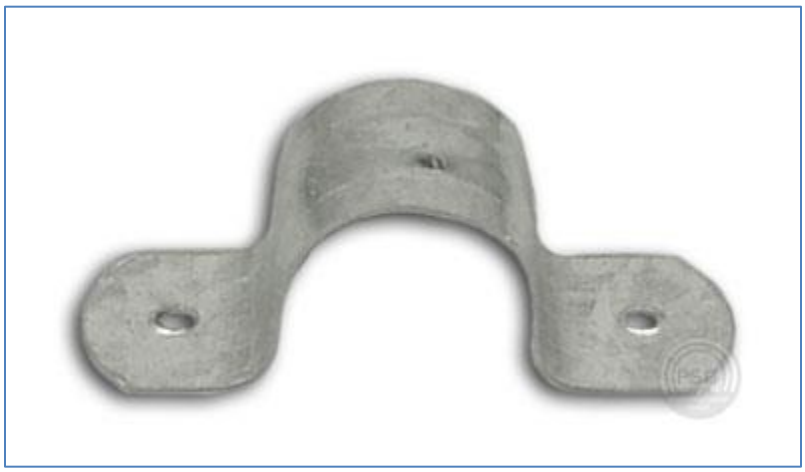


Figure 7. Pipe mounting bracket.

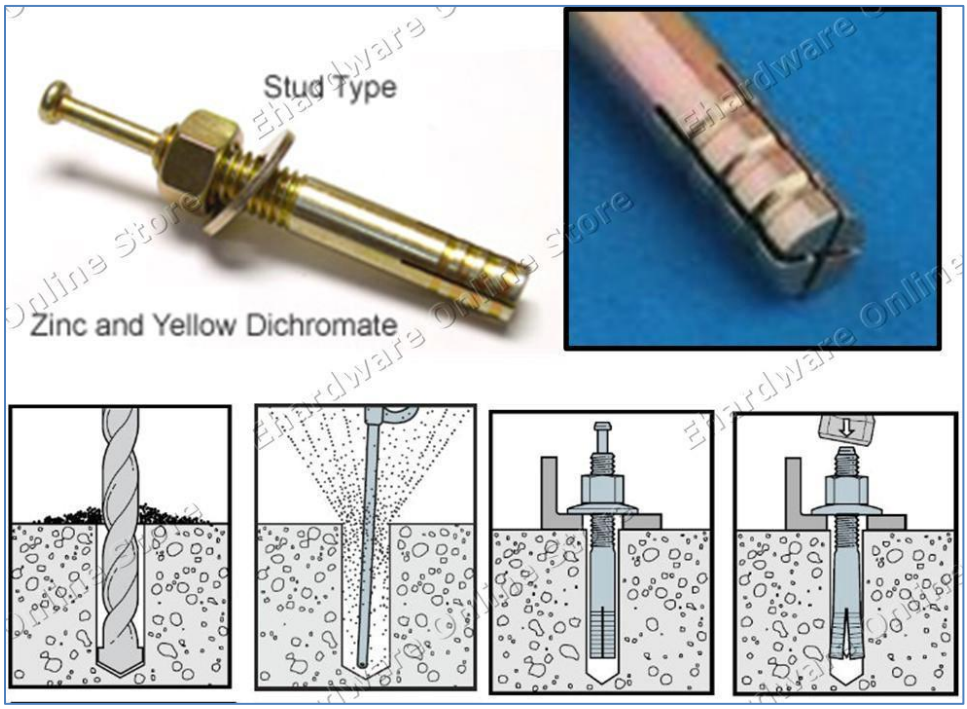
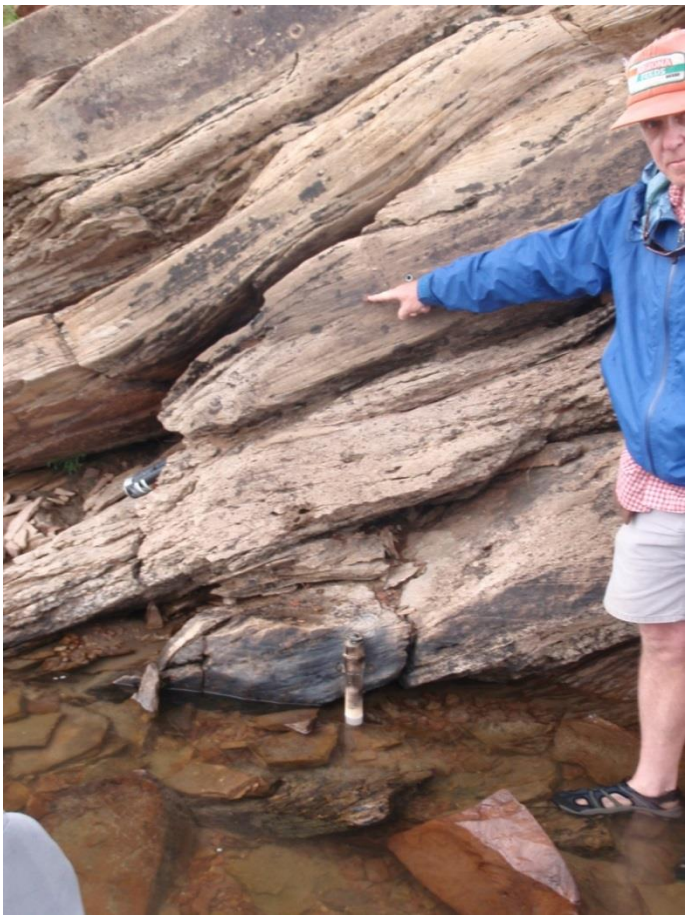


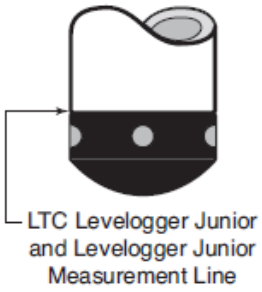
Figure 8. Expansion bolt.

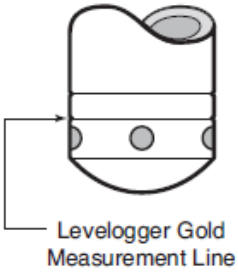

Figure 9. Example of transducer placed in the water with the reference mark noted by the person pointing at the reference mark.

J. To install the pressure transducer in the well, attach one end of the cord to the eybolt on the casing. Lay the Kevlar cord and transect tape on the ground and measure the appropriate length of cord. Align the appropriate measurement line on the bottom of the transducer with the casing so that the transducer is approximately 5-6 cm up from the bottom of the casing.
K. Cut the Kevlar cord at the mark you just created.
L. Attach the end of the Kevlar cord to the hanger on the pressure transducer.
M. Carefully measure the distance between the pressure transducer sensor scribe line and the tip of the eye bolt (Figure 10) with the meter tape to the nearest 0.1 cm. *All subsequent data analysis relies on an accurate measurement of the sensor deployment depth.* Record this number on the Transducer data sheet.
N. Record the serial number of the transducer and the following additional measurements on the datasheet (Appendix 1):
    1. Reference mark to top of eyebolt
    2. Eyebolt to water line
    3. Reference mark to water line

    Note that at some times the measurement to water may be negative if the reference mark or eyebolt is under water. These three numbers are recorded even though they are somewhat redundant – measurements #1 + #2 = #3. So if these numbers are way off (>1-2 cm), measure again.
O. Lower the pressure transducer into the casing, and tighten the well cap with pipe wrenches.







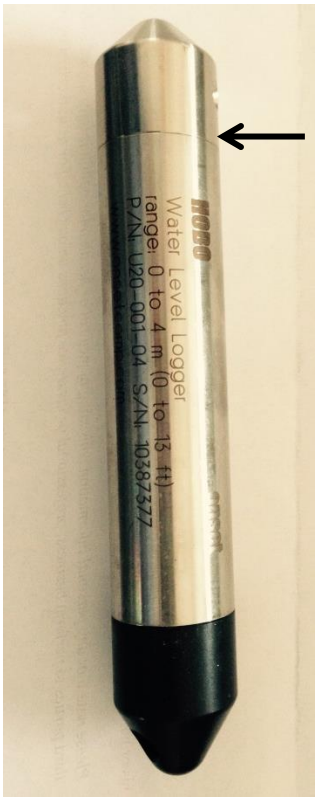


Figure 10. Pressure transducer measurement line. The sensor is located in the bottom of the pressure transducer underneath a protective plastic covering with four holes in it. To determine the depth of the pressure transducer sensor to top of eyebolt, align the meter mark on the tape with the appropriate measurement line on the pressure transducer and measure the length of the rope to the tip of the eye-bolt. Levelogger edge is on the top left, junior in the top middle and Gold on the top right and Hobo on the bottom. The measurement lines are denoted by black arrows.

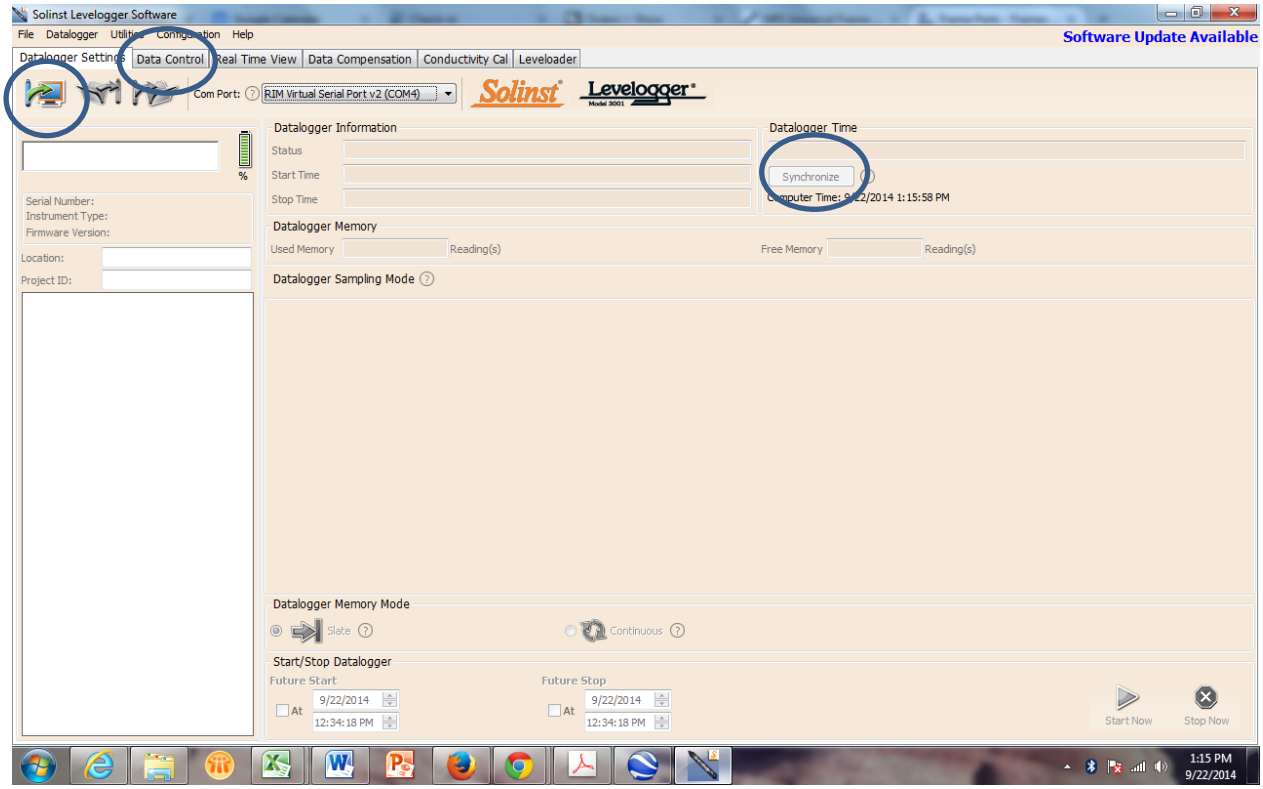
2. Return Site Visits

Each set of transducers monitoring wells is visited at a minimum of once a year from March through November. On each visit to the transducers the following procedures should be performed. Record measurements on the Transducer data sheets in Appendix 1.

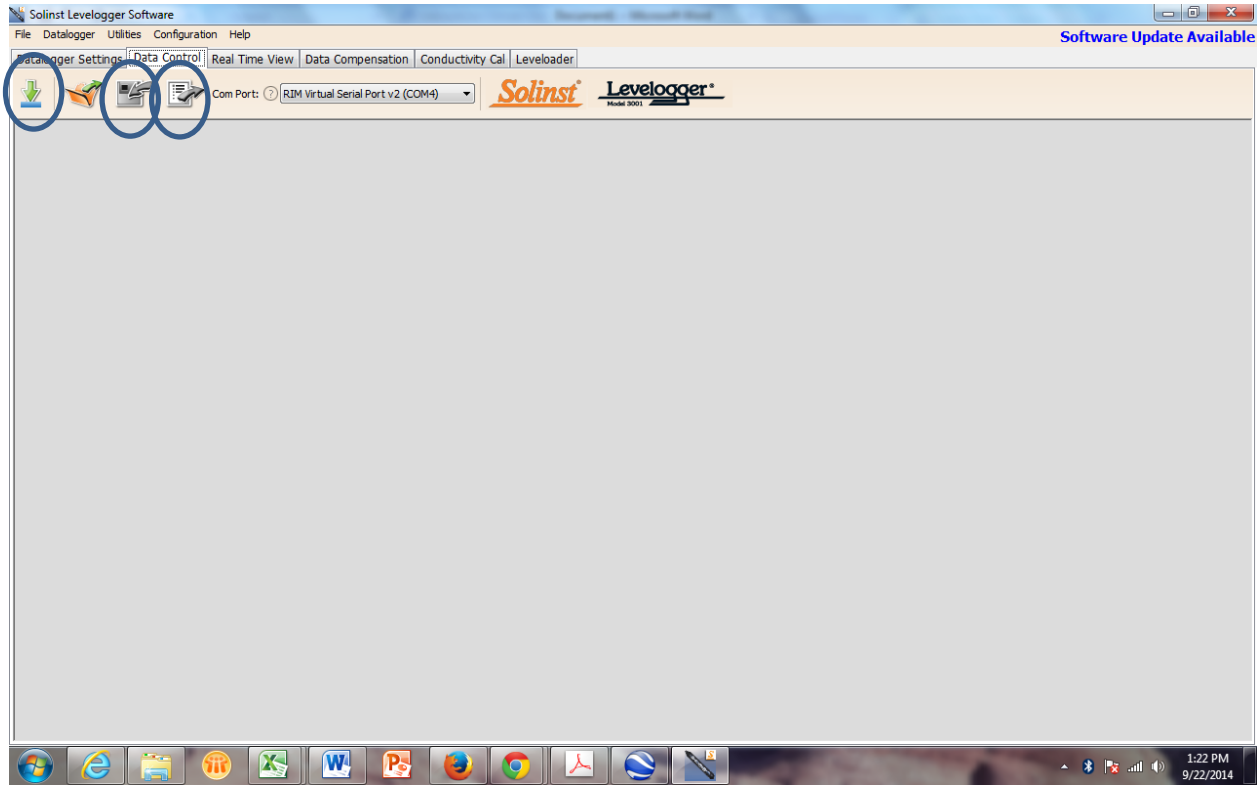
1. Before unscrewing the casing take the following measurements – reference mark to eyebolt, eyebolt to water, and reference mark to water. Note that at some times the measurement to water may be negative if the reference mark or eyebolt is under water. Record on the transducer data sheet. When possible it is best to make these measurements as close to the top of the hour as possible when the transducer will also be taking a measurement. Record the time of the measurements. These three numbers are recorded even though they are somewhat redundant – measurements #1 + #2 = #3. So if these numbers are way off (>1-2 cm), measure again.
2. Unscrew the cap, remove the instrument, and measure and record Eyebolt to Scribe line (Figure 10).
3. Unscrew the black top (carabiner is attached to this top) to the transducer.
4. Turn on computer.
5. Refer to Solinst Software instructions for CANY and DINO and Hobo software instructions for BLCA.

Solinst Software – CANY and DINO.

1. Start Solinst Software 4.0.3
2. Unscrew the cap on the transducer and plug into USB the connector that will download the transducer to the laptop.
3. Insert transducer into connector.
4. Press the “Retrieve Logger Settings” button in the top left. This should download the information and serial number. Make sure you record the serial number with the transducer. If there are difficulties reading, then make sure to change to the correct port. A driver is also needed to be downloaded from Solinst.



5. If it allows you to do so, press the “Synchronize” button to get the times the same.
6. Then press the “Data Control” tab.
7. On the Data Control, press the “Download Data” button. Select “All Data” from the drop down menu. You will see the downloading start. Don’t overwrite data.



8. Once the downloading has been completed, press the "Save File As" button. Save the file as a .xle file. Use the following naming conventions with date – BrownsParkUS071515, BrownsParkDS071515, BrownsParkAir071515, BB091515etc.
9. Now export the data by pressing the "Export Data" button. Export the file as a data (.csv) file and graph (.bmp) file with the same naming convention as above. To double check to see if the data has downloaded, open Excel and open the .csv file.
10. When possible (staying overnight on sight), take all three transducers out of there casings and place them in a stable environment (i.e. tent) for as long as possible. Then repeat steps 1-9 except naming this as a test. (See section 1.1E-G above for atmospheric pressure test procedures). If all water transducers are recording within 3 cm, proceed to step 11. If there is obvious drift, replace the entire set of transducers with a set that has gone through atmospheric pressure tests in the office as outlined in section 1.1 above.
11. You are done, take out the transducer, put the cap back on, retake the following measurements – Eyebolt to measuring scribe line, reference mark to eyebolt, eyebolt to water, and Reference Mark to water. Note that at some times the measurement to water may be negative if the reference mark or eyebolt is under water. Record on the transducer data sheet. Make sure to record the time and when possible make these measurements as close to the top of the hour as possible.
12. Surveyors will survey in the top of the eyebolt and the reference mark during the visit. If the rod cannot be placed on top of the reference mark or eyebolt and kept level, then take a picture of the rod on top of the eyebolt in the position that was done while surveying so that there is no question where the rod was. If the rod cannot be placed on top of the eyebolt, measurements must be taken to describe where the rod was relative to the top of the eyebolt.
13. Surveyors will also survey the water surface as close to the transducer as possible. Times must be recorded with these measurements.

Hobo Software – BLCA. From HOBO Waterproof Shuttle (U-DTW-1) Manual

1. Start HOBOware Pro Software 2.2 or greater.
2. Make sure the shuttle's large cap and center cap are closed securely. Tighten the center cap until it is just flush with the large cap, or until the O-ring is no longer visible.
3. Make sure the communication end of the shuttle is clean. Attach the U-20 Water Level coupler for the logger, and ensure that it is seated properly.
4. Insert the logger into the coupler Make sure groove drops down into coupler.
5. Momentarily press the coupler lever (pressing hard enough so the lever bends). Readout should begin immediately. The amber LED blinks continuously while readout and relaunch are in progress. Do not remove the logger when the amber LED is blinking.
6. After reading out the logger, the shuttle synchronizes the logger's clock to the shuttle's internal clock and relaunches the logger, using the description, channels to log, logging interval, and other settings that are already in the logger. (If the logger was launched with multiple logging intervals, the final defined logging interval will be used.)
7. When the relaunch has completed, the green LED blinks for 15 minutes, or until you momentarily press the coupler lever to stop it (press hard enough so the lever bends). If the red LED blinks instead, there was an error, and the logger may have stopped.
8. Remove the logger from the coupler. The shuttle's memory has 63 "banks." One logger readout can be stored in each bank. To check the shuttle's memory and batteries in the field, remove the logger and press the coupler's lever for at least three seconds (pressing hard enough so the lever bends). When you release the lever, the green LED blinks once for each unoccupied bank in the shuttle's memory. (Press the lever momentarily to stop the blinking, pressing hard enough so the lever bends.) If the shuttle's batteries are running low, all of the shuttle banks are full, or the clock has not been set, the red LED blinks. (Press the lever momentarily to stop the blinking, pressing hard enough so the lever bends) Use HOBOware to check the shuttle's battery level, available memory, and clock. You may need to change the batteries, or offload the datafiles to the host computer and delete them from the shuttle to free up memory before you can continue reading out loggers.

Always check the shuttle batteries prior to going in the field.

The shuttle's batteries should last about one year or at least 50 complete memory fills in typical conditions. When the shuttle's batteries run low (2.2 V or less), any logger data that is already in the shuttle will remain safe, but the shuttle will not read out another logger until its batteries are replaced. To avoid battery problems, always check the shuttle's batteries in HOBOware before going into the field, and replace them if needed. If you cannot replace the bad batteries right away, you should remove them as soon as possible to ensure that they do not leak and damage the shuttle.

To change the shuttle's batteries:

1. Work over a clean surface to provide a safe platform for the disassembly.

2. Unscrew the center cap on the shuttle. If the cap is too tight to loosen by hand, insert a screwdriver through the lanyard hole and rotate counterclockwise until the cap is loosened.

3. Use the center cap to help you carefully pull the rubber loop free of the large cap. The large cap cannot be removed while the rubber loop is in place.

4. Turn the large cap counter-clockwise slightly, then pull it off. Turn the shuttle over and tap it gently. The circuit board should slide into your hand.

6. Remove the old batteries and install two new ones in the correct orientation. Both batteries should be turned the same way, with their positive ends facing the USB port on the board. (When the second battery makes contact, all of the shuttle's LEDs will blink in unison.)

7. Put the board back into the case, taking care not to bend the communication LEDs. Align the circuit board with the runners in the case. The USB port should face the open end of the shuttle, and the LEDs should show through the window on the label.

8. Close the shuttle's case. Line up the tabs on the large cap with the slots on the case, press gently, and turn slightly clockwise until the large cap is closed securely.

9. Replace the rubber loop and center cap. Tighten the center cap until it is just flush with the large cap, or until the O-ring is no longer visible.

10. Using HOBOware, offload any datafiles that are on the shuttle and launch the shuttle before going into the field again. The shuttle will not read out and relaunch loggers until the clock has been synchronized.

In order to conduct atmospheric pressure tests, the data needs to be downloaded to a computer. It is recommended that this be done in the field when possible.

To offload datafiles from a shuttle to a computer:

1. Connect the shuttle to the computer.

2. Choose Manage Shuttle from the Device menu. Alternate Method: To quickly offload all of the new datafiles that are on the shuttle, choose Readout from the Device menu.

3. Choose files to offload: Waterproof Shuttle - Only the files that have not previously been offloaded and saved are selected by default. To check or uncheck individual files, click the checkbox next to each file. Use the Check All and Uncheck All buttons next to Previously Offloaded Files and New Files (Not Offloaded) to control the selection of these groups of files. To automatically delete files from a Waterproof Shuttle after you offload and save them, enable the Delete Contents Upon Offload option. Files will be automatically deleted only after you successfully save them to the host computer.

4. Offload Files. Click the Offload Checked button to begin offloading the datafiles. Once offloading begins, the Offload Checked button will change to Cancel Offload. When offloading is complete, the Files on Shuttle panel on the Shuttle Management window will change to a Files Offloaded From Shuttle panel. You can now save the files to your computer.

5. Save Folder. The default location for the save is indicated in the Save Folder box. To change to another location, click Choose and browse to the location.

2. Automatically Open Files. To have the folder automatically open on the desktop after the files are saved, check: Open Folder in Windows Explorer after Save.

3. Choose files to save. By default, all of the files you offloaded will be selected for saving. To uncheck individual files, click the checkbox next to each file. To uncheck all files, click the Uncheck All button. To save all files (if you have already unchecked a few), click the Check All button.

4. Datafile Name. Enter a new name if desired.

5. Cancel Save. To exit without saving any files, click Cancel Save.

6. Save Checked. Click this button to save all checked files. The files are saved to the specified folder.

7. To automatically delete files after you offload and save them, enable the Delete Contents Upon Offload option before clicking Offload Checked. Files will be automatically deleted only after you save them. To select specific files to delete, click the checkbox for each unwanted file on the Shuttle Management window. To select all of the files that have already been offloaded, click the Check All button next to Previously Offloaded Files. Then click Delete Checked. To delete all files from a Waterproof Shuttle, whether they have been offloaded or not, click the Launch Shuttle button on the Shuttle Management window to launch the shuttle. This will also reset the shuttle's clock and its Last Launched time.

3. Hydrologic Data Processing

Detailed methods for data archiving and processing are provided in Appendix 2. While in the field, measurements are made on a paper data sheet and entered into the big river database when back from the field. Water stage data are barometrically compensated, and all data are visually reviewed for gaps or errors. Data are inspected for error or drift, and relevant corrections are applied. Derived datasets convert the raw data to data referenced to a permanent datum, referenced to the ground surface, and referenced to a stage-discharge rating curve. Finally, daily mean datasets are derived from approved data for data summary and analysis.

Appendix 1. Hydrologic Data Sheets

BLCA Transducers Data entered by: Data verified by: Page ____ of ____
Date entered: ____/____/____ Date verified: ____/____/____

NCPN Big River Monitoring Big River Monitoring - SOP #7 - Version 1.02- Feb 2018

River (circle): **Gunnison** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
BEFORE DOWNLOAD											
EP East Portal	W	EPW1									
	W	EPW2									
	W	EPW3									
	W	EPW4									
	W	EPW5									
	W	EPW6									
	W	EPW7									
	W	EPW8									
	A	EPA1									
	A	EPA2									
RR Red Rocks	W	RRW1									
	W	RRW2									
	W	RRW3									
	W	RRW4									
	W	RRW5									
	A	RRA1									
	A	RRA2									

BLCA Transducers

Data entered by:
Date entered: ___/___/___

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): **Gunnison** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
AFTER DOWNLOAD											
EP East Portal	W	EPW1									
	W	EPW2									
	W	EPW3									
	W	EPW4									
	W	EPW5									
	W	EPW6									
	W	EPW7									
	W	EPW8									
	A	EPA1									
	A	EPA2									
RR Red Rocks	W	RRW1									
	W	RRW2									
	W	RRW3									
	W	RRW4									
	W	RRW5									
	A	RRA1									
	A	RRA2									

CANY Transducers

Data entered by:
Date entered: ____/____/____

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): **Green** **CAbvC** **CBlwC** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
BEFORE DOWNLOAD											
MC Millard Canyon	W	MCUS									
	W	MCDS									
QA Queen Anne's	W	QAW									
BB Bonita Bend	W	BBW									
	A	BBA									
HC Holeman Canyon	W	HCUS									
	A	HCA									
	W	HCDS									
SP Sphinx	W	SPW									
UT Upper Tuxedo	W	UTW									
	A	UTA									

CANY Transducers

Data entered by:
Date entered: ___/___/___

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): **Green** **CAbvC** **CBlwC** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
BEFORE DOWNLOAD											
SG Sangria	W	SGUS									
	A	SGA									
	W	SGDS									
LH Lockhart	W	LHUS									
	A	LHA									
	W	LHDS									
MM Musselman	W	MMUS									
	A	MMA									
	W	MMDS									

CANY Transducers

Data entered by:
Date entered: ___/___/___

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): **Green** **CAbvC** **CBlwC** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
AFTER DOWNLOAD											
MC Millard Canyon	W	MCUS									
	W	MCDS									
QA Queen Anne's	W	QAW									
BB Bonita Bend	W	BBW									
	A	BBA									
HC Holeman Canyon	W	HCUS									
	A	HCA									
	W	HCDS									
SP Sphinx	W	SPW									
UT Upper Tuxedo	W	UTW									
	A	UTA									

CANY Transducers

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Date entered: ___/___/___

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): **Green** **CAbvC** **CBlwC** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
AFTER DOWNLOAD											
SG Sangria	W	SGUS									
	A	SGA									
	W	SGDS									
LH Lockhart	W	LHUS									
	A	LHA									
	W	LHDS									
MM Musselman	W	MMUS									
	A	MMA									
	W	MMDS									

DINO Transducers

Data entered by:
Date entered: ___/___/___

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): GAbvC GBlwC Yampa **Observer** **Recorder** **Date:** ____/____/_____

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
BEFORE DOWNLOAD											
DL Deerlodge	W	DLUS									
	W	DLDS									
	A	DLA									
HH Harding Hole	W	HHUS									
	W	HHDS									
	A	HHA									
LP Laddie Park	W	LPUS									
	W	LPDS									
	A	LPA									
EP Echo Park	W	EPUS									
	W	EPDS									
	A	EPA									
BP Browns Park	W	BPUS									
	W	BPDS									
	A	BPA									
WN Winnie's Rapid	W	WNUS									
	W	WNDS									
	A	WNA									
LS Limestone	W	LSUS									

DINO Transducers

Data entered by:
Date entered: ____/____/____

Data verified by:
Date verified: ____/____/____

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NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): **GAbvC** **GBlwC** **Yampa** **Observer** **Recorder** **Date: ____/____/_____**

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
LS Limestone	W	LSDS									
	A	LSA									
SC Seadiff	W	SCUS									
	W	SCDS									
	A	SCA									
IP Island Park	W	IPW1									
	W	IPW2									
	A	IPA									

DINO Transducers

Data entered by:
Date entered: ___/___/___

Data verified by:
Date verified: ____/____/____

Page ____ of ____

NCPN Big River Monitoring — Big River Monitoring - SOP #7 - Version 1.02 - Feb 2018

River (circle): GAbvC GBlwC Yampa **Observer** **Recorder** **Date:** ____/____/_____

Check Your Math!

Eyebolt ⇢ Waterline
+ Reference Mark ⇢ Eyebolt
Reference Mark ⇢ Waterline

Site	Transducer			Pulled/Downloaded		Distance (cm)				Surveyed?	Comment
	Type (A=air W=wate)	#	Serial #	Date	Time	Refer Mark to...		Eyebolt to...			
						Waterline	Eyebolt	Waterline	Scribe Line		
AFTER DOWNLOAD											
DL Deerlodge	W	DLUS									
	W	DLDS									
	A	DLA									
HH Harding Hole	W	HHUS									
	W	HHDS									
	A	HHA									
LP Laddie Park	W	LPUS									
	W	LPDS									
	A	LPA									
EP Echo Park	W	EPUS									
	W	EPDS									
	A	EPA									
BP Browns Park	W	BPUS									
	W	BPDS									
	A	BPA									
WN Winnie's Rapid	W	WNUS									
	W	WNDS									
	A	WNA									
LS Limestone	W	LSUS									

DINO Transducers

Data entered by:
Date entered: ____/____/____

Data verified by:
Date verified: ____/____/____

Page ____ of ____

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						Waterline	Eyebolt	Waterline	Scribe Line		
LS Limestone	W	LSDS									
	A	LSA									
SC Seadiff	W	SCUS									
	W	SCDS									
	A	SCA									
IP Island Park	W	IPW1									
	W	IPW2									
	A	IPA									

Appendix 2. Hydrologic Data Processing

Hydrologic data collection methods are detailed in SOP #7. Upon returning from a field visit, field measures are entered into an electronic datasheet, and datalogger files are uploaded to the NCPN server. Water stage data are barometrically compensated, and all data are visually reviewed for gaps or errors. Data are inspected for error or drift, and relevant corrections are applied. Derived datasets convert the raw data to data referenced to a permanent datum, referenced to the ground surface, and referenced to a stage-discharge rating curve. Finally, daily mean datasets are derived from approved data for data summary and analysis.

Acronyms and Naming Conventions

For naming purposes, the following codes should be used:

Park Code	Park
BLCA	Black Canyon of the Gunnison National Park
CANY	Canyonlands National Park
DINO	Dinosaur National Monument

Dates use Year-Month-Day (YYYYMMDD) format, e.g., 20120514

Firmware and Software Deployment History

Logger	**Compatible software**
Solinst Levelogger Gold	Solinst Levelogger v.4.0.3
Solinst Barologger Gold	Solinst Levelogger v.4.0.3
Solinst Levelogger Edge	Solinst Levelogger v.4.0.3
Solinst Barologger Edge	Solinst Levelogger v.4.0.3
Hobo Level Logger 0 to 4 m	HOBOware 2.2 or greater

Temporary data storage

Upon completing a field visit, data are uploaded to the NCPN server at X:\Active_Monitoring_Projects\Big_Rivers\Data\Hydro Data.

Scan the datasheet and upload to X:\Active_Monitoring_Projects\Big_Rivers\Data\Hydro Data\Field Forms in the appropriate park, stream reach and date (YYYY) folder.

Upload photos to X:\Archive\NCPN Photos\Incoming\Monitoring\Big_Rivers to the appropriate year and project folder. Leave photo names as produced by the camera.

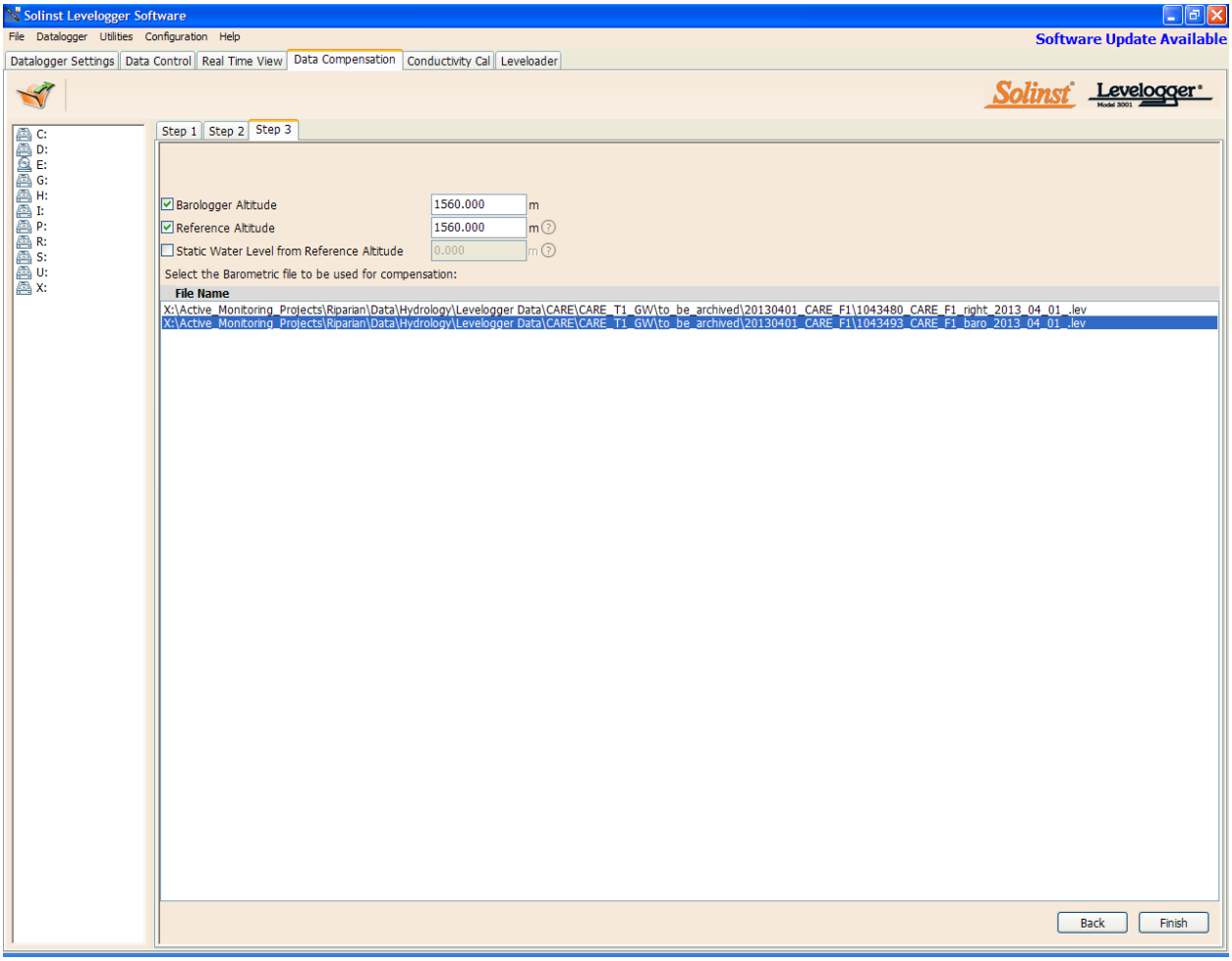
Barometric Pressure Compensation of Water Level Logger Data

All water transducer data must be barometrically compensated by subtracting the barometric pressure recorded by the atmospheric pressure transducer from the water stage recorded by each water transducer. Barometric pressure compensation can be completed using Solinst Levelogger or Hobo software depending on transducer type. Compensated data are then adjusted to the manual water level measurement taken during the field visit at the beginning of the logger record using Solinst Levelogger software.

Software compensation - Solinst

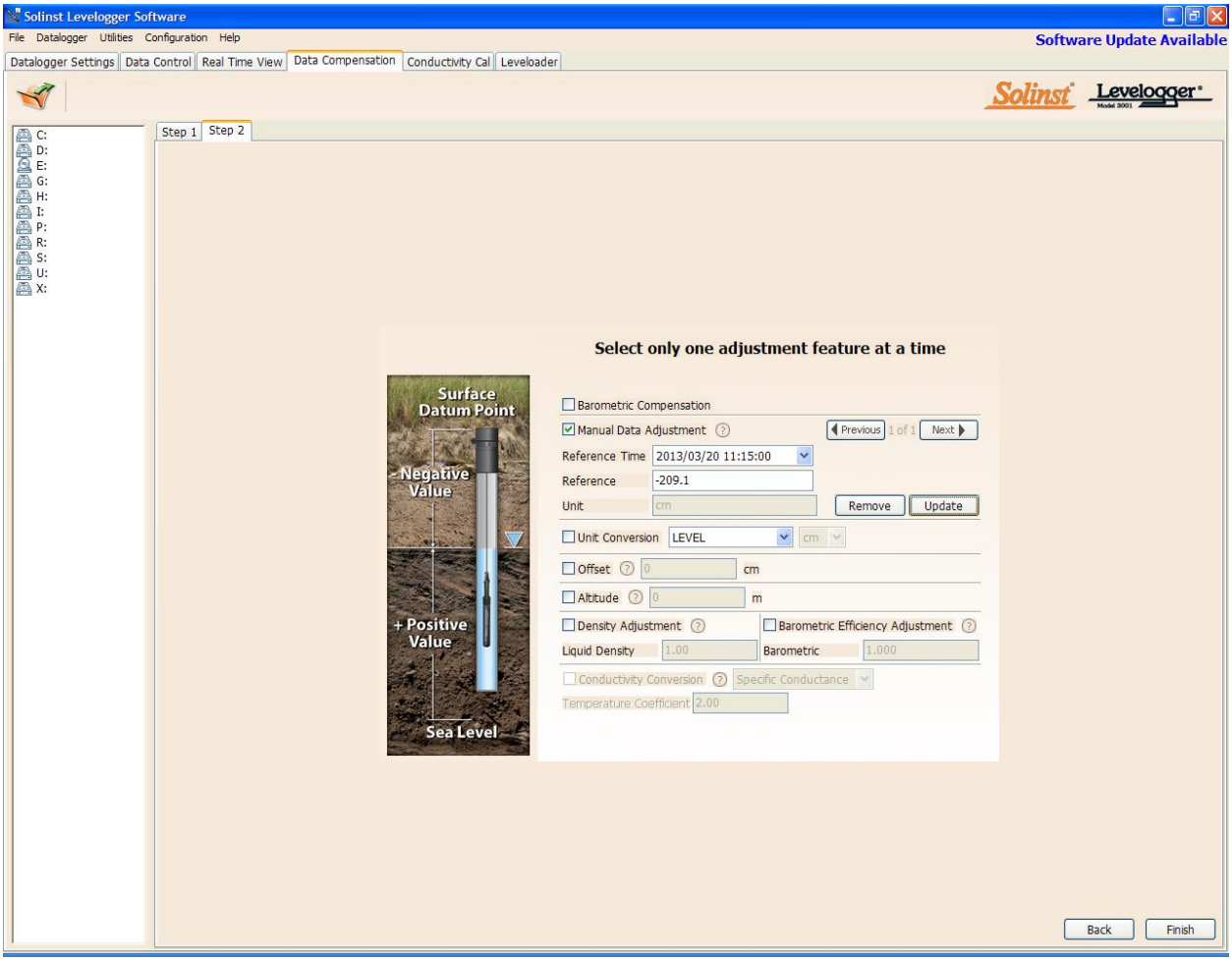
These instructions are written for Solinst Levelogger Software v. 4.0.3 for use with the Levelogger Edge series.

1. Open Solinst Levelogger Software.
2. Open appropriate data file.
3. Select Data Compensation tab.
    a. Make sure submerged levelogger file toggle is active, then click next .
    b. Check Barometric Compensation, then click next.
    c. Open and select the barologger file that is associated with the levelogger file that you are compensating.
    d. Add the elevations of the submerged levelogger and the barologger.
    e. Click Finish. The software will automatically add the word COMPENSATED to the original levelogger file name and save it in the same location.



4. Open the compensated levelogger file you just created.

a. Look at the dataset to determine the earliest date and time closest to the field visit measurement time that shows the datalogger is correctly deployed in the water (look for changes in temperature and stage).
b. Select the Data Compensation tab and the compensated dataset, then click next.
c. Select Manual Data Adjustment. Choose the date and time corresponding to the equilibrated datapoint noted above.
d. In the Reference cell, enter the negative value of the manual depth to water measurement (to the -0.1 cm) recorded at the field visit that corresponds to the beginning of the test. For example, if the measured depth to water on 2/14/13 at 11:45 MST was 125.3 cm from the top of the eyebolt, enter (-125.3) as the Reference for 2/14/13 at 12:00 MST on the logger file. Click Add, then Finish.
e. The software will automatically add the word COMPENSATED to the original levelogger file name and save it in the same location.



5. Open the adjusted levelogger file you just created (filename_compensated_compensated.lev). Export the adjusted and compensated levelogger file as a comma separated value (filename.csv) file. All files should be saved in the same folder on X (original, compensated, and exported .csv files).
6. Open the .csv file and delete any measurements taken prior to the equilibrated measurement. Round the level measurement column to the nearest 0.1 cm and the temperature measurement column to the nearest 0.01°C.
7. Repeat steps 2-6 for each levelogger file (riparian groundwater and instream leveloggers).

Adjusting for sensor drift

To check for and offset drift, compare the levelogger readings with the derived manually measured elevation above the sensor.

In the Data Correction toolbox, open the logger (Stage.compensated logger) time series as the Target and the derived field visit stage (Stage. calculated manual) time series as the Surrogate. If field visit values are offset from the time series, check for possible user errors such as: an offset of one hour due to differences between Daylight Savings and Standard time, an offset of 6 cm due to incorrectly entering measured instead of calculated manual stage data, etc. If no user errors are apparent, select the appropriate period of record, and select “Drift Correction”.

Click on the hand icon and select the crosshairs at the end of the selected region. Drag the crosshairs to the manual water level reading data point. Note the calibration drift offset, and click Apply. When prompted, add a note indicating the series was adjusted to the manual water level reading and the level of offset, e.g., “adjusted to manual water level reading, offset =- 1.2 cm.” Save.

Interpolating missing data

Missing data can occur due to equipment failure, staff turnover, ice, flooding, siltation or other causes. Gaps of less than two hours may be filled using linear interpolation, although caution should be used during flood events. Open the time series of interest in the Data Correction toolbox. Select the gap of interest, and choose “Fill Data Gaps” and “Linear Interpolation.” Apply and save.

Other data corrections

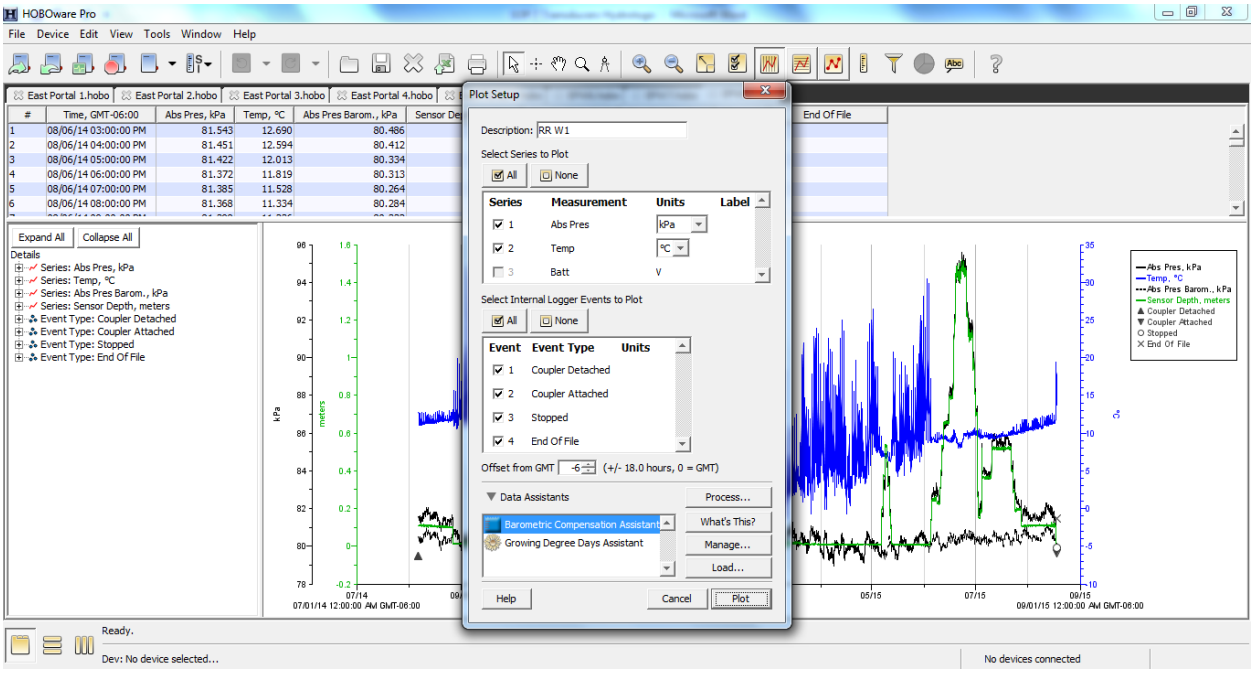
No other routine data corrections are anticipated at this time. However, should the need for additional data corrections arise, make sure each correction is documented using an explanatory note in Aquarius.

Approving the time series for data summary and analysis

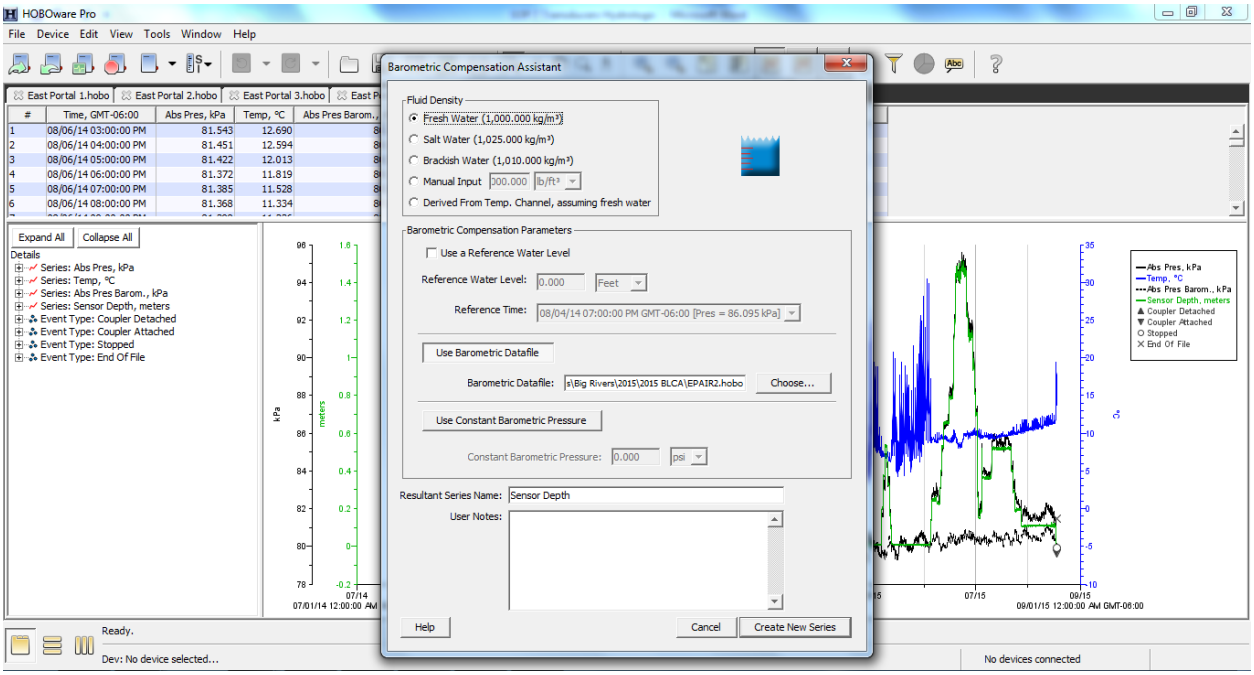
Once the data have been corrected and edited and are ready for use in derived datasets, data summary and analysis, select the appropriate period of record, and select “Set Approval.” Select “Approved,” and apply it to the time series. Save and close.

Software compensation - Hoboware

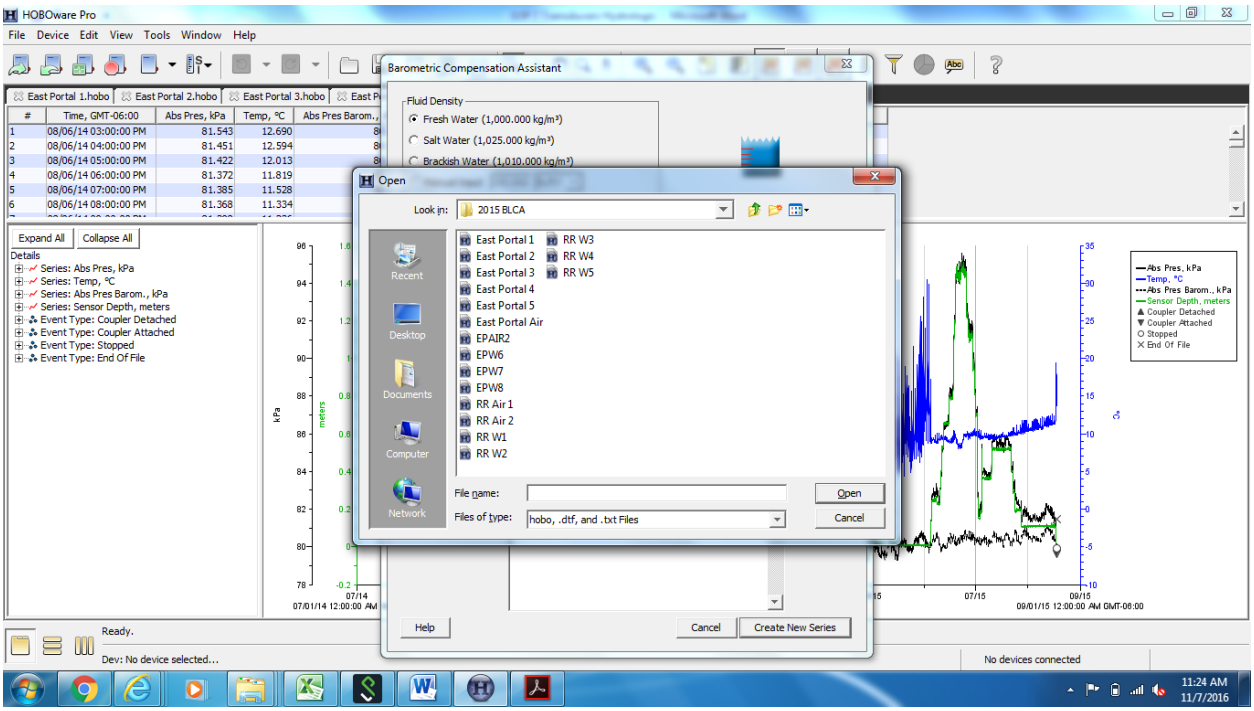
1. Open Solinst Hoboware Software.
2. Open appropriate data file.
3. When Plot Setup window opens, in the “Data Assistants” section select “Barometric Compensation Assistant”, then select “Process”



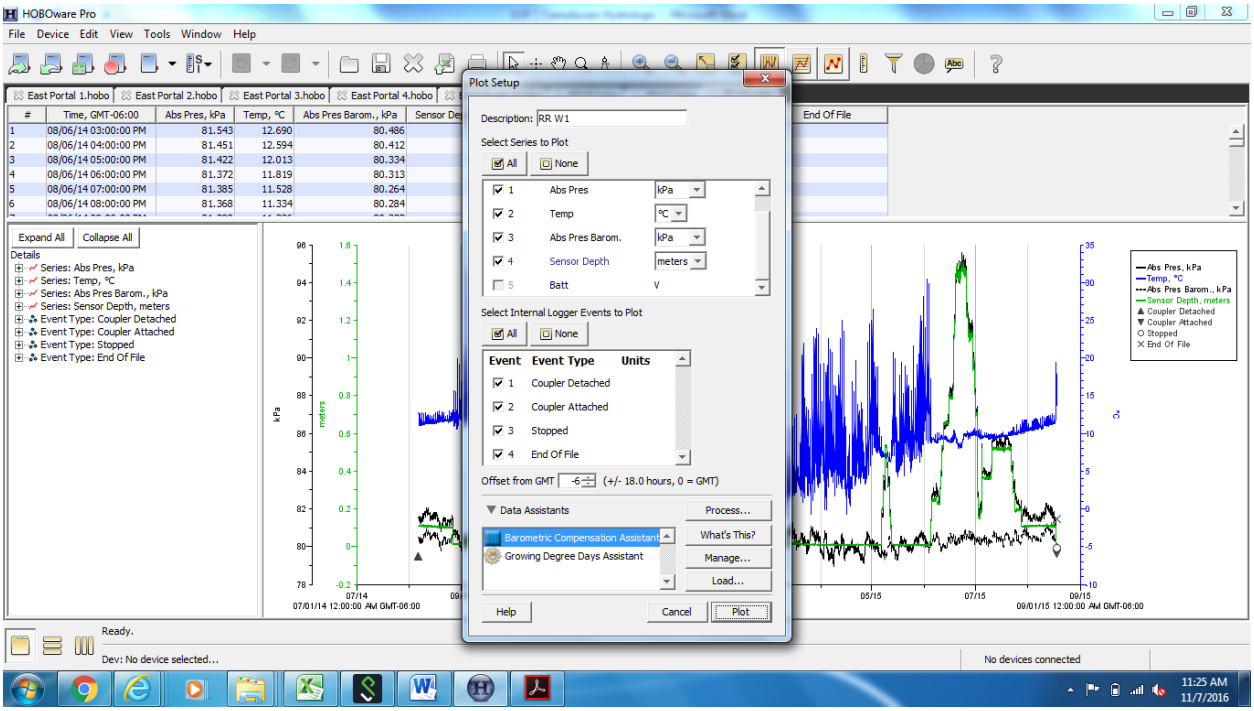
4. Select “Fresh Water” under “Fluid Density”
5. Under “Barometric Compensation Parameters”, select “Use Barometric Datafile” and “Choose”



6. Select appropriate atmospheric pressure transducer file



7. Select “Create New Series”
8. Select “Plot



9. Save project file with the following namenclature, two letter code for site (EP for East Portal or RR for Red Rocks), water or atmospheric pressure transducer (W or A), number of transducer (1-8), underscore, and year. For example EPW1_2015 or RRA2_2015.
10. Export project as a .csv file with the following namenclature, two letter code for site (EP for East Portal or RR for Red Rocks), underscore, number of water transducer (W1-8), underscore, compensated, underscore, and year. For example EP_W1_compensated_2015 or RRA_W2_compensated_2015.

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

Standard Operating Procedure (SOP) #8

Surveying

Version 1.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	2/2018	D. Perkins	Editorial	Peer review comments	1.01

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 (DINO only). 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	FZ	Boundary of the flood zone
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#15, 102, 103, 104 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.

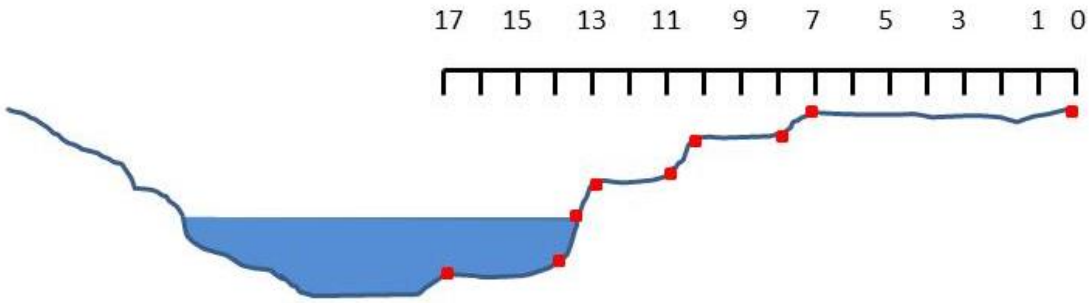


Figure 2. Example of slope breaks points (red) and one-meter intervals (black) surveyed.

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 15, 102, 103, 104 (Figure 3).

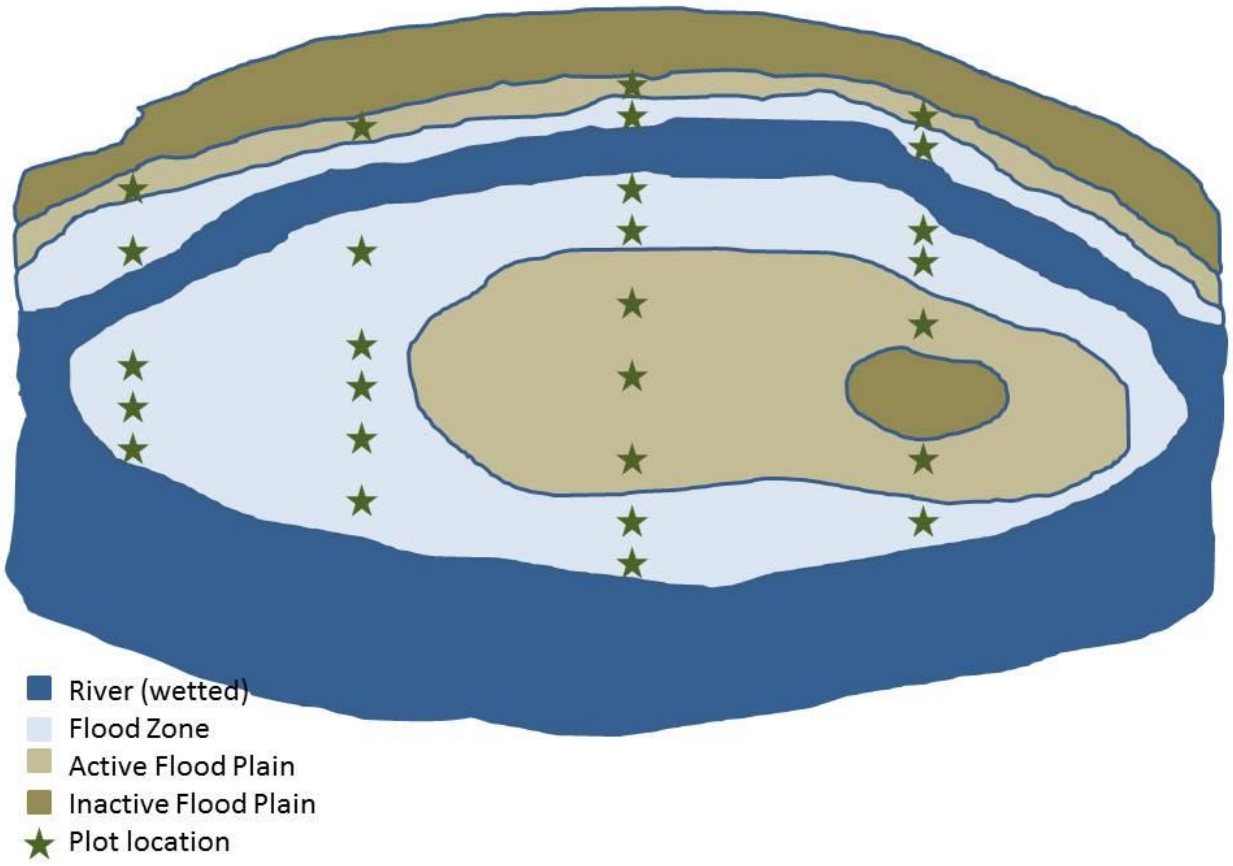


Figure 3. Locations of vegetation plots to be surveyed in. The topographic survey should also capture the boundaries of the geomorphic surfaces shown here.

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 personal floatation device 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:

- Toes and tops of banks that are closest to the main channel and back channel and sand caps (particularly new ones) are the highest priority. Note that only the TOB and TOE that are readily apparent should be surveyed. Do not try to force a TOB and TOE to exist if they are ambiguous. After TOEs, TOBs, and sand caps, the focus should be on chutes and areas where it is clear that water was present that year. Generally most breaklines that are less than 15 cm in height are less important.
- At a minimum 2 breakline features need to be surveyed 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.

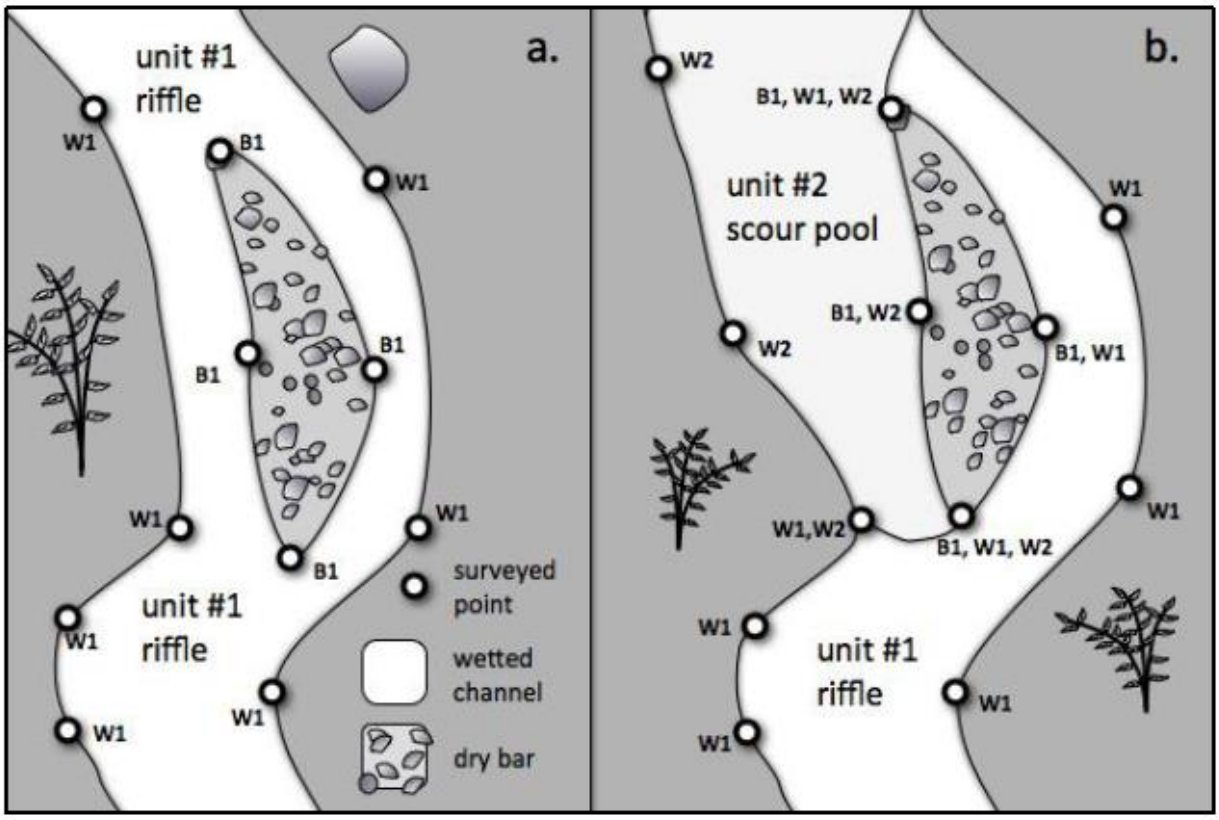


Figure 4. Example of coding points to describe the perimeters of channel units and bars showing which points require multiple codes.

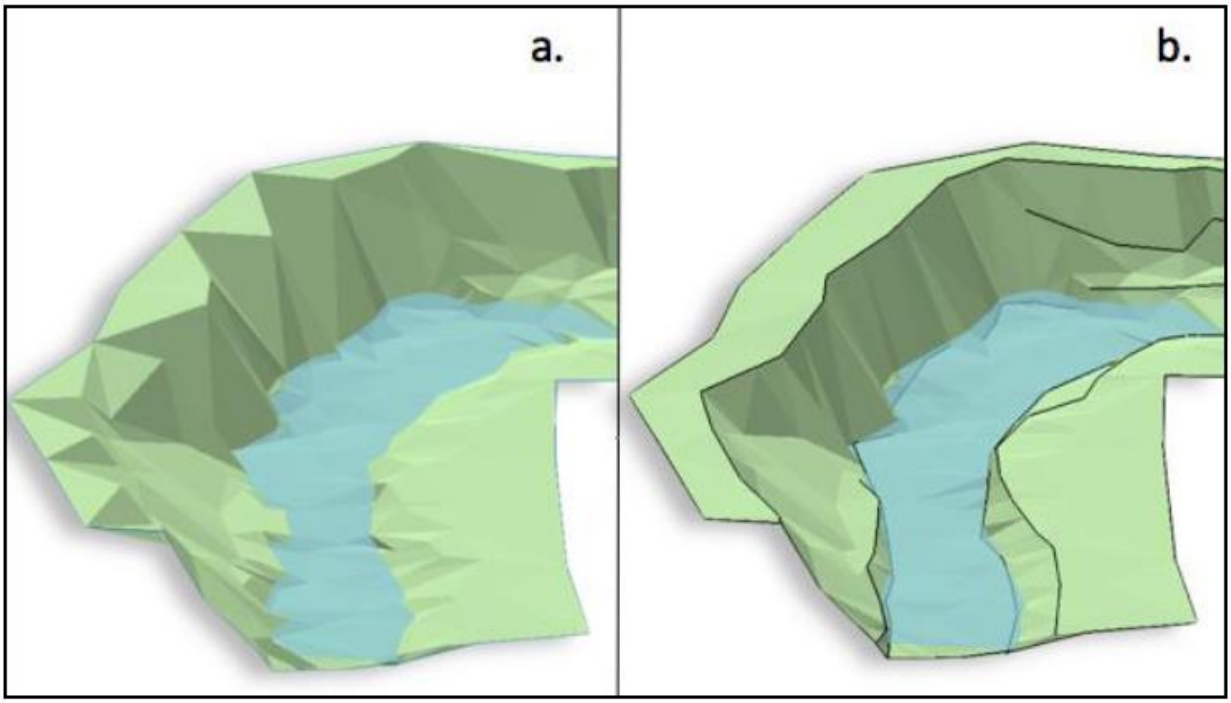


Figure 5. Example of streambank surfaces rendered a) without, and b) with breaklines surveyed at the TOB and TOE of the bank.

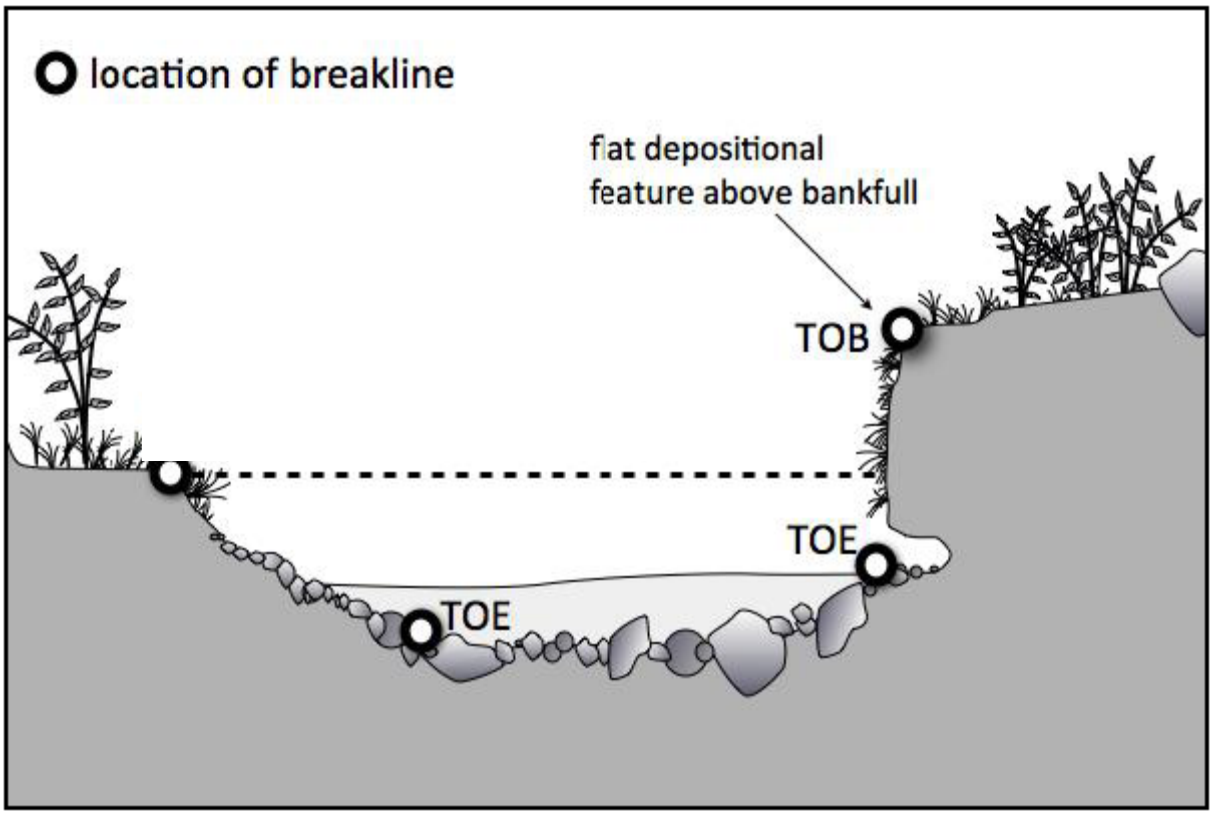


Figure 6. Cross-sectional view of a stream channel demonstrating the appropriate placement of TOB, and TOE breaklines. The TOE and TOB may not be readily identifiable, for example on the left side of this figure.

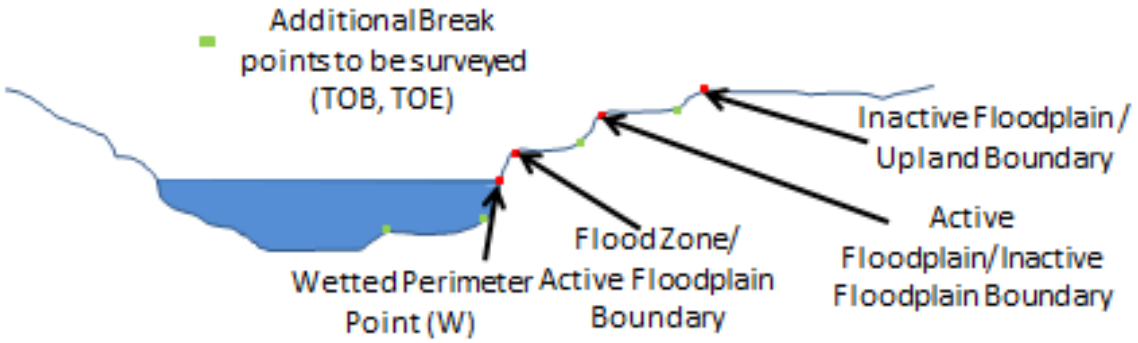


Figure 7. Cross-sectional view of a stream channel demonstrating the wetted perimeter, flood zone, active floodplain, inactive floodplain, upland, and break points. .

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 A or B 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.

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.

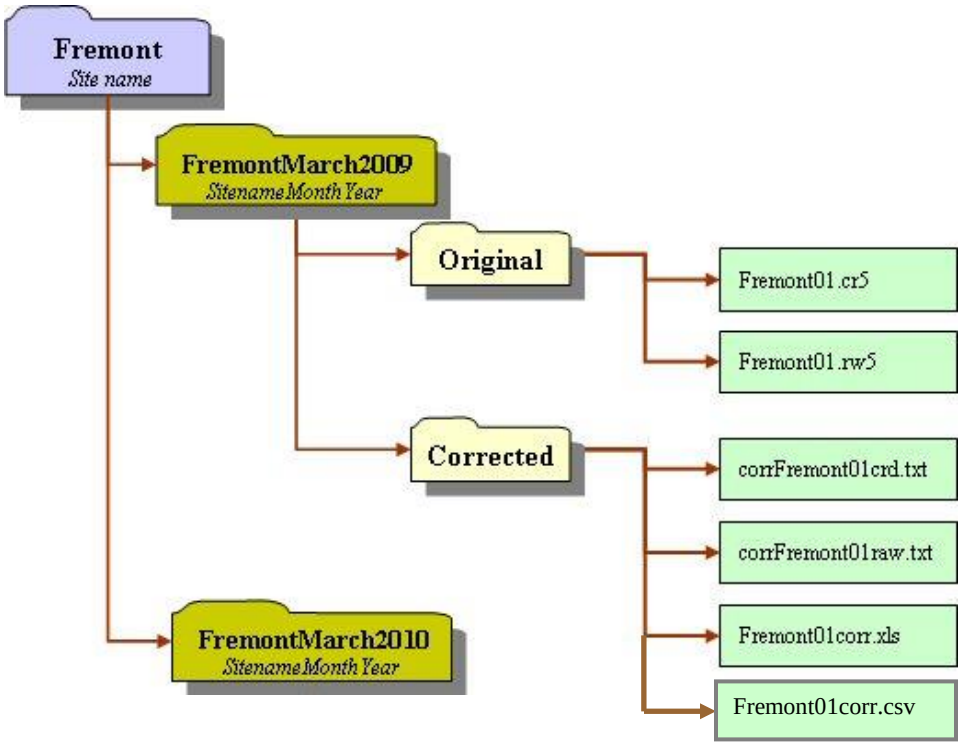


Figure 3. Folder and file naming conventions for survey data.

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 1.01 (December 2015)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	12/17/15	D. Perkins	Editorial	Clarity	1.01

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 and RTK 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. Charge RTK equipment.

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 #11. 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) #11

Data Management

Version 1.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	2/2018	D. Perkins	Editorial	Peer review	1.01

This Standard Operating Procedure (SOP) describes data management procedures for all data derived from big river monitoring in Northern Colorado Plateau Network (NCPN) park units. The procedures for data management given in this SOP follow guidelines and standards that are described in the NCPN Data Management Plan (Beer et al. 2005).

Acronyms and Definitions

CSV	Comma Separated Values
FGDC	Federal Geographic Data Committee
GIS	Geographic Information Systems
GPS	Global Positioning System
I&M	Inventory & Monitoring Program of the National Park Service
NCPN	Northern Colorado Plateau Network
NPS	National Park Service
PDF	Portable Document Format
RTK	Real Time Kinematic
SOP	Standard Operating Procedure
Certified data	Data have been through all QC procedures as outlined in the published protocol and the associated published Quality Assurance Plan. Data either meet the documented quality standards, or data that do not meet the standards are appropriately identified at the record level. Procedures for data collection, processing, and transformation have been documented in appropriate metadata formats. Data are suitable for reporting and distribution.

Data products	Information that is derived from certified project data.
Data Store	NPS-wide repository for documents, publications, and datasets related to NPS natural and cultural resources (https://irma.nps.gov/DataStore).
Legally protected	Data that are covered under existing statute as exempt from public dissemination.
NPSpecies	NPS web-based tool for documenting the occurrence and status of species on National Park Service lands (https://irma.nps.gov/NPSpecies).
Operationally protected	Data withheld from release to protect resources or site fidelity but may be subject to release upon request.
Provisional data	Data that have undergone all planned QA procedures, have been entered into the system of record, and have passed verification procedures to ensure that data in the system of record match source data (field forms, sensor data files, etc.). Verified data have not undergone QC procedures.
Quality assurance (QA) procedures	Procedures used to ensure collection of data with minimal errors.
Quality control (QC) procedures	Procedures used to flag or modify data to ensure that data meet established data quality standards.
Raw data	Data in their state of original collection, either in the form of paper or electronic field forms, electronic sensor files, or digital media (photograph, video, or audio). These data generally have been collected following some QA procedures, but have not undergone any QC procedures.

1 Data Collection and Database Design

1.1 Project File Storage Conventions

All files associated with the development and implementation of the big river monitoring protocol will be stored according to the procedures described in the NCPN Directory Structure Guidance Document (NCPN 2007a). Each NCPN project uses a similar folder structure replicated on both the active (X:\) and archive (R:\) network drives. Active project files are stored on the X:\ drive. At the end of each field season, certified data, completed products, and other seasonal files are transferred to the permanent project folder on the R:\ drive, where they are stored in read-only format.

The big river monitoring folder locations are as follows:

Active: X:\Active_Monitoring_Projects\Big_Rivers
Archive: R:\Monitoring_Archive\Big_Rivers

The big river monitoring folder will contain the following folders at a minimum:

- **Data**:
    - **Database:** Contains database frontend, backend, and backup files.
    - **Field_Data**: Contains scanned field data sheets organized by site.

    - **GIS_Data**: Contains geospatial data for items that need to be relocated at sampling locations, e.g., transect points, orientation pins, transducer locations.
    - **Hydro_Data**: Contains hydrologic data files organized by site.
    - **Survey_Data**: Contains geomorphic data files organized by site.
- **Field_Crews**: Contains files used by field crews, e.g., plant lists, trip reports.
- **Permits**: Contains copies of permits for conducting field work.
- **Project_Life_Cycle**: Contains files related to project data life cycle tracking, e.g., QA/QC documentation.
- **Protocol**: Contains protocol narrative and SOP documents.
- **Reports**: Contains annual and trend reports.

All big river monitoring files will be backed up regularly, with a backup rotation scheme that includes off-site storage of backups.

1.2 Data Collection

Data are acquired as specified in the protocol SOPs using two different methods: 1) digitally recorded using a total station or RTK (geomorphic), data logger (hydrology), or camera (photograph); and 2) manually recorded on paper data sheets (vegetation, photograph, hydrology, facies mapping, and grain size).

1.2.1 Digital Data Collection

Geomorphic data are digitally recorded using a total station or RTK and uploaded to the NCPN file server for post-processing. The raw data files are stored in their native format. After post-processing, a limited subset of geomorphic (survey) data is imported into the big rivers database to provide a linkage between surveyed locations and vegetation data. For more details on geomorphic data processing, refer to SOPs 8 and 17.

Continuous hydrology data are recorded using data loggers. Data logger files are uploaded to the Aquarius system hosted by the NPS Water Resources Division. Aquarius is commercial software for managing time series data. Most processing and analysis of the hydrology data is done within Aquarius. Copies of raw data logger files and derived datasets generated in Aquarius are stored on the NCPN server. For more details on hydrologic data processing, refer to SOP 7.

Big river monitoring photographs are collected and managed according to the procedures in the NCPN Photograph Management Guidance Document (NCPN 2008a). Photographs are initially uploaded to the big rivers incoming photograph folder on the NCPN shared drive:

X:\Archive\NCPN Photos\Incoming\Monitoring\Big_Rivers

Photograph metadata is recorded in the NCPN big rivers database. Data management staff subsequently imports this metadata into the NCPN photograph database, renames the image files, and moves the image files to the NCPN read-only shared drive:

R:\NCPN_Photos_Archive\NCPN Photos\BigRivers

1.2.2 Paper Data Collection

All other big river monitoring data will be recorded on paper data sheets until an electronic data collection system is deemed practical. To minimize potential ambiguity of data recorded on data sheets, the big river monitoring field crew will be trained to follow certain best practices: writing legibly, correcting mistakes by drawing a line through the mistake and initialing (mistakes should not be erased), and writing the full Latin name of a species the first time it is encountered and then subsequently recording only the species code.

Before leaving a site, the crew leader is responsible for reviewing all data sheets to ensure that they have been filled out completely, and that all data are legible and logical. Upon returning from a field trip, the data sheets will be scanned to 300 dpi or greater PDF files and checked to ensure the files are legible. Data sheets that are corrected subsequently will be re-scanned. The original data sheets will be stored in the big rivers filing cabinet in the NCPN office until they are archived.

1.3 Database Design

The big rivers database is a Microsoft Access database developed by the NCPN. It currently accommodates sentinel site, vegetation, and photograph data, as well as a subset of the hydrology and geomorphic data collected for big river monitoring. It is compatible with Access 2007 and 2010, and has a frontend/backend file structure:

- *big_rivers_app.accdb*: This frontend file contains all queries, forms, reports, modules, classes, and associated Visual Basic for Applications (VBA) application code.
- *big_rivers_be.accdb*: This backend file contains the database tables.

The frontend/backend file structure allows multiple users to enter data in a network environment, and allows for easy backup and transfer of the data tables. Users typically launch the frontend file, and a utility will prompt them to establish a link to the backend file.

The big rivers database design is inspired by the Inventory and Monitoring (I&M) program's Natural Resource Database Template, but with modifications which bring it in line with the 2015 I&M database standards (Frakes et al. 2015). Core database tables include a hierarchical set of tables identifying sampling location information (park, river, site, feature) and an Event table which stores basic sampling visit information. Additional tables store the variety of data collected during a sampling visit. The relationships between the primary data tables are shown in Figures 1 and 2 (all tables are not shown). Figure 1 shows the sampling location-related tables (*Park*, *River*, *Site*, *Feature*), the *Event* table, and tables containing vegetation sampling information (e.g., *VegPlot*, *VegWalk*).

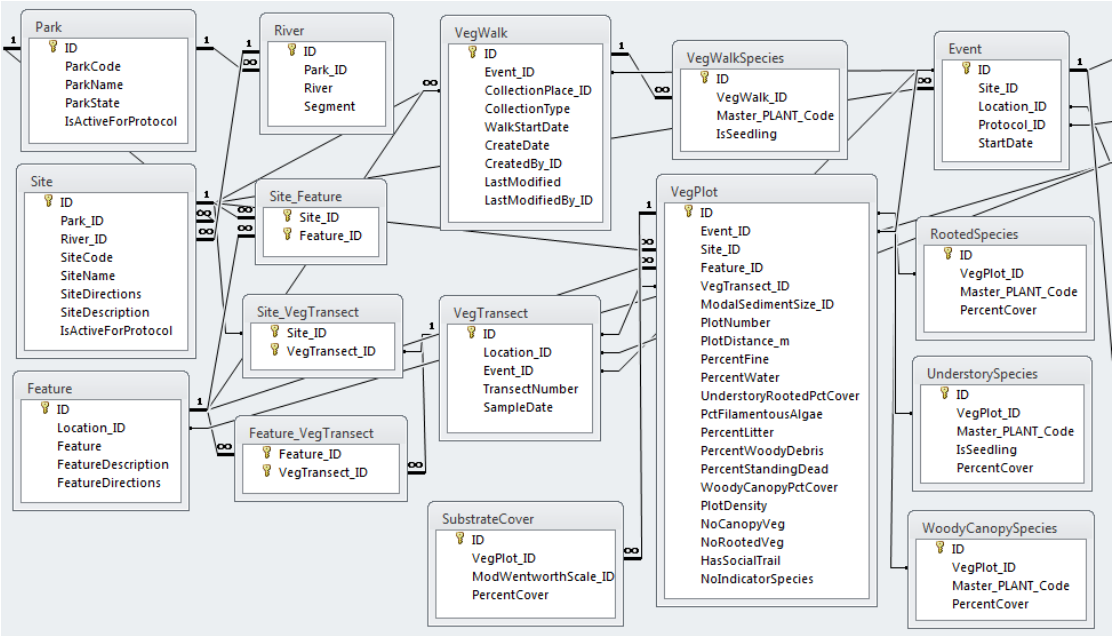


Figure 1. Sampling Location, Event, and Vegetation Sampling Database Tables

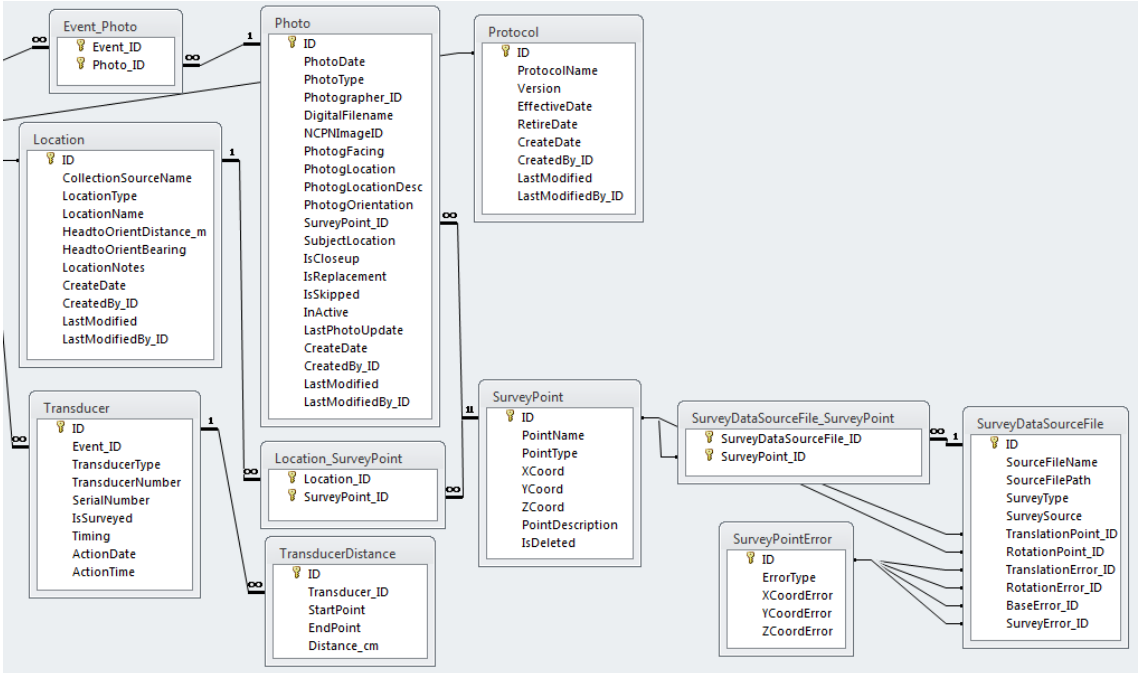


Figure 2 shows the tables containing photograph data (*Photo* and *Event_Photo*), hydrology data (*Transducer* and *TransducerDistance*), and geomorphic data (e.g., *SurveyPoint*).

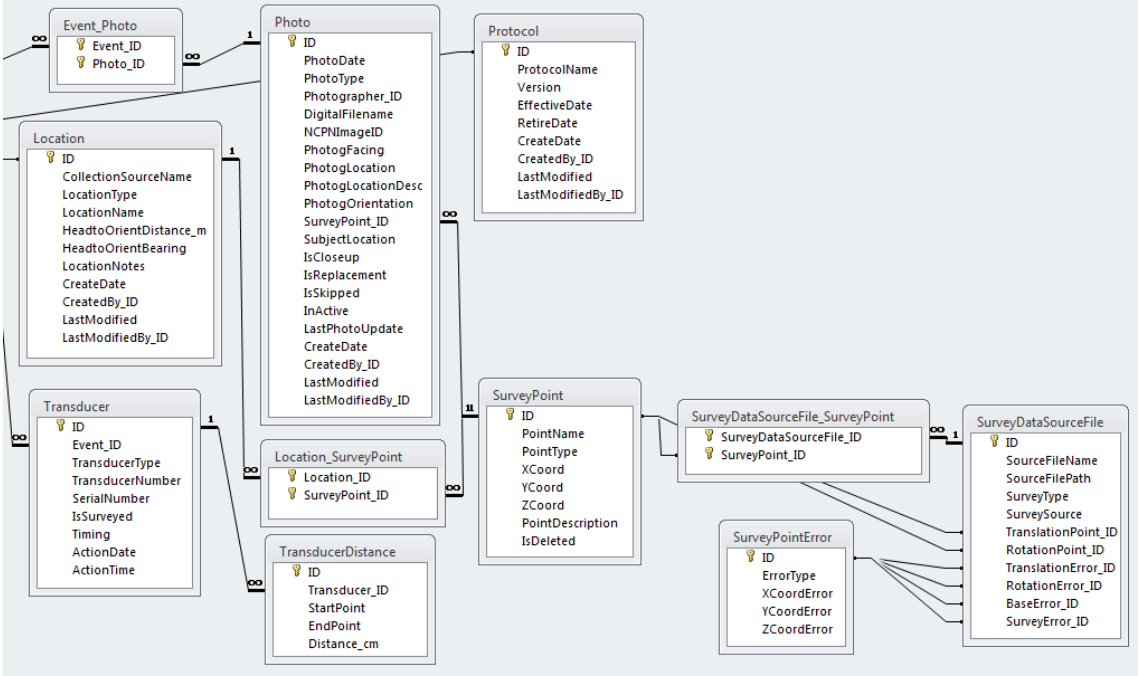


Figure 2 Photograph, Hydrology, and Geomorphology Database Tables

Any time a revision is made to the database, a complete copy of the database will be made and stored in an archive folder. In addition, the version history information will be updated in the database (in the *tsys_App_Releases* table).

Documentation of all tables and fields in the big rivers database is provided in Appendix 1.

2 Data Entry and Import

Data recorded on paper data sheets will be manually entered into the big rivers database. This includes vegetation plot, plant walk, photograph, and certain hydrologic measurement data. Data will be entered into the big rivers database as soon as possible after a field visit. Data entry should be completed by someone who participated in data collection or is familiar with the project and data. The primary goal of data entry is to transfer the data from paper into the database with 100% accuracy.

The data entry interface is designed to minimize data entry errors. Pick lists and range limits are incorporated wherever possible. Conditional formatting is used extensively to provide visual indications that a data validation rule has been violated, e.g., a required data field is highlighted until a valid value is entered. Error messages alert the data entry technician to correct mistakes.

Any errors or omissions discovered during data entry should be resolved as soon as possible. If necessary, the data entry technician should contact the person who collected the data for clarification. If the data sheet needs to be corrected, it should be annotated by drawing a line through the original entry and initialing.

After entering all the data on a data sheet, the data entry technician should annotate the data sheet in the designated section at the top indicating that the data have been entered. A database user's guide is under development that will provide detailed data entry instructions.

A subset of the geomorphic data will be imported into the big rivers database after it has been post-processed. The geomorphic data files are in a comma separated values (CSV) format. The big rivers database has a CSV import utility that will allow the user to import the CSV files into the appropriate database tables.

The database will be backed up regularly to maximize the ability to recover should irreversible errors or problems occur during a data entry or import session.

3 Data Verification and Validation

Verification and validation of big river monitoring data will be performed according to the procedures described in the NCPN Quality Assurance and Quality Control Guidance Document (NCPN 2008b). *Data verification* checks that data entered into a secondary (i.e., electronic) format match the source data, while *data validation* checks that the data make sense.

3.1 Data Verification

All big river monitoring data will be verified or proofed after data entry. This task should be completed by someone other than the person who completed the original data entry. Any transcription errors that are discovered are corrected in the database. After verifying all the data on a data sheet, the reviewer should annotate the data sheet in the designated section at the top indicating that the data have been proofed. The reviewer should also update the verification status in the database to indicate that the data have been proofed.

In addition, queries will be run that detect missing or duplicate records. For example, a listing and count of the vegetation transects and plots sampled for a given park, site, and year will help identify missing or duplicate records. These queries are under development and upon completion will be incorporated in an appendix to this document.

When data verification is complete, the dataset is considered to be provisional. The data processing levels referred to in this document are more fully described in Certification Guidelines for Inventory and Monitoring Data Products (National Park Service 2016). These data processing levels will be tracked in the database.

3.2 Data Validation

The protocol lead and data management staff will work collaboratively to validate big river monitoring data. Queries will be run to check for range and logic errors that are not captured by the automated validation that is built into the data entry interface. For example, species recorded during vegetation sampling will be compared to the expected species list for the park and any discrepancies flagged for review. A database utility is

being developed that will allow the user to run a set of validation queries, review the results, and make corrections as needed.

Other, more specific, validation routines will be worked out with the protocol lead and incorporated into the database as appropriate. Data management staff will work closely with the protocol lead to provide any needed database queries, reports, graphs, or export file formats to assist with validation.

Flags will be built into the database to identify data that do not meet data quality standards. For example, a species that is not on the expected list for the park and was not collected for identification would be flagged.

Corrections to errors detected during validation should be applied to the original data sheets, and those data sheets should be re-scanned. Modifications to the data sheets, whether made during data collection or subsequently, should be clear and concise while preserving the original data entries or notes. The original data entries should be crossed out with a single line and initialed - *they should not be erased*.

All newly collected geospatial data will be visually reviewed for accuracy using ArcGIS. This review will take place at the end of the field season.

As part of the validation process, sensitive data will be identified and flagged. NCPN staff will work with the appropriate park representative at each big river monitoring park to determine which data are to be protected, the level of protection (legally protected or operationally protected), and the associated dissemination rules. This protected status information will be stored in the database so that data can be redacted as needed when generating outputs intended for public distribution.

Detailed validation procedures are under development and upon completion will be incorporated in an appendix to this document.

4 Data Documentation and Certification

After all data verification and validation have been completed, the accompanying metadata is completed. Metadata, which is defined as structured information about the content, quality, condition, and other characteristics of data, is a critical step toward ensuring that datasets are usable for their intended purposes well into the future. Metadata for big river monitoring datasets will be created following NCPN metadata procedures (NCPN 2007b). An FGDC- and NPS-compliant metadata record in XML format will be created for each big river monitoring dataset. Any data that were flagged as not meeting data quality standards during the validation process will be identified in the metadata.

Another important component of the metadata for big river monitoring is the protocol (protocol narrative and SOPs) and associated version information. All narrative and SOP version changes are recorded in a master version table (MVT), which is maintained in the big rivers database and is reported in SOP #13. Any time the 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 MVT is essential for big river monitoring data to be properly interpreted and analyzed. *The protocol narrative, SOPs, and data should not be distributed independently of this table.*

After the above metadata procedures have been completed for a dataset, the dataset is considered to be certified and is suitable for reporting and distribution. Certification status will be recorded in the database.

5 Data Dissemination

Dissemination of big river monitoring data will follow the procedures outlined in the NCPN Data Dissemination Guidance Document (NCPN 2010a). After certification, the data, metadata, reports, and other data products will be made available on the Data Store. Redacted datasets and data products may be posted depending on the outcome of the protected data assessment described in Section 3.2.

In addition, NPSpecies will be updated with any newly documented species that were discovered during big river monitoring.

6 Data Archiving and Maintenance

Archiving is a critical step in ensuring the long-term preservation of data. Archiving of big river monitoring data and project files will follow the procedures described in the NCPN Archiving Guidance Document (NCPN 2010b). After the data for the field season have been certified, the database and metadata files will be moved to the big rivers archive folder on the NCPN server. All files in the archive folder will be stored in read-only format. The native format copy of the database will be supplemented by a platform-independent copy of the database tables in ASCII format. Other digital files that will be archived include digital copies of data sheets, geomorphic and hydrology data files, protocol narrative and SOPs, and reports and other data products.

Big river monitoring project files will also be archived at the Western Archeological and Conservation Center (WACC). WACC is the official archival repository for NCPN records. This facility provides temperature and humidity-controlled storage conditions and a professional archive staff, and it meets all NPS museum standards. The digital files listed above will be burned onto an archival-standard CD or DVD and sent to WACC. Hard copy materials, including original data sheets, field notebooks, and archival copies of reports, will also be sent to WACC for permanent storage.

After the big river monitoring data have been certified and archived, any subsequent edits to the data will be documented in an edit log. The edit log will be maintained in the database and will include details such as a description of the change, the reason for the change, the date of the change, and the individual who made the change. The edit log information will be exported from the database and included in the metadata.

7 References

Beer, M., E. Nance, A. Wight, M. Powell, and R. DenBleyker. 2005. Northern Colorado Plateau Network data management plan. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT. 86 pp plus appendices.

Frakes B., S. Kingston, and M. Beer. 2015. Inventory and Monitoring Division database standards: September 11, 2015. Natural Resource Report NPS/NRSS/NRR—2015/1035. National Park Service, Fort Collins, Colorado.

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Northern Colorado Plateau Network (NCPN). 2007a. Directory structure guidance document, version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

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Northern Colorado Plateau Network (NCPN). 2010a. Data dissemination guidance document, version 1.01. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

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Appendix 1. Documentation of Big Rivers Database Tables

Data Tables

Table Name: AppComment
Description: Observations, remarks, notes relating to data/data collection

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated number (PK)	dbLong	4
CommentType	Category of the comment (plot, transect, etc.)	dbText	255
CommentType_ID	ID of the specific plot, transect, etc. (FK)	dbLong	4
Comment	Observations, remarks, or notes	dbText	255
CreateDate	Timing of when comment was entered	dbDate	8
CreatedBy_ID	Contact ID for person who created comment (FK)	dbLong	4
LastModified	When comment was last changed	dbDate	8
LastModifiedBy_ID	Contact ID for person who last modified comment (FK)	dbLong	4

Table Name: ChangeLog
Description: Change/edit log documenting edits to data

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated change log record identifier	dbLong	4
ChangeType	Type of change (delete, update, etc.)	dbText	10
Change	Description of change	dbText	255
EditReason	Reason for changes	dbText	255
EffectiveDate	First date change applies	dbDate	8
RetireDate	Date change no longer applies for the protocol	dbDate	8
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Table Name: Contact
Description: Office or field persons involved in data collection, entry, analysis

Field Name	Field Description	Field Type	Field Width
ID	Autonumber contact ID (PK)	dbLong	4
LastName	Last name	dbText	50
FirstName	First name	dbText	25
MiddleInitial	Middle initial	dbText	4
Organization	Organization or employer	dbText	50
PositionTitle	Title or position description	dbText	50
Email	E-mail address	dbText	50
WorkPhone	Phone number (numbers only)	dbInteger	2
WorkExtension	Phone extension	dbInteger	2
IsActive	Is the contact active (1= true, 0 = false)	dbByte	1
IsNPS	Is the contact an NPS employee (1 = true, 0 = false)	dbByte	1
Username	Login username (AD user)	dbText	75

Table Name: Event
Description: Monitoring visit information including protocol version in use

Field Name	Field Description	Field Type	Field Width
ID	Event ID	dbLong	4
Site_ID	Sentinel site ID FK	dbLong	4

Field Name	Field Description	Field Type	Field Width
Location_ID	Location ID FK unique location identifier	dbLong	4
Protocol_ID	Protocol ID FK	dbLong	4
StartDate	Visit Start Date	dbDate	8

Table Name: Feature
Description: Big Rivers feature descriptions and direction with ties to location. A feature is a specific area within a river segment on a site that's given a name (A, B, etc.). BLCA is the only park at this time which contains features.

Field Name	Field Description	Field Type	Field Width
ID	PK - Feature autogenerated ID	dbLong	4
Location_ID	Location_ID FK	dbLong	4
Feature	BLCA: letter assigned downstream to upstream (A, B, C, etc.)	dbText	2
FeatureDescription	Description of the feature	dbText	255
FeatureDirections	Directions to feature	dbMemo	0

Table Name: Location
Description: Physical location information including name and type (F - feature, T- transect, P - plot)

Field Name	Field Description	Field Type	Field Width
ID	PK autogenerated unique location identifier	dbLong	4
Site_ID	Site identifier (FK) (ties to park via Site)	dbLong	4
CollectionSourceName	Collection feature ID (A, B, C, ...) or Transect number (1-8)	dbText	25
LocationType	Location type (F- feature, T- transect, P - plot)	dbText	1
LocationName	Location name - site, feature, transect	dbText	100
HeadtoOrientDistance_m	Distance from headpin to orientation pin (meters)	dbInteger	2
HeadtoOrientBearing	Bearing from headpin to orientation pin (0-360)	dbInteger	2
LocationNotes	Establishment comments, general notes on the location	dbMemo	0
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Table Name: Photo
Description: Captures photograph ancillary data for various photograph types (R - reference, F - feature, O - overview, T - transect)

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated unique photograph identifier	dbLong	4
PhotoDate	Date photograph was taken	dbDate	8
PhotoType	Transect, Feature, Reference or Overview (T, F, R, O - transect, feature, reference, overview/point-to-point). Other photographs can be accommodated by varchar(2), but are not initially included and may be stored separately.	dbText	2
Photographer_ID	Photographer (Contacts)	dbLong	4

Field Name	Field Description	Field Type	Field Width
DigitalFilename	P, 1-character month (Jan-Sep = 0-9, Oct-Dec=A-C), 2 digit day (01-31), 4-digit camera photograph sequence # (ex: PA010300 - photograph taken Oct 1, #0300)	dbText	50
NCPNImageID	NCPN image ID (data management staff)	dbText	50
PhotogFacing	Identifies direction the photographer is facing. Values depend on type of photograph. Transect (RR-river right, RL-river left), feature (upstream - US, downstream - DS), reference & overview - (US, DS, RR-river right, RL-river left, & combo of US/DS & RR/RL)	dbText	4
PhotogLocation	Location of photographer. Value depends on photograph type and park. See SOP & datasheets for details.	dbText	10
PhotogLocationDesc	Reference photograph location description (water's edge, etc.), NULL for F T O	dbText	255
PhotogOrientation	Photograph taken from (US, DS - upstream, downstream) - BLCA only, NULL others	dbText	255
SurveyPoint_ID	SurveyPoint coordinate ID for photograph location (FK)	dbLong	4
SubjectLocation	Position of subject in photograph. Varies depending on photograph type and park. See SOP & datasheets for details.	dbText	10
IsCloseup	Boolean value for whether photograph is a closeup (1) or not (0)	dbByte	1
IsReplacement	Boolean value for whether photograph is a replacement (0 = not a replacement, 1 = replacement)	dbByte	1
IsSkipped	Boolean value for whether photograph was skipped (0 = not skipped, 1 = skipped)	dbByte	1
InActive	Boolean value for whether photograph can be used or not (0 = active/useable, 1 = inactive/do not use)	dbByte	1
LastPhotoUpdate	Photograph data entry timestamp for correlating changes between Photograph table & Photograph db	dbDate	8
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Table Name: RecordAction
Description: Record action metadata including who took action and what role the person had (observer, recorder, data entry, verifier, certifier)

Field Name	Field Description	Field Type	Field Width
ID	Automatically generated identifier	dbLong	4
ReferenceType	Table name of referenced record (Event, Photograph, etc.)	dbText	25
Reference_ID	Record referenced (event/visit, vegplot, vegwalk, etc.)	dbLong	4
Contact_ID	Person's (contact) who took action ID (FK)	dbLong	4
Activity	Person's action (O-observer, R-recorder, DE-data entry, V-verifier, C-certifier)	dbText	2
ActionDate	Date the action took place	dbDate	8

Table Name: River

Description: Rivers, segments, and acronyms

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated river identifier	dbLong	4
Park_ID	Park ID (FK)	dbLong	4
River	Full river or river segment name (Green, Yampa, Green above confluence, etc.)	dbText	25
Segment	Full or section of river abbreviation (Green, Yampa, GAC, GBC, etc.)	dbText	10

Table Name: RootedSpecies
Description: Rooted vegetation data

Field Name	Field Description	Field Type	Field Width
ID	Rooted cover ID PK	dbLong	4
VegPlot_ID	VegPlot ID FK	dbLong	4
Master_PLANT_Code	tlu_NCPN_Plants Master PLANT Code FK	dbText	20
PercentCover	Percent of plot cover that is rooted cover (0,5,10,...90,95), 99=<complete cover but > 97.5, 0.5=trace, 0=complete absence of cover	dbDouble	8

Table Name: Site
Description: General site characteristics, directions and description

Field Name	Field Description	Field Type	Field Width
ID	Sentinel site autogenerated ID	dbLong	4
Park_ID	Park ID FK	dbLong	4
River_ID	River ID FK	dbLong	4
SiteCode	2 character code (EP=east portal, RR=red rock, etc.)	dbText	2
SiteName	Valid site name (East Portal, Red Rock Canyon, Warner Point, etc.)	dbText	50
SiteDirections	Directions to site	dbMemo	0
SiteDescription	Site description	dbText	255
IsActiveForProtocol	Is site currently active for the protocol? (1=True, 0=false, default)	dbByte	1

Table Name: SubstrateCover
Description: Substrate class percent cover data for vegplots

Field Name	Field Description	Field Type	Field Width
ID	Substrate ID PK	dbLong	4
VegPlot_ID	VegPlot ID FK	dbLong	4
ModWentworthScale_ID	Modified Wentworth Scale class size ID FK	dbLong	4
PercentCover	Percent of plot cover that is this substrate (0,5,10,...90,95), 99=<complete cover but > 97.5, 0.5=trace, 0=complete absence of cover	dbDouble	8

Table Name: SurveyDataSourceFile
Description: Survey data source file metadata including translation and rotation and error foreign keys

Field Name	Field Description	Field Type	Field Width
ID	PK for CSV source file	dbLong	4

Field Name	Field Description	Field Type	Field Width
SourceFileName	Survey CSV source file name	dbText	255
SourceFilePath	Survey CSV source file path	dbText	255
SurveyType	Type of survey - open transit (O), closed loop (C)	dbText	1
SurveySource	Type of equipment or source - RTK, TS (Total Station), USGS, etc.	dbText	4
TranslationPoint_ID	GPS point used for translating total station data (NULL for others)	dbLong	4
RotationPoint_ID	GPS point used for rotating total station data (NULL for others)	dbLong	4
TranslationError_ID	Translation point errors (X,Y,Z) - averaged errors if open loop	dbLong	4
RotationError_ID	Rotation point errors (X,Y,Z) - averaged errors if open loop	dbLong	4
BaseError_ID	Base station errors (X,Y,Z) - averaged errors if open loop	dbLong	4
SurveyError_ID	Survey point errors (X,Y,Z) - averaged errors if open loop	dbLong	4

Table Name: SurveyPoint
Description: Survey point data from survey imported CSV files

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated survey point identifier	dbLong	4
PointName	Point name for survey points	dbText	255
PointType	Point type for survey points (CP - control point, XS - cross section, ...)	dbText	4
XCoord	Easting, X coordinate	dbDouble	8
YCoord	Northing, Y coordinate	dbDouble	8
ZCoord	Elevation Z coordinate (Z_Coord)	dbDouble	8
PointDescription	Point distinguishing characteristics	dbText	255
IsDeleted	Deletion flag (1 - deleted point, 0 - used point), Points are deleted due to errors, etc.	dbByte	1

Table Name: SurveyPointError
Description: Survey data point errors

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated survey point error identifier	dbLong	4
ErrorType	Point type for survey points (T-Translate, R-Rotate, B-Base, S-Survey...)	dbText	255
XCoordError	Easting X coordinate errors	dbDouble	8
YCoordError	Northing Y coordinate errors	dbDouble	8
ZCoordError	Elevation Z coordinate errors	dbDouble	8

Table Name: Tagline
Description: Tagline line distances and line heights for various points (SC - slope change, RS - river stake, U - upland, R - river)

Field Name	Field Description	Field Type	Field Width
ID	Line distance autogenerated PK	dbLong	4
LineDistanceSource	Line distance source (T = transect, P = plot)	dbText	1
LineDistanceSource_ID	VegTransect_ID FK or VegPlot_ID FK	dbLong	4
LineDistanceType	Measurement type (WP-water pin, SC-slope	dbText	2

Field Name	Field Description	Field Type	Field Width
	change, U-upland, R-river) - initially ALL = SC		
LineDistance_m	Measurement (meters) - BLCA: River - Line distance along transect of upland (smallest) edge of plot within XS (m), Upland - Line distance along transect of streamward (edge) edge of plot within XS (m)	dbDecimal	16
HeightType	Height of tagline above ... (H-headpin @ 0, W-water, G-ground, V-vegetation, WRS - water @ water pin), SC: Points where tagline bends or stretches while slope changes (W-water, G-ground, V-vegetation, R- rock, D-debris)	dbText	3
Height_cm	Measurement (nearest cm) to tagline. Can be negative for water pins (tagline below water)	dbDecimal	16

Table Name: Transducer
Description: Transducer properties and metadata

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated transducer identifier (PK)	dbLong	4
Event_ID	Event identifier (FK)	dbLong	4
TransducerType	Transducer type (W-water, A-air)	dbText	1
TransducerNumber	Transducer designator (US-upstream, DS-downstream, Air, Water, IPW1, etc.)	dbText	10
SerialNumber	Transducer logger serial number	dbText	50
IsSurveyed	Boolean indicating if transducer is surveyed in (1-transducer is surveyed, 0-transducer is not surveyed)	dbByte	1
Timing	Timing of actions (BD-before-download, AD-after-download/reinstallation)	dbText	2
ActionDate	Date of measurement (mm/dd/yyyy short date)	dbDate	8
ActionTime	Time of measurement (24-hour short time - 17:34)	dbDate	8

Table Name: TransducerDistance
Description: Transducer distance measurements

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated transducer distance ID (PK)	dbLong	4
Transducer_ID	Transducer identifier (FK)	dbLong	4
StartPoint	Point distance is measured from (R-reference mark, E-eyebolt)	dbText	1
EndPoint	Point distance is measured to (W-waterline, E-eyebolt, SL-scribe line)	dbText	2
Distance_cm	Distance between start and end point (cm)	dbInteger	2

Table Name: UnderstorySpecies
Description: Understory rooted cover vegetation data

Field Name	Field Description	Field Type	Field Width
ID	Understory cover autogenerated ID PK	dbLong	4
VegPlot_ID	VegPlot ID FK	dbLong	4
Master_PLANT_Code	tlu_NCPN_Plants Master PLANT Code FK	dbText	20
IsSeedling	Boolean indicating if plant is a seedling (IsSeedling = 1) or not (IsSeedling = 0, default)	dbByte	1
PercentCover	Percent of plot cover that is understory cover	dbDouble	8

Field Name	Field Description	Field Type	Field Width
	(0,5,10,...90,95), 99=<complete cover but > 97.5, 0.5=trace, 0=complete absence of cover		

Table Name: UnknownSpecies
Description: Unknown plant species table

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated unique identifier (PK)	dbLong	4
UnknownCode	Temporary code for unknown species (UNK...)	dbText	15
CollectedBy_ID	Person collecting specimen (Contact FK)	dbLong	4
CollectionMethod	Collection method	dbText	50
Location_ID	Collection location identifier (Location FK)	dbLong	4
PlantType	Plant type: herb, shrub, tree, grass, sedge, other	dbText	15
PlantDescription	General description	dbMemo	0
SalientFeature	Most salient feature	dbText	255
LeafType	Leaf type: compound/simple, arrangement	dbText	50
LeafMargin	Leaf margin	dbText	50
LeafCharacteristics	Other leaf characteristics: pubescence, sap, stipules	dbText	255
StemCharacteristics	Stem characteristics: shape, pubescence, bud	dbText	255
FlowerCharacteristics	Flower characteristics: color location floral formula	dbText	255
GeneralCharacteristics	General and microhabitat characteristics	dbText	255
Collected	Was plant collected	dbByte	1
BestGuess	Best guess species name	dbText	50
ConfirmedCode	Confirmed species code	dbText	50
HasPhotos	Are there photographs?	dbByte	1
ForbGrassType	Annual or Perennial	dbText	10
PerennialGrasses	Perennial grass type: Bunchgrass or Rhizomatous	dbText	15
IdentifiedBy_ID	Person making final identification (Contact FK)	dbLong	4
IdentifiedDate	Date of identification	dbDate	8
TransectPosition	Position on Transect (m)	dbInteger	2

Table Name: VegPlot
Description: Plot vegetation data

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated PK for plot	dbLong	4
Event_ID	Sampling visit event ID FK	dbLong	4
Site_ID	Site ID FK	dbLong	4
Feature_ID	Feature ID FK	dbLong	4
VegTransect_ID	VegTransect ID FK	dbLong	4
ModalSedimentSize_ID	Modal (by plan view area) diameter of surficial sediment in plot (Modified Wentworth Scale code ID, FK), 2017 on this is overall (substrate cover captured separately)	dbLong	4
PlotNumber	Number assigned to the plot (DINO only, other parks do not have plot numbers)	dbInteger	2
PlotDistance_m	Location of plot along transect as measured from the downstream corner of the plot (in meters)	dbInteger	2

Field Name	Field Description	Field Type	Field Width
PercentFine	Percent of plot that is fines	dbDouble	8
PercentWater	Percent of plot that is inundated (water)	dbDouble	8
UnderstoryRootedPctCover	Total percent of plot cover that is rooted cover (0,5,10,...90,95), 99=<complete cover but > 97.5, 0.5=trace, 0=complete absence of cover	dbDouble	8
PctFilamentousAlgae	Percent of understory cover that is Filamentous Algae, incl. attached macrophytes & FA < 0.5 cm long	dbDouble	8
PercentLitter	Percent of plot that is litter (added 2017 field season)	dbDouble	8
PercentWoodyDebris	Percent of plot that is woody debris (added 2017 field season)	dbDouble	8
PercentStandingDead	Percent of plot woody canopy cover (WCC) that is standing dead (rooted/non-rotted), includes all species (added 2017 field season)	dbDouble	8
WoodyCanopyPctCover	Total percent of plot cover that is woody canopy cover (like URC) (added 2017 field season)	dbDouble	8
PlotDensity	Denominator of the fraction of plots sampled (e.g., 4 is recorded to represent 1/4 = 1 of 4 plots monitored for a given section of transect). Current value ranges from 1 to 8.	dbInteger	2
NoCanopyVeg	Boolean value indicating if a plot contains no woody canopy cover (NoCanopyVeg = 1) or if there is woody canopy vegetation (NoCanopyVeg=0)	dbByte	1
NoRootedVeg	Boolean value indicating if a plot contains no understory rooted vegetation (NoRootedVeg = 1) or if there is rooted vegetation (NoRootedVeg=0) - DINO & CANY understory only	dbByte	1
HasSocialTrail	Boolean value indicating if a plot contains social trails (1=true, 0=false)	dbByte	1
NoIndicatorSpecies	Boolean indicating if no understory indicator species are found in a plot (1=no indicator species found, 0=indicator species were present) - BLCA only	dbByte	1

Table Name: VegTransect
Description: Transect vegetation data

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated transect PK	dbLong	4
Location_ID	Location ID FK	dbLong	4
Event_ID	Event ID FK	dbLong	4
TransectNumber	Transect number (BLCA, CANY, DINO, range 1-8)	dbInteger	2
SampleDate	Date transect data taken	dbDate	8

Table Name: VegWalk
Description: Walk basic data

Field Name	Field Description	Field Type	Field Width
ID	Veg walk autogenerated identifier	dbLong	4

Field Name	Field Description	Field Type	Field Width
Event_ID	Event_ID FK	dbLong	4
CollectionPlace_ID	Location Feature (sentinel site) FK	dbLong	4
CollectionType	Site or Feature to handle prior non-site data (S or F)	dbText	50
WalkStartDate	Start date of timed plant walk	dbDate	8
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Table Name: VegWalkSpecies
Description: Walk vegetation species found

Field Name	Field Description	Field Type	Field Width
ID	Veg walk autogenerated identifier	dbLong	4
VegWalk_ID	Event_ID FK	dbLong	4
Master_PLANT_Code	tlu_NCPN_Plants Master PLANTS Code FK	dbText	20
IsSeedling	Boolean value indicating if species is a seedling (IsSeedling = 1) or an adult (IsSeedling = 0)	dbByte	1

Table Name: WoodyCanopySpecies
Description: Woody canopy vegetation data

Field Name	Field Description	Field Type	Field Width
ID	Woody canopy cover ID PK	dbLong	4
VegPlot_ID	VegPlot ID FK	dbLong	4
Master_PLANT_Code	tlu_NCPN_Plants Master PLANT Code FK	dbText	20
PercentCover	Percent of plot cover that is woody canopy cover (0,5,10,...90,95), 99=<complete cover but > 97.5, 0.5=trace, 0=complete absence of cover	dbDouble	8

Linking Tables

Table Name: Contact_Access
Description: Link between Contact and their Access level (and its associated application permissions)

Field Name	Field Description	Field Type	Field Width
Contact_ID	Contact ID (FK)	dbLong	4
Access_ID	Access level ID (FK)	dbLong	4

Table Name: Event_Photo
Description: Events to Photographs linking table

Field Name	Field Description	Field Type	Field Width
Event_ID	Event ID FK	dbLong	4
Photo_ID	Photo ID FK	dbLong	4

Table Name: Feature_VegTransect
Description: Feature to transect linking table

Field Name	Field Description	Field Type	Field Width
Feature_ID	Feature ID FK	dbLong	4
VegTransect_ID	VegTransect ID FK	dbLong	4

Table Name: Location_SurveyPoint
Description: Location to survey point linking table

Field Name	Field Description	Field Type	Field Width
Location_ID	Location identifier (FK)	dbLong	4
SurveyPoint_ID	Survey point identifier (FK	dbLong	4

Table Name: Measurement_Flags
Description: Flags join table for measurement records

Field Name	Field Description	Field Type	Field Width
RecordTable	Referenced table name	dbText	50
Record_ID	Referenced table record ID (FK)	dbLong	4
RecordField	Referenced table field	dbText	50
Flag_ID	Flag identifier for the record field (FK)	dbLong	4

Table Name: Site_Feature
Description: Site to feature linking table

Field Name	Field Description	Field Type	Field Width
Site_ID	Sentinel Site FK	dbLong	4
Feature_ID	Feature FK	dbLong	4

Table Name: Site_VegTransect
Description: Site to transect linking table

Field Name	Field Description	Field Type	Field Width
Site_ID	Sentinel Site ID FK	dbLong	4
VegTransect_ID	VegTransect ID FK	dbLong	4

Table Name: SurveyDataSourceFile_SurveyPoint
Description: Survey source file to survey points linking table

Field Name	Field Description	Field Type	Field Width
SurveyDataSourceFile_ID	FK Survey source file ID	dbLong	4
SurveyPoint_ID	FK Survey point ID	dbLong	4

Lookup Tables

Table Name: Flags
Description: QA/QC and other flags (missing data, etc.)

Field Name	Field Description	Field Type	Field Width
ID	Flag autogenerated ID (PK)	dbLong	4
FlagGroup	Flag category (Missing Value, Quality, etc.)	dbText	20
FlagType	Flag sub-category (Error, Certification, etc.)	dbText	15
FlagName	Flag short name	dbText	25
Code	Flag code used in alphanumeric fields	dbText	255
NumericCode	Flag code used in numeric fields	dbInteger	2
Label	Flag description	dbText	255

Table Name: IndicatorSpecies
Description: BLCA/CANY/DINO indicator species list. Lookup table identifying species on lists used in the field

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated indicator species record identifier	dbLong	4

Field Name	Field Description	Field Type	Field Width
Park_ID	Associated park identifier	dbLong	4
River_ID	Associated river identifier	dbLong	4
Master_Plant_Code	Plant master code (tlu_NCPN_Plants) FK	dbText	20
ListType	List type for target species (WC=woody canopy, U=understory, I=invasive, W=veg walk)	dbText	2
TargetYear	Year (4-digit) species on list	dbInteger	2

Table Name: IsDeadSpecies
Description: List of species which are differentiated as standing dead tamarisk. Lookup table.

Field Name	Field Description	Field Type	Field Width
Master_PLANT_Code	NCPN master plants plant code (FK)	dbText	20

Table Name: IsSeedlingSpecies
Description: List of species which are differentiated as seedlings (as well as adults) Lookup table.

Field Name	Field Description	Field Type	Field Width
Master_PLANT_Code	NCPN master plants plant code (FK)	dbText	20

Table Name: Logger
Description: Transducers used at various Sites (Park & River segment derived from Site)

Field Name	Field Description	Field Type	Field Width
ID	Logger (transducer) autogenerated ID (PK)	dbLong	4
Site_ID	Link to monitoring site identifier (also ties into river segment & park) (FK)	dbLong	4
SensorType	Type of sensor (Air, Water)	dbText	5
SensorNumber	Identifying number for the sensor (combines site abbreviation, A-air/W-water, and sequence of sensor) (EPW1, RRW2, etc.)	dbText	10
SamplingOrder	Sampling order along river (datasheet ordering)	dbInteger	2

Table Name: ModWentworthScale
Description: Modified Wentworth Scale sediment size categories

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated identifier (PK)	dbLong	4
Code	1-3-letter sediment size code	dbText	3
Label	Modified Wentworth sediment size category description (verbose)	dbText	25
DiameterRange_mm	Sediment size range (mm) or reference to SOP definition	dbText	255
CategoryOrder	Sequence of categories (smallest to largest)	dbInteger	2
KeyOrder	Sequence of categories for datasheet displays (2-column report order)	dbInteger	2
ActiveYear	4-digit year category use began	dbInteger	2
RetireYear	4-digit year category was retired (year last used, inclusive)	dbInteger	2

Table Name: Park
Description: Look-up table of parks in the Northern Colorado Plateau Network

Field Name	Field Description	Field Type	Field Width

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated park identifier (PK)	dbLong	4
ParkCode	Four-letter abbreviation for park code	dbText	4
ParkName	Full name of park where data were collected	dbText	50
ParkState	State code	dbText	2
IsActiveForProtocol	Is park currently active for the protocol? (1=True, 0=false, default)	dbByte	1

Table Name: PhotoPoint
Description: Photograph point locations, coordinates, and number of photographs per point. Lookup reference for field sheet preparation.

Field Name	Field Description	Field Type	Field Width
ID	Photo point autogenerated ID	dbLong	4
Location_ID	Reference to location of photo point (FK)	dbLong	4
SurveyPt_ID	Photo point surveyed point identifier (FK)	dbLong	4
PhotosPerPoint	Number of photographs taken per photo point location	dbInteger	2

Table Name: Priority
Description: Task priorities

Field Name	Field Description	Field Type	Field Width
ID	Priority autogenerated ID (PK)	dbLong	4
Priority	Item priority	dbText	15
Icon	Priority icon file name	dbText	255
Sequence	Status numeric value	dbInteger	2

Table Name: ProtectedStatus
Description: Lookup table of protected status values

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated identifier (PK)	dbLong	4
Code	Protected status code (LP, OP, NP)	dbText	2
Name	Protected status name (Legally Protected, Operationally Protected, Not Protected)	dbText	25
Description	Protected status description	dbMemo	0

Table Name: SensitiveLocations
Description: Holds list of locations identified as sensitive on a per park basis

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated identifier (PK)	dbLong	4
Park_ID	Park ID FK	dbLong	4
Location_ID	Location identifier (FK Location)	dbLong	4
CreateDate	Date/time record created	dbDate	8
CreatedBy_ID	Contact ID (FK) for person who created record	dbInteger	2
LastModified	Date/time record last modified	dbDate	8
ModifiedBy_ID	Contact ID (FK) for person who modified record	dbInteger	2

Table Name: SensitiveSpecies
Description: Holds list of species identified as sensitive on a per park basis

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated identifier (PK)	dbLong	4

Field Name	Field Description	Field Type	Field Width
Park_ID	Park ID FK	dbLong	4
Master_PLANT_Code	tlu_NCPN_Plants Master PLANT Code FK	dbText	20
CreateDate	Date/time record created	dbDate	8
CreatedBy_ID	Contact ID (FK) for person who created record	dbInteger	2
LastModified	Date/time record last modified	dbDate	8
ModifiedBy_ID	Contact ID (FK) for person who modified record	dbInteger	2

Table Name: Status
Description: Task status

Field Name	Field Description	Field Type	Field Width
ID	Status autogenerated ID (PK)	dbLong	4
Status	Item status description	dbText	15
Icon	Status icon file name	dbText	255
Sequence	Numeric status	dbInteger	2

Table Name: tlu_NCPN_Plants
Description: Contains all NCPN master plant species

Field Name	Field Description	Field Type	Field Width
Master_Family	Master family	dbText	50
Master_PLANT_Code	Master species code; primary key (USDA PLANTS Database)	dbText	20
Master_Species	Master species name (Integrated Taxonomic Information System)	dbText	50
UT_Family	Utah family	dbText	50
CO_Family	Colorado family	dbText	50
WY_Family	Wyoming family	dbText	50
Utah_PLANT_Code	Utah species PLANTS code	dbText	20
Utah_Species	Utah species name (Welsh et al 2003)	dbText	50
Co_PLANT_Code	Colorado species PLANTS code	dbText	20
Co_Species	Colorado species name (Weber & Wittmann 2001)	dbText	50
Wy_PLANT_code	Wyoming species PLANTS code	dbText	20
Wy_Species	Wyoming species name (Dorn 2001)	dbText	50
Add_Synonyms	Additional synonyms	dbMemo	0
Taxonomic_Notes	Taxonomic notes	dbMemo	0
Master_Common_Name	Master common name	dbText	50
ARCH	Park presence descriptor for ARCH	dbText	15
BLCA	Park presence descriptor for BLCA	dbText	15
BRCA	Park presence descriptor for BRCA	dbText	15
CANY	Park presence descriptor for CANY	dbText	15
CARE	Park presence descriptor for CARE	dbText	15
CEBR	Park presence descriptor for CEBR	dbText	15
COLM	Park presence descriptor for COLM	dbText	15
CURE	Park presence descriptor for CURE	dbText	15
DINO (UT)	Park presence descriptor for DINO - Utah	dbText	15
DINO (CO)	Park presence descriptor for DINO - Colorado	dbText	15
FOBU	Park presence descriptor for FOBU	dbText	15
GOSP	Park presence descriptor for GOSP	dbText	15
HOVE (UT)	Park presence descriptor for HOVE - Utah	dbText	15

Field Name	Field Description	Field Type	Field Width
HOVE (CO)	Park presence descriptor for HOVE - Colorado	dbText	15
NABR	Park presence descriptor for NABR	dbText	15
PISP	Park presence descriptor for PISP	dbText	15
TICA	Park presence descriptor for TICA	dbText	15
ZION	Park presence descriptor for ZION	dbText	15
Lifeform	Lifeform derived from USDA PLANTS	dbText	255
Duration	Duration derived from USDA PLANTS	dbText	255
Nativity	Nativity derived from USDA PLANTS	dbText	255
Trinomial	True if species code represents a trinomial name	dbBoolean	1
Unique_Species	True if species code represents a genus and species designation	dbBoolean	1
New_Record	Is it a new record?	dbBoolean	1
LU_Code	Shorthand (a.k.a. 6-letter) lookup code	dbText	25
Wetland_Code	Code identifying wetland designation (see http://plants.usda.gov/wetinfo.html#categories)	dbText	20
Wetland_Code_Info_Source	Information source used to determine wetland classification	dbText	50
Photosynthetic_Pathway	Photosynthetic pathway designation (source: Osborne et al. 2014, doi: 10.1111/nph.12942)	dbText	5
ProtectedStatusID	Protected status assigned to plant (FK to ProtectedStatus table)	dbLong	4
ProtectedStatusNotes	Notes about protected status designation	dbText	255

Metadata Tables

Table Name: Protocol
Description: Protocol attributes including version, effective and document retirement date

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated PK	dbLong	4
ProtocolName	Name of protocol	dbText	100
Version	Protocol version	dbText	100
EffectiveDate	First date version applies for the protocol	dbDate	8
RetireDate	Date version no longer applies for the protocol	dbDate	8
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Table Name: SOP
Description: SOP attributes including version, effective and document retirement date.

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated PK	dbLong	4
FullName	Full name of Standard Operating Procedure (SOP)	dbText	100
Code	SOP abbreviation	dbText	20
SOPNumber	SOP numeric identifier	dbInteger	2

Field Name	Field Description	Field Type	Field Width
Version	SOP version (#.## format)	dbDouble	8
EffectiveDate	First date version applies for the protocol	dbDate	8
RetireDate	Date version no longer applies for the protocol	dbDate	8
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Application Tables

Table Name: Access
Description: Lookup table for application user access levels

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated access level identifier (PK)	dbLong	4
AccessLevel	Access level (admin, power user, data entry, read only)	dbText	15

Table Name: AppEnum
Description: Application enumerations for user interface

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated enum type (PK)	dbLong	4
EnumType	Category enum belongs to	dbText	25
Label	Enum text	dbText	255
Summary	Description of enum (if text)	dbText	255
Sequence	Order of display	dbInteger	2

Table Name: AppReport
Description: Includes reports within application for listing

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated	dbLong	4
DisplayName	Display name of report	dbText	25
ReportName	Name of report to open	dbText	25
FormatIcon	Icons to display for report best formats (uDocument, uPDF, etc.)	dbText	50
Sequence	Display order	dbInteger	2

Table Name: Icon
Description: Application icons and images embedded within the application

Field Name	Field Description	Field Type	Field Width
ID	Autonumber identifier (PK)	dbLong	4
IconID	Icon ID (FK)	dbInteger	2
Icon	Graphic file (icon) for use in Access database	dbLongBinary	0

Table Name: ImportedData
Description: Lists instances of CSV imported data, identifying source file, destination table and records imported

Field Name	Field Description	Field Type	Field Width
ID	Unique identifier for the import (PK)	dbLong	4
ImportDate	Timestamp of when the import was accomplished	dbDate	8

Field Name	Field Description	Field Type	Field Width
SourceFile	CSV file data is being imported from	dbText	50
DestinationTable	Name of table that data is being imported to	dbText	25
NumberOfRecordsImported	Total number of records imported	dbInteger	2
StartRecord_ID	ID of the first record imported (FK)	dbInteger	2
EndRecord_ID	ID of the last record imported (FK)	dbInteger	2

Table Name: tsys_App_Defaults
Description: Application table - Manages the application defaults

Field Name	Field Description	Field Type	Field Width
ID	Default unique ID (PK)	dbLong	4
Project	Default project code	dbText	50
Release_ID	Database release version of the report	dbLong	4
DataTimeframe	Field season year or range of dates for the current data set (used to populate the quality assurance table)	dbText	30
UserName	Current user	dbText	50
Park	Default park	dbText	50
BackupPromptOnStartup	Prompt user for backups on application startup (0 - true, 1-false)	dbByte	1
BackupPromptOnExit	Prompt user for backups on application exit (0 - true, 1-false)	dbByte	1
CompactBEOnExit	Prompt user for compact the back-end db on application exit (0 - true, 1 - false)	dbByte	1
VerifyLinksOnStartup	Verify table connections on application startup (0 - true, 1 - false)	dbByte	1
WebURL	Web address for application downloads	dbText	200
AppContactName	Application developer contact name	dbText	50
AppContactOrg	Contact organization for the application	dbText	50
AppContactPhone	Contact phone number for the application	dbText	50
AppContactEmail	Contact email for the application	dbText	50

Table Name: tsys_App_Releases
Description: Application table - Application release history

Field Name	Field Description	Field Type	Field Width
ID	Release unique ID (PK)	dbLong	4
ReleaseDate	Date of the release	dbDate	8
DatabaseTitle	Title of the database	dbText	100
VersionNumber	Version control number	dbText	20
FileName	Filename, used to identify older versions of the database	dbText	50
ReleaseBy_ID	Contact ID of person issuing release (FK)	dbLong	4
ReleaseBy	Person who issued the release	dbText	50
ReleaseNotes	Release notes, which may include a summary of revisions	Memo	0
IsSupported	Indicates the support level of this release: 0=user must use a newer version; 1=supported but newer available; 2=full support, current version	dbByte	1

Table Name: tsys_BE_Updates
Description: Application table - Database release updates that need to be reflected in remote back-end copies upon connecting

Field Name	Field Description	Field Type	Field Width

Field Name	Field Description	Field Type	Field Width
ID	Unique identifier for the update record (PK)	dbText	50
IsDone	Indicates whether the update has already been run	dbBoolean	1
RunDate	Date and time that the update statement was run	dbDate	8
SQLStatement	SQL statement for the update record	Memo	0
UpdateDesc	Text description of the update	dbText	100

Table Name: tsys_Datasheet_Defaults
Description: Datasheet settings to determine number of rows to list species and number for blanks

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated ID number (PK)	dbLong	4
Park_ID	Park identifier (FK)	dbLong	4
River_ID	River segment identifier (FK)	dbLong	4
CoverType	Vegetative cover type (ARC = all rooted cover, WCC = woody canopy cover, URC = understory rooted cover)	dbText	3
SpeciesRows	Number of species to list on vegplot datasheets for this cover type	dbInteger	2
BlankRows	Number of blank rows to include on vegplot datasheets for this cover type	dbInteger	2

Table Name: tsys_Db_Templates
Description: Application table - Database templates (primarily SQL queries)

Field Name	Field Description	Field Type	Field Width
ID	Autogenerated unique ID (PK)	dbLong	4
Version	Template version	dbDouble	8
IsSupported	Indicates the support level of this release: 0=user must use a newer version; 1=supported but newer available; 2=full support, current version	dbInteger	2
Context	Where template is used (prefixes: qa_ = QA/QC, qsys_ = system, s_ = select, u_ = update, i_ = insert, d_ = delete)	dbText	255
Syntax	Syntax/language compatibility, identifies if template can be used for only Access, SQL Server, or other (JET=MS Access only, T-SQL = MS SQL Server only, SQL=both JET/MS Access & SQL Server, etc.)	dbText	10
TemplateName	User readable name	dbText	255
Params	| delimited parameters list (!param1:datatype1|param2:datatype2), ! = required parameter	dbText	255
Template	SQL (or other)	Memo	0
Remarks	Brief comments @ template	dbText	255
EffectiveDate	Date template is used (effective)	dbDate	8
RetireDate	Date template is no longer in use (retired)	dbDate	8
CreateDate	Date record created	dbDate	8
CreatedBy_ID	Contact ID for record creator	dbLong	4
LastModified	Date record last modified	dbDate	8
LastModifiedBy_ID	Contact ID for record modifier	dbLong	4

Table Name: tsys_Link_Dbs
Description: Application table - Linked back-end databases

Field Name	Field Description	Field Type	Field Width

Field Name	Field Description	Field Type	Field Width
LinkType	Back-end database type	dbText	255
LinkDb	Linked database name (no path)	dbText	100
DbDesc	Brief description of the type of database - e.g., data tables, lookup tables, systems tables, etc.	dbText	50
Backups	Indicates whether this back-end gets backed up by user-initiated front-end backups	dbByte	1
IsODBC	Indicates whether this back-end is linked through ODBC (e.g., SQL Server)	dbByte	1
IsNetworkDb	Indicates whether this back-end is remote (a network file)	dbByte	1
FilePath	Full path to back-end file (for Access back-ends)	dbText	255
Server	Server name (for ODBC links)	dbText	100
NewDb	Temporarily stores the new database name when updating connections	dbText	100
NewPath	Temporarily stores the new file path when updating connections	dbText	255
NewServer	Temporarily stores the new server name when updating connections	dbText	100
SortOrder	Display sort order	dbInteger	2

Table Name: tsys_Link_Files
Description: Application table - Name and path of back-end databases

Field Name	Field Description	Field Type	Field Width
Link_type	Back-end database type	dbText	50
Link_file_name	Back-end file name (no path)	dbText	100
Link_file_path	Full path to back-end file	dbText	255
Link_description	Describes the types of data tables included in the link	dbText	255
New_file_name	Temporarily stores the new file name when updating connections	dbText	100
New_file_path	Temporarily stores the new file path when updating connections	dbText	255

Table Name: tsys_Link_Tables
Description: Application table - Tables linked from back-end databases

Field Name	Field Description	Field Type	Field Width
LinkType	Link type - indicates the back-end database it is connected to	dbText	50
LinkTable	Table name	dbText	100
LinkDb	Linked database name	dbText	100
TableType	Type of table (e.g., project table, standard table, etc.)	dbText	50
DescriptionText	Table description	dbText	255
IsHidden	Should table be hidden in database view? (0 - false, 1 - true)	dbByte	1
AllowEditsLookup	Should table be available for user edits in lookup browser? (0 - false, 1 - true)	dbByte	1
BrowserView	Should table be available for viewing with data browser? (0 - false, 1 - true)	dbByte	1
Is_hidden	Indicates whether the table should be hidden in database view	dbBoolean	1
Allow_edits_lookup	Indicates whether the table should be available for user edits in the lookup browser	dbBoolean	1

Field Name	Field Description	Field Type	Field Width
Browser_view	Indicates whether the table is available for viewing with the data browser	dbBoolean	1
SortOrder	Sort order for table listings	dbByte	1

Table Name: tsys_Logins
Description: Application table - Log of user access to the database through the front-end

Field Name	Field Description	Field Type	Field Width
TimeStamp	Time stamp of activity record	dbDate	8
UserName	Login name of the user	dbText	50
ActionTaken	Action taken by the user	dbText	50
ReleaseNumber	Application version (1.0.0, etc.)	dbText	20
AccessLevel	Access level when action taken	dbText	25

Table Name: USysRibbons
Description: Handles custom ribbon menus

Field Name	Field Description	Field Type	Field Width
RibbonName	Custom ribbon name to be associated with this customization	dbText	255
RibbonXML	Ribbon Extensibility XML (RibbonX) that defines the ribbon customization	Memo	0

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

Standard Operating Procedure (SOP) #12

Data Analysis and Reporting

Version 1.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	2/18	D. Perkins	Editorial	Peer review comments	1.01

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 or site 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 or site, and sub-samples recorded on plots must be scaled to this level. Vegetation and geomorphology data may be integrated at the transect level, flow level (flow at which the plot inundated), or geomorphic surface (active channel, active floodplain, etc.). Summary queries should be created in Access to expedite this process.

Vegetation Summaries

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.

Vegetation Community Indices
Data from the 1-m plots are used to calculate several community indices and metrics, such as species richness all, native and exotic species, unique species encountered, species composition, species guilds, community types, evenness, and diversity indices.

Geomorphology Summaries

After 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
Changes in channel cross sections (BLCA and CANY), changes in overall erosion/accretion rates (DINO) will be calculated for the feature using data from the geomorphology survey transects. Changes in sediment size will be calculated from vegetation plot data.

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 indicators of active channel, active floodplain, and inactive floodplain plant cover by surface elevation and species richness and percent cover by geomorphic surface and flow elevation. Changes in the portions of the feature that are active channel, active floodplain, and inactive floodplain can be followed over time

Inundation duration of the floodplain/active channel (% 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.

We will also seek to incorporate sediment transport data collected by Grand Canyon Monitoring and Research Center (USGS) in DINO and CANY. With these data we can develop correlations between sediment load, number of storms that exceed a particular sediment concentrations, duration of time where a certain concentration was exceeded, vs changes in channel/floodplain attributes. These data are available at https://www.gcmrc.gov/discharge_qw_sediment/.

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.*)

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

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 Reporting

Annual Briefs

Each year, information from 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.

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.

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 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 an estimate measure of the intercept and slope along with the uncertainty of this estimate, the significance of the slope 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 2).

Table 2. 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

Burnham, K. P. and D. R. Anderson. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, NY

Gelman, A., J. B. Carlin, H. S. Stern, and D. B. Rubin. 2000. Bayesian Data Analysis. Chapman & Hall/CRC, New York.

Larsen, D. P., N. S. Urquhart, and D. L. Kugler. 1995. Regional scale trend monitoring of indicators of trophic condition of lakes. Water Resources Bulletin, 31:117-140.

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Pugesek, B. H., A. Tomer, and A. von Eye. 2003. Structural equation modeling. Cambridge University Press, Cambridge, UK.

Van Bruggen, A. H. C. and P. A. Arneson. 1986. Path coefficient analysis of effects of *Rhizoctonia solani* on growth and development of dry beans. Phytopathology, 76:874-878.

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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 1.07 (January 2018)

Revision History Log

Previous 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
1.02	1/1/2014	H. Thomas	Updated master version table.	To reflect new versions of SOPs.	1.03
1.03	1/1/2015	H. Thomas	Updated master version table.	To reflect new versions of SOPs.	1.04
1.04	1/1/2016	H. Thomas	Updated master version table.	To reflect new versions of SOPs.	1.05
1.05	1/1/2017	H. Thomas	Updated master version table.	To reflect new versions of narrative and SOPs.	1.06
1.06	1/1/2018	H. Thomas	Updated master version table.	To reflect new versions of narrative and SOPs.	1.07

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.

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	-	-	-	-	-	-	-	-	-	-
1/1/2014	-	1.01	1.00	-	-	-	-	-	1.00	1.00	1.00	-	1.00	1.03	-	2.00	-	-	-	-	-	2.00	2.01	2.00	-	-	-	-	-	-
1/1/2015	-	-	1.00	-	-	-	-	1.00	1.00	1.00	1.00	-	1.00	1.04	-	2.00	-	-	-	-	-	2.01	2.10	-	1.01	1.00	1.00	2.10	2.11	1.00
1/1/2016	-	1.02	1.01	1.02	3.00	3.00	3.00	1.01	1.00	1.01	1.00	-	1.00	1.05	1.01	2.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1/1/2017	1.00	1.03	1.01	1.02	3.00	3.00	3.10	1.01	1.00	1.01	1.00	1.00	1.00	1.06	1.01	2.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-
1/1/2018	1.01	1.03	1.01	1.02	3.01	3.01	3.21	1.02	1.01	1.01	1.00	1.01	1.01	1.07	1.02	2.01	1.00	1.01	1.01	-	-	-	-	-	-	-	-	-	-	-

References

Northern Colorado Plateau Network (NCPN). 2009. Protocol versioning guidance document, version 1.0. National Park Service, Inventory and Monitoring Program, Northern Colorado Plateau Network, Moab, UT.

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

Standard Operating Procedure (SOP) #14

Facies Mapping and Grain-Size Distribution (DINO)

Version 1.02 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	12/17/15	D. Perkins	Minor wordsmithing and renumbering	Clarity, new SOP numbers	1.01
1.01	2/2018	D. Perkins	Editorial	Peer review comments	1.02

This SOP describes the methods for facies mapping and grain size distribution sampling at sentinel sites in Dinosaur National Monument. It covers the years from 2013 to present. Facies is defined as "the character of a rock expressed by its formation, composition, and fossil content." Facies mapping takes place on each sentinel site along with measuring grain size distributions at each facie and is recorded either on the iPad or on the *Facies Mapping and Grain Size Distribution* paper data sheet (Appendix 1).

1.0 Facies Mapping

A. Facies mapping should be done towards the end of the sentinel site visit. After completing the vegetation work, a 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. All data is recorded in the description field for the mapped facie on the iPad. At each facie:

1. 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….

2. How is the facie vegetated (bare to sparse <5%, sparse 5-25%, becoming vegetated 26-50%, vegetated >50%)?
3. Are there wake or shadow deposits downstream of sparse individual plants or stands?
    i. Are the wake or shadow deposit sedimentologically different than the rest of the facie?
    ii. Are ridges forming (>30 cm) in wake/shadow deposits?
4. Is there any large woody debris?
    iii. Are wake or shadow deposits associated with these?
    iv. Are the wake or shadow deposit sedimentologically different than the rest of the facie?
    v. Are ridges forming (>30 cm) in wake/shadow deposits?
5. Is there any fine woody debris?

B. If wake or shadow deposits are sparse (<5) and have a different grain size distribution than surroundings, consider mapping as an individual facie.

C. Take Photosynth from center of facie (see section 4.4).

2.0 Grain Size Distributions

Grain size distributions do not need to be taken every year, but should be done a minimum of once every 3 years or if a state change is observed (event-driven sampling), for example a cobble bar is now covered with sand. In other years, it can be done time permitting. 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 on the *Facies Mapping and Grain Size Distribution* data sheet.

A. Draw a sketch of the facies on the feature and label each facies. This sketch will correspond with the way the facies were mapped on the iPad.

B. Surface Grain Size Distribution
    1. 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 will be needed.
    2. 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.
    3. 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.
    4. 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.

5. Any remaining material should be in the bottom bucket and is finer than 2 mm.
6. Weigh all buckets. Be sure to account for weight of sieves. Record weights on data sheet.
7. Take photo of sample location.

C. 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.

Appendix 1. Data Sheet

Data entered by: Data proofed by:

Facies Mapping & Grain Size Distribution

DINO-Site: **Date:** **Observer:** **Recorder:**

Facies #	Location	Photo	Weight (kg)			
			>64 mm	16-64 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) #15

Non-Survey Field Methods (CURE)

Version 2.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	6/5/2014	D. Perkins	Major change in numbering of SOPs and in field methods. Methods used previously (2012) are in SOP #101 (retired).	Clarity and simplicity in the field for crew; previous methods did not work well.	2.00
2.00	2/2018	D. Perkins	Editorial	Peer review comments	2.01

This SOP describes the methods for conducting monitoring at Curecanti National Recreation Area from 2014 to present. A list of necessary equipment for these procedures can be found in SOP #1.

1. Measuring Vegetation

1.1 Sentinel Site Establishment

Record directions to the transects

Write directions to the transect and include sufficient detail for someone who has never been there to relocate it. Begin with road travel from a designated location (such as Neversink Parking Area, Cooper Ranch West Parking Area) 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).

1.2 Vegetation and Geomorphology Transects

Ten vegetation transects were randomly placed and are established and surveyed exclusively using GPS units. NCPN sampling will be done along transects that span the entire riparian bottom. Dominant geomorphic and vegetation types will be recorded along the entire transect using GPS. These transects have been pre-determined and will be programmed into GPS units (Figure 1).

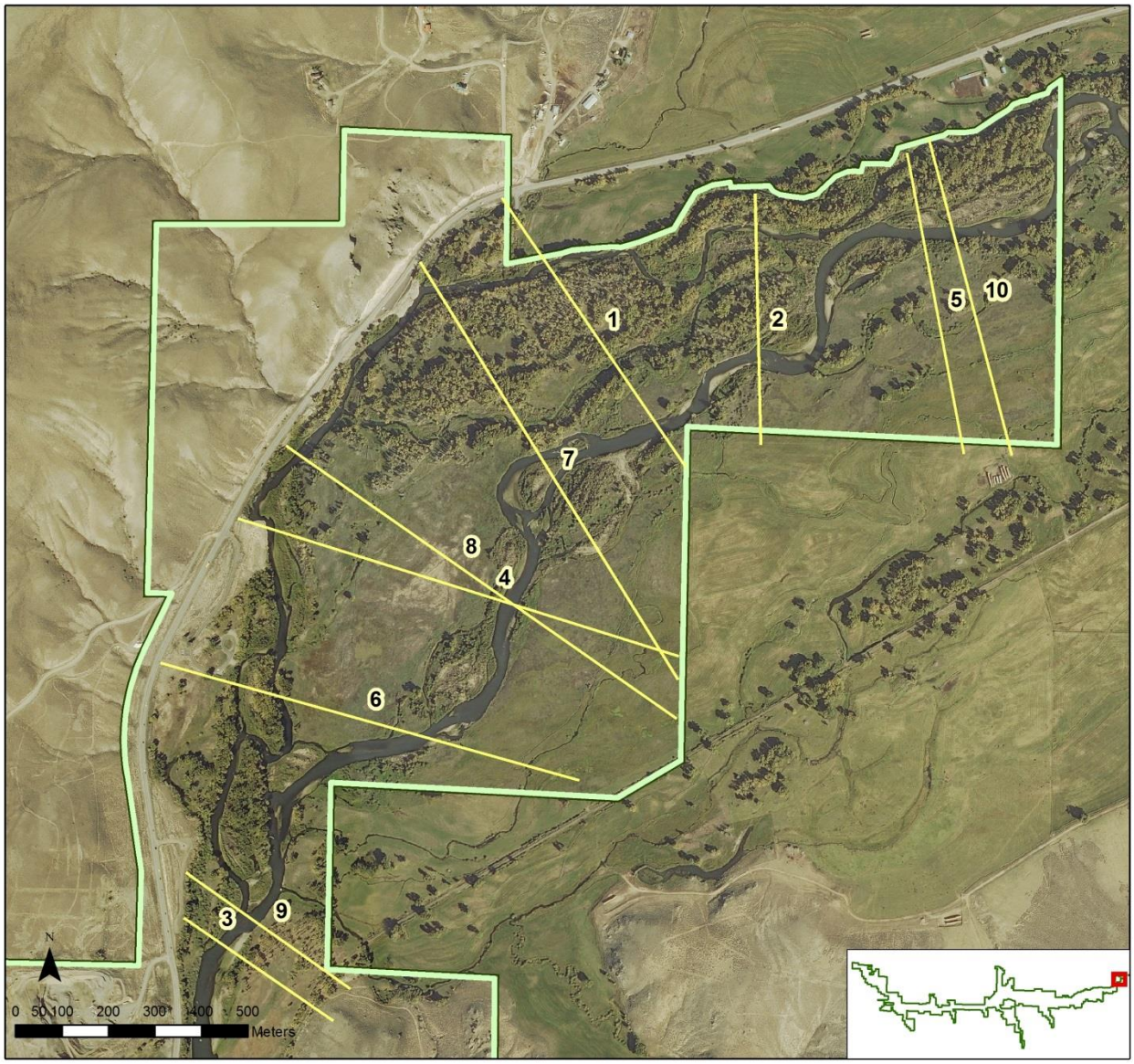


Figure 1. Transects established at Curecanti NRA.

A. While walking along the transect the observer will record breaks in vegetation, cottonwood size classes, and geomorphology (see below) (Figure 2). The data dictionary will consist of marking the transition zones between each geomorphic surface.
B. The observer will walk the transects with a GPS beginning at one edge of the transect. Transition zones of the following geomorphic types (Appendix 1) will be recorded as points:
    a. Water's edge

b. Active channel - unvegetated channel/Active flood plain transition. The active channel area that is flooded every 1-2 years. Usually with very low vegetation cover. The active flood plain can be noted by the presence of indicator species can be used to mark this line (*Elymus* spp., *Populus angustifolia, Phalaris arundinacea, Salix* spp. *Alnus* spp.). This area is flooded every 2-15 years and is dominated by species that can withstand flooding. Vegetation cover is usually more than 40% and sediment is dominated by fines.
c. Active flood plain/Inactive flood plain transition. The inactive floodplain can be noted by the presence of indicator species (*Conyza canadensis, Distichlis spicata, Pascopyrum smithii*). This area is rarely flooded, usually every 15-25 years and often looks like an alluvial terrace.
d. Inactive flood plain/Uplands transition. Uplands can be noted by the change in vegetation and lack of flood indicators (i.e. driftwood, fluvial deposits, cut banks).
e. Abandoned meander or dry water channel
f. If there are areas where an abrupt transition (i.e. between active channel and active floodplain) is not evident (the transition area occurs over a larger area), place the point in the middle of this transition area.

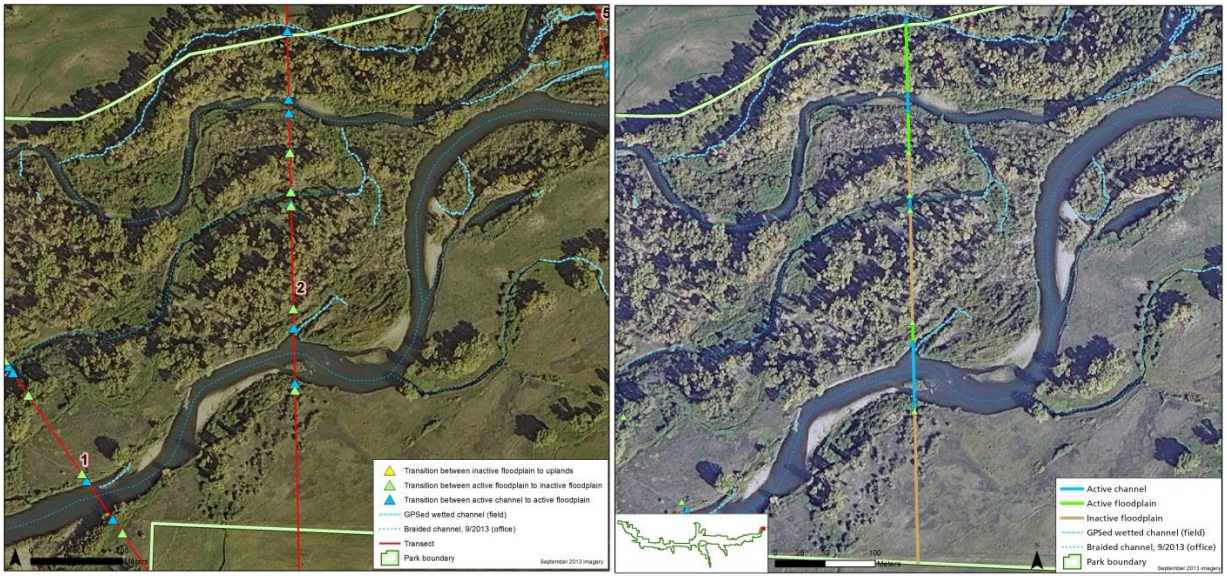


Figure 2. On the left is how geomorphic surfaces are recorded in the field, on the right is the result with the delineations of the geomorphic surfaces.

C. The observer will also record start and stop locations of size classes of narrow-leaf cottonwood (*Populus angustifolia*) (Figure 3). Observers are looking for cohorts in these size classes, not individual trees. Seedlings and saplings arising from beaver-browsed stumps do not count, but if beaver browsing results in any poles, these do count. Only live trees are counted.
    a. Seedlings (<0.25 m in height). There must be at least 5 seedlings within a 10m x 10 m area to mark this as a start of seedlings. This area includes 5m either side of this person while standing on the transect and 10 m in front of them. It is constantly moving with the observer. So if there is >10m without at least 5 seedlings, this is considered a gap and a stop point is established. For seedlings a

density measure is applied to the area that is in between the start and stop: "low" is 1-25 individuals/sq m; "medium" is 26-100 individuals/sq m; and "high" is >100 individuals/sq m.

b. Saplings (0.25 m to 1.37 m in height or <10 cm DBH). The same density rules for starting and stopping seedlings apply to saplings.
c. Poles (>1.37 m and 10 to 20 cm DBH). Poles are marked when the canopy crossed a transect line. We would imagine a bird's eye view and stand directly below the canopy edge on the transect to mark the point. In order to record a stop, there must be a gap of 25 m. Canopy is started if there is canopy within 5 m of the transect.
d. Mature cottonwoods (>20 cm DBH). Mature cottonwoods are marked the same as poles.

The above categories are not exclusive, so more than one size class can be recorded at the same point along a transect.

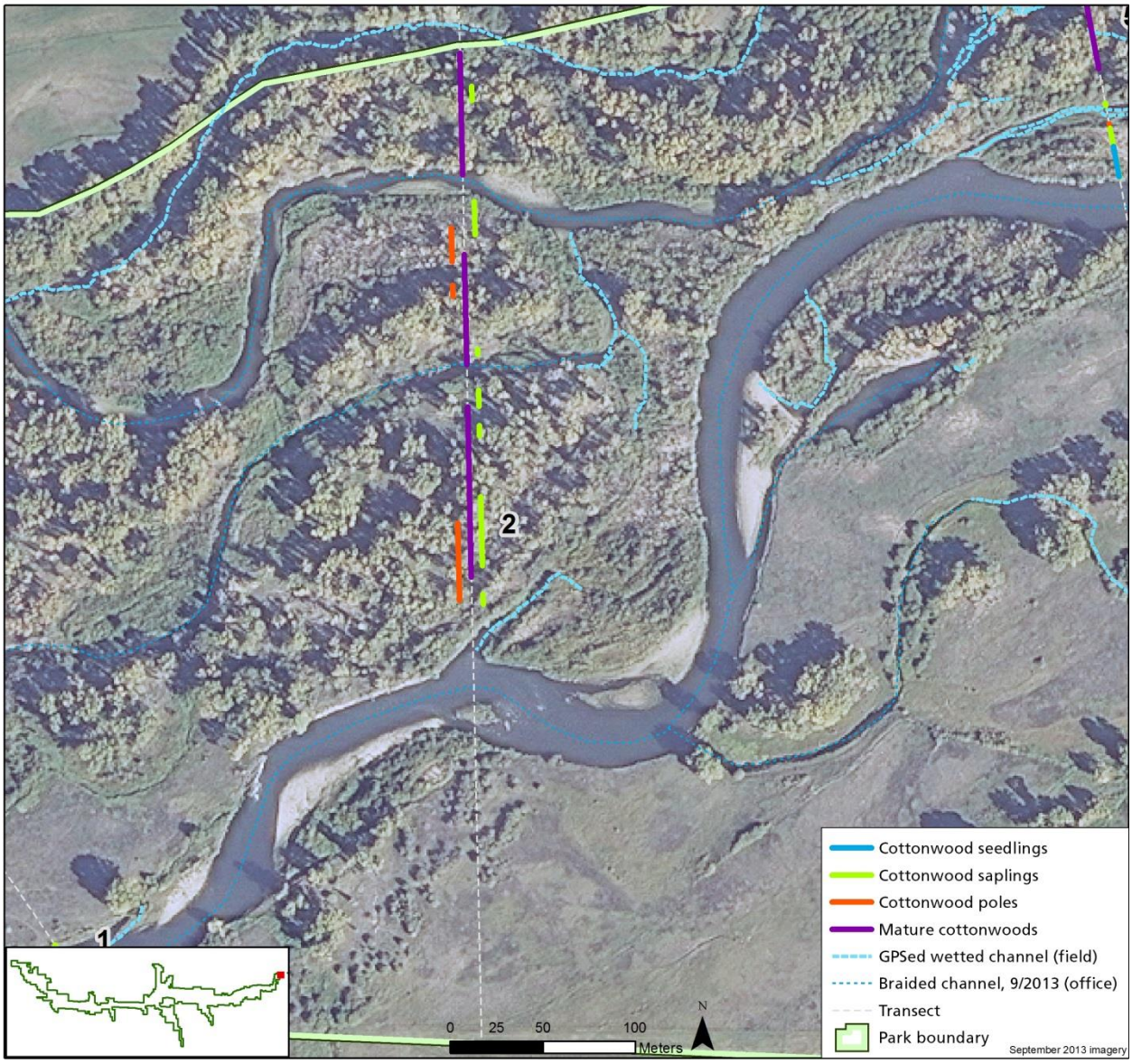


Figure 3. Results of cottonwood size class sampling along transect 2 at Curecanti NRA.

1.3 Wetted Channel Location

Prior to the field vist, the wetted channel will be delineated using the most recent imagery or the most recent visit. This will be loaded onto GPS units, iPads and hard copy aerial maps. Crew members will verify the current channels or make note with GPS where there current wetted channel does not match the pre-determined line either by drying up or where an avulsion has occurred. When the wetted channels are reduced to damp mud depressions with lots of vegetation, note that it is "not wetted". Intermittent wetted areas along the channel can also be marked. If the area remains wetted and matches the data loaded onto GPS and hard copy maps, nothing needs to be noted.

2. Photographs

2.1 Overview Photographs

These photographs are taken from above the feature.

A. The observer selects points where the large portions of the study area can be seen from one picture. The best place for this to occur will be on NPS land north and west of Highway 50. Multiple locations may be necessary to capture the monitoring site.

B. Take photograph and GPS photograph location for repeat visits.

C. Take reference photographs (see section 2.2 below) of the location where the photographer was located.

D. Repeat visits. Print out the overall feature photographs as well as the reference photographs that showed the location of the photographer. Use the GPS and reference photographs to get to the location.

E. Use the previous year's photograph to center the photograph on the same place. When possible the same time of day is desired.

2.2 Transect photographs

A. Transect photographs are taken along the transects at any river channels, abandoned meanders, secondary channels, or anywhere else we found had a high density of seedlings/saplings. At each point, 4 photographs are taken. A chalkboard is included in in the photograph (usually someone has to hold the chalkboard to make it visible). Chalkboard is labeled with CURE/T#-PP#/direction/date.

B. The photograph directions are based on the transect line. Upstream (US)/downstream (DS) is perpendicular from the transect line and river right (RR)/river left (RL) is in line with the transect. The direction on the chalkboard also relates to where the photographer was standing and facing (e.g., US ->DS means that photographer was standing on the transect line and facing downstream, RR -> RL means that the photographer was facing river left). Most of the photographs are portrait orientation. Occasionally, a photograph was taken slightly off the transect line in order to better capture a feature.

C. GPS the photograph location.

D. Repeat visits. Print out the overall feature photographs as well as the reference photographs that showed the location of the photographer. Use the GPS with pre-loaded points and reference photographs to get to the location.

E. Use the previous year's photograph to center the photograph on the same place. When possible the same time of day is desired.

2.3 Reference Photographs

Take reference photographs to document locations of 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.

A. 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), and date.

B. Place the chalkboard in a location where it will be easy to read in the photograph.

C. 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 photograph. Unlike repeat photographs, you may include anything in reference photographs that may assist with re-locating the point (i.e., crew members, bright-colored flagging, etc.).

D. Take a photograph and check the quality. If the photograph is blurry or otherwise not acceptable, delete it and take another one.

E. Record the subject, direction (facing), digital file name, photographer, and any comments on the Reference Photographs data sheet (Appendix 2).

2.4 Other Photographs

Crew members are encouraged to take other photographs to document specific aspects of a reach or to provide scenic or fieldwork photographs for publications or social media. This information can be filled out on the bottom of the Photograph data sheets.

A. Fill in the type of photograph: Animals, Plants, Cultural, Scenic, Disturbance, Weather, Field Work, other.

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

Appendix 1. Big Rivers Data Dictionary for Curecanti National Recreation Area

Observer Feature – This feature identifies who the observer is for the transect. An Observer point should be taken at the beginning of a transect or when the observer and recorder switch positions.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Observer	• NCPN field crew name • NCPN field crew name • Other	Entry permitted in the field	Menu
Comment	Any comments regarding the observer.	Entry permitted in the field	Text – Optional
WaterEdge Feature (Water's edge) - This feature maps the start and stop of the water's edge.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu
Comment	Any comments/notes regarding this transducer	Entry permitted in the field	Text – Optional
AFP_AC Feature (Active floodplain/Active channel) - This feature maps the boundary of inactive vs active floodplain zone (or vice versa)			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Comments about the AFP_AC transition point	Entry permitted in the field	Text – Optional
Notes	Any comments/notes regarding this point	Entry permitted in the field	Text – Optional
IFP_AFP (Inactive floodplain/active fp) Feature – This feature maps the boundary of the transition between inactive and active floodplain (or vice versa)			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Comments about the IFP_AFP transition point	Entry permitted in the field	Text – Optional
Notes	Any additional notes about the transition point	Entry permitted in the field	Text – Optional
IFP_Upland (Inactive floodplain/uplands) Feature – This feature maps the transition zone between inactive floodplain and upland zone. (or vice versa)			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the route feature	Entry permitted in the field	Text – Optional
DryChannel (Dry water channel (Abandoned meander) – This feature maps the start and stop when a dry channel bed is crossed by the transect. GPS both a start and stop for this feature.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu
Comment	Any comments about the start or stop of the dry channel point.	Entry permitted in the field	Text – Optional
SeedlingCottonwood (Seedlings(<.25m in height)) - This feature maps the start and stop of a population of seedling cottonwoods.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu

Comment	Any comments about the start or stop of the cottonwood seedling population.	Entry permitted in the field	Text – Optional
SaplingCottonwood (Sapling(.25 – 1.37m in height or <5cm DBH)) - This feature maps the start and stop of a population of sapling cottonwoods.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu
Comment	Any comments about the start or stop of the cottonwood sapling population.	Entry permitted in the field	Text – Optional
PolesCottonwood (Sapling(>1.37m in height, 5-25cm DBH)) - This feature maps the start and stop of a population of pole cottonwoods.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu
Comment	Any comments about the start or stop of the cottonwood pole population.	Entry permitted in the field	Text – Optional
MatureCottonwood (Mature (>25cm DBH)) - This feature maps the start and stop of a population of mature cottonwoods.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu
Comment	Any comments about the start or stop of the cottonwood mature population.	Entry permitted in the field	Text – Optional
ReedCanaryGrass (Phalair arundinacea) - This feature maps the start and stop of a population of mature cottonwoods.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
StartStop	• Start • Stop	Entry permitted in the field	Menu
Comment	Any comments about the start or stop of the cottonwood mature population.	Entry permitted in the field	Text – Optional
PhotoPt - This feature maps the locations where photographs were taken along the transects and site overview photographs.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
PhotoNum	Unique photograph number. Transect # - Photograph number (example: T3-PP2)	Entry permitted in the field	Text – Optional
PhotoType	• Transect photograph • Overview photograph • Reference photograph • Other	Entry permitted in the field	Menu
Comment	Any comments about the photograph location	Entry permitted in the field	Text – Optional
Notes	Any other addition notes about the photograph location	Entry permitted in the field	Text – Optional
Other – This feature can be used to map any incidental observations.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comment	Any comments about the photograph location	Entry permitted in the field	Text – Optional

Notes	Any other addition notes about the photograph location	Entry permitted in the field	Text – Optional
WettedChannel (wetted channel) – This line feature is to be used to map channels containing water that are not already displayed on the GPS unit.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Not Wetted	Channel is no longer wetted	Not wetted	Text – Optional
Comments	Comments about the channel line	Entry permitted in the field	Text – Optional
Route – This line feature is to be used to map routes to/from a site that would aide future field crews through the easiest path. Generally, GPS this on the way back.			
Attributes	**Attribute Explanation**	**Entry**	**Type**
Comments	Comments about the route	Entry permitted in the field	Text – Optional

Appendix 2. Data Sheets

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

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) #16

Trimble RTK Basic Operating Instructions in the Field

Version 1.00 (April 2017)

Revision History Log:

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

1 Overview of Trimble GNSS survey system

This document describes setup and operation of the Trimble R6 GNSS survey system used by Northern Colorado Plateau Network (NCPN). The equipment is configured for single-base radio-broadcast RTK method.

This system depends on using a coordinated point for setting up the base receiver.

- If you are starting a new survey at a new site and have no known coordinated points then you need to first select a base station location. See *Base Station Selection (section 1.2)*.
- If you are re-surveying a known site then you may need to find the base point using the controller as a hand-held personal GPS device. See *Using the controller as a "stand-alone" GPS device (section 2.5)*.

1.1 The Gear: Trimble R6 Model-4 system using one rover.

The equipment shown is configured primarily for a single base radio broadcast RTK survey method with one rover, however, additional rovers may be used as equipment and personnel allow. Figure 1 provides a general idea of what a minimal setup might look like when packed for transport. We often have an additional Pelican case and base battery as well as an additional solar charger setup to charge spare batteries, computers, I-pad, etc. at camp. This is the minimal setup we use for an RTK system using one rover. Typically, we are in remote areas in difficult terrain making a return trip to the base for any reason during a survey, other than to turn it on or off, very time consuming and inefficient. We minimize two common problems (power failure and wind tip-over of the radio antenna) by using a solar battery charger and mounting the base receiver and radio antenna on high quality solidly built tripods.

a)



b)



Figure 1 – Trimble R6 Model 4 GPS surveying equipment. a) equipment packed up in Pelican cases and bags b) GPS equipment completely unpacked.

1.2 Base Station Selection:

This topic is often overlooked in the rush to get the base set up and get surveying so others who need the survey data can also get to work. However, base station selection can have a very strong impact on how efficiently, or inefficiently, this survey system functions. Because we are using single base radio broadcast RTK survey method, any wireless communication problems involving satellite signal and/or radio broadcast issues can cause extensive time consuming delays. Following are some helpful guidelines when deciding on where to set the base point (in order of importance):

1. Pick a site that will allow for the best radio coverage to the sites it serves. Generally this will be an elevated prominent spot if available.
2. Stay away from potential multi-pathing obstructions like chain link fence, canyon walls, large monoliths, etc.
3. The site needs to have adequate sky visibility. Look for a spot that has the least amount of tall obstructions like tall trees or canyon walls nearby. Better visibility to the South is preferred if you have to make a choice.
4. What kind of permanent monument can you use (or are allowed to use) to mark the point?
5. Reasonable accessibility to haul the gear in and out?

1.2.1 Example Base station setup:

Figure 2 shows a typical base station setup showing the base receiver over a survey mark (X engraved into rock, Figure 4), the broadcast radio mounted on one of the legs of the base receiver tripod, broadcast/transmit antenna (relatively short -- about 3m tall mounted on the other tripod), and the power system (base battery and solar charger).

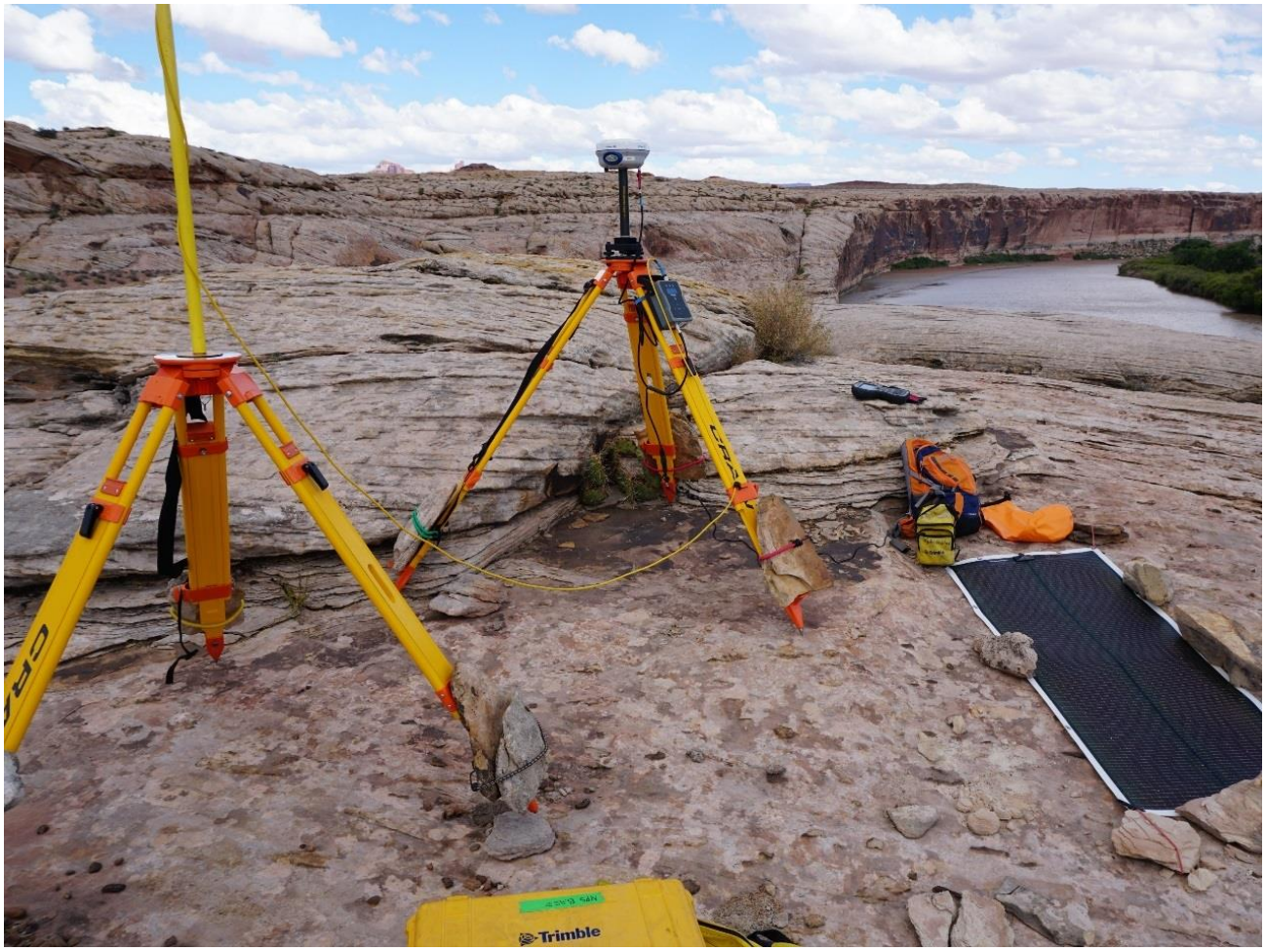


Figure 2 – Example of base station setup with base receiver, radio antenna, battery and solar panel

Notice the rocks bungeed onto the tripod legs to help prevent wind topple and the solar panel is weighted down also. The tripod legs are spread out relatively wide and the height is kept relatively short.

This base point was chosen to provide the best radio broadcast to the three sites it serves (Millard Canyon, Queen Anne, and Bonita Bend in Canyonlands NP) while maintaining good sky visibility for the base receiver and acceptable accessibility to haul the equipment in and out. This setup has slightly different looking components but function identically to what is pictured in the equipment layout photo. For instance, the radio coax cable here is yellow, not black and the stubby rod is black, not yellow.

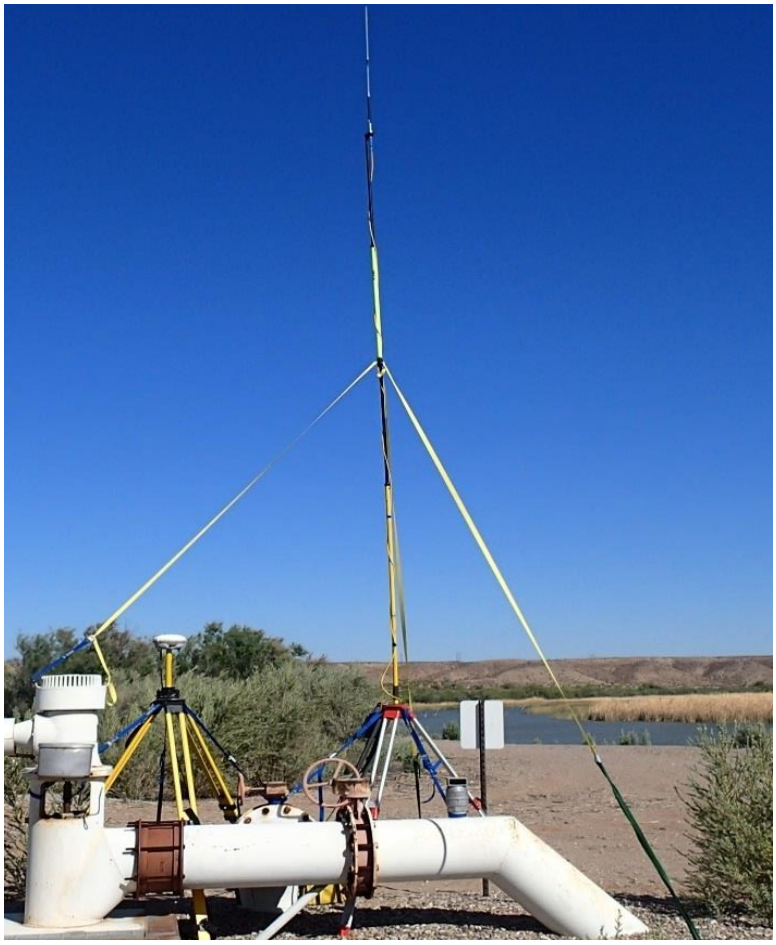


Figure 3 – Example of base radio setup with a tall antenna mast

Figure 3 shows an example of where there was no higher ground within reasonable proximity to the survey site to locate the Base radio and antenna. As a result, the surveyor chose the base point based on the other criteria listed above but had to rely on a tall radio broadcast antenna (approximately 20 feet tall) and high transmit power (35 Watts) to make the RTK survey system work effectively throughout the entire area of interest. Rover receivers still experienced radio reception drop-out in some places where dense vegetation was present. In this situation, a repeater radio could be utilized if one is available to re-broadcast the base radio signal further. Currently the NPS NCPN group does not have a repeater radio setup.



Figure 4 – Example of base station cross/plus etched into rock surface

Figure 4 shows an example of a typical base point where permanent rebar/markers are not able to be placed. In these circumstances a 1-2 inch cross/plus is engraved into a rock surface using either a grout saw, rock chisel, or a battery operated Dremel tool. These markings are very unobtrusive and, unless you have been to the location repetitively, you will need to use the TSC3 survey controller (or similar) in the stand-alone GPS mode to navigate to the point. These crosses can fill in with a little sand/silt and become nearly invisible. Often we put a somewhat ‘suspicious looking’ rock or group of rocks over it to mark the spot.

2 Trimble TSC3 Hand Controller

This section describes controller operation and functionality for the Trimble Survey Controller Model-3 (TSC3) device (Figure 5). This is a Windows OS device with touch-screen capability. Although it has many features and functionality, only certain functionality is enabled on this device, namely:

- Global Navigation Satellite System (GNSS) functionality using external receivers and radios for precise survey methods. (For us that means single base, radio broadcast, RTK method and other static/semi-static methods.)
- Stand-alone GPS navigation and positioning as a hand-held unit. (Internal GPS)
- USB and Bluetooth communication standards.
- Compass, Camera and Flashlight

2.1 Controller notification and keys:

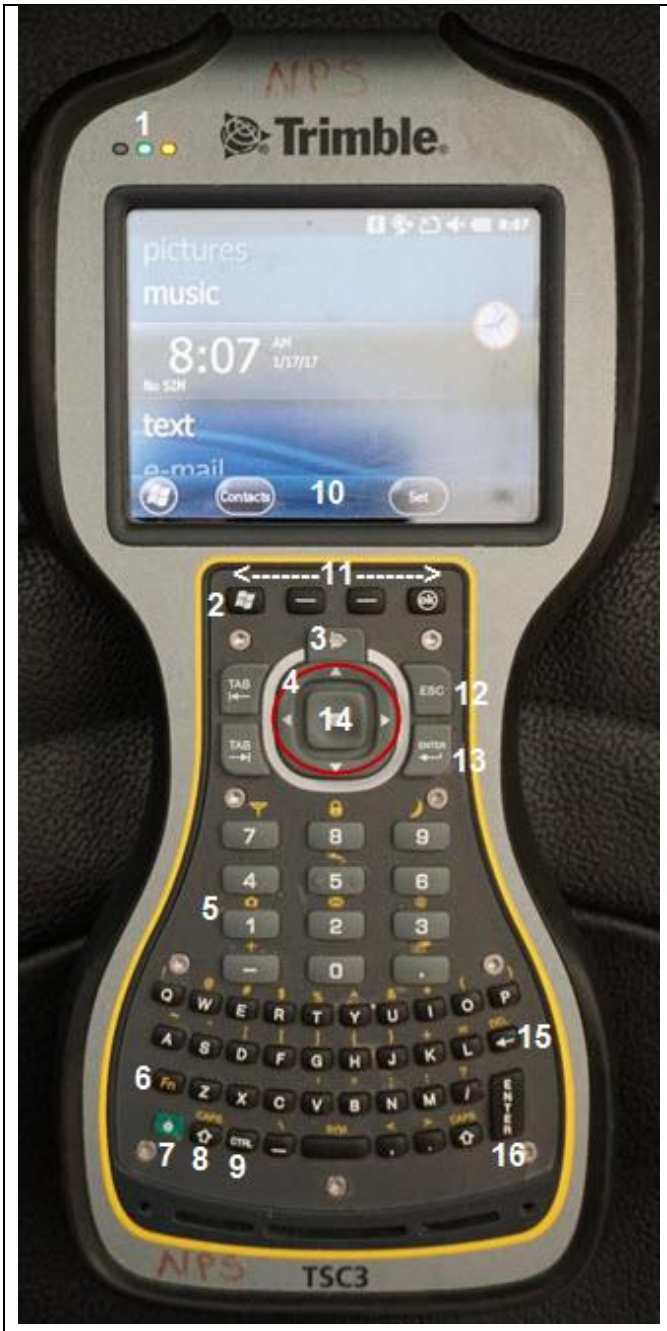


Figure 5 – Trimble TSC3 hand controller

1. LED status lights

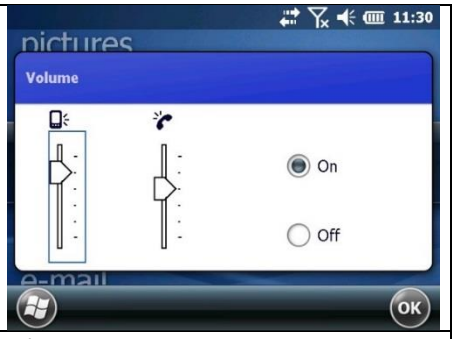
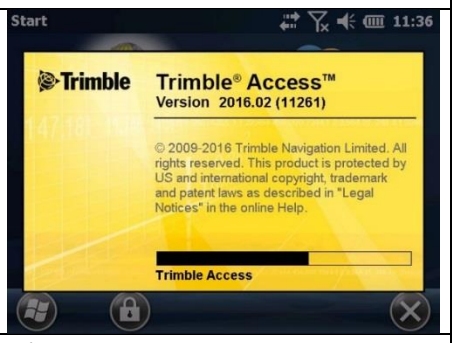
Notification LEDs

At the top of the unit are three LEDs that provide status information:

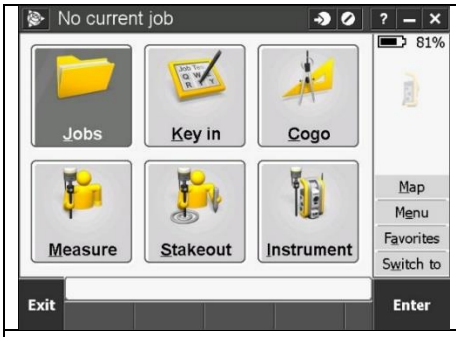
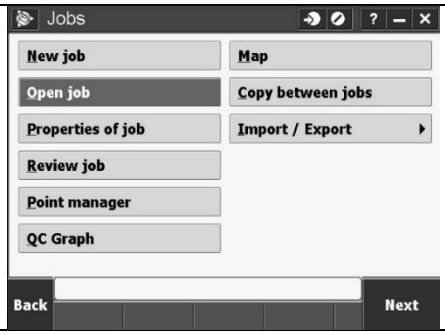
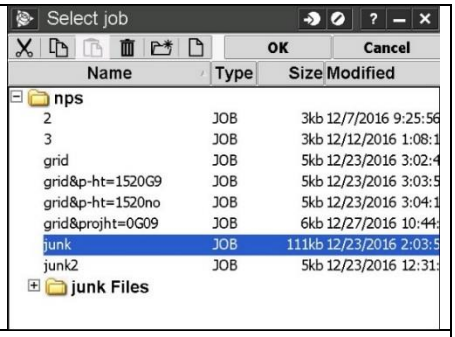
Left LED	Center LED	Right LED
Colors: amber, green, red	Colors: amber, green, red	Colors: amber, blue, green
Battery Status: Green: fully charged Amber: charging Red: battery error	**OS Status** (application dependent): Red-blinking: alarm **WWAN Status:** Amber-blinking: 2G connection Green-blinking: 3G connection (if OS status alarm and WWAN is on, the red will blink faster)	**Bluetooth on:** Blue-blinking **Wi-Fi on:** Amber-blinking **GPS on:** Green-blinking (LED will flash in a sequence if multiple features are on)

2. Windows key
3. Trimble Access key
4. Curser direction (arrow) buttons
5. Camera key (Fn > 1)
6. Function (Fn) key
7. Power key (green). Quick press for On/Off. Hold for reset (warm boot).
8. Upper case (Caps) key. One press for one-time use, Fn > Caps for continued Upper case.
9. Control (CTRL) for shortcut functions.
10. Touch screen with screen protector. Keep a spare one or two in the field with you.
11. These four black keys can control the soft key displays above them if there are any.
12. Escape (ESC) key
13. Enter key
14. Enter button
15. Backspace/Delete key (position curser past item to be deleted)
16. Enter key

2.2 Opening a Job from the Device Home screen:

<table>
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<td>a.) The Device Home screen. Notice the Device Status Indicator bar at the top.</td>
<td>b.) Tapping on the device status bar opens an icon menu for the active device functions.</td>
<td>c.) Tapping on the Speaker icon opens the sound options, pick the one on the left to adjust the volume and options for ON/Off.</td>
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<td>e.) Tapping the Clock icon brings up the time and date options. For accurate records, please check/set the time correctly. This is very important for total station work as it is used for the time stamp on all measurements taken.</td>
<td>f.) Pressing the Windows key (lower left) brings up the Windows Applications screen. The Trimble Access application is currently highlighted.</td>
<td>g.) To create or open a survey job you need to start the Trimble Access application. Tap The icon or press the Enter key on the keypad (Figure 5 item #3) and you should briefly see this message.</td>
</tr>
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<tr>
<td>h.) This is the Trimble Access Home screen. General Survey is what you need to get into the survey functions. Settings will be discussed later and the Files option is the same as Windows Explorer.</td>
<td>i.) The upper bar names the root folder, in this case nps.

Tap the General Survey icon or highlight it using the arrow key button and press the Enter key.</td>
<td>j.) This is the General Survey screen. The job's Status Bar is on the right side and the job's Status Line is along the bottom of the display. These two information boxes (and perhaps the Map) is where you will spend most all of your time looking at the controller screen during a survey.</td>
</tr>
</table>

		
k.) To open or create a job, tap on the ***Jobs*** icon or highlight the *Jobs* icon and press the *Enter* key.	l.) The ***Jobs options*** screen is displayed and you can pick an option. In this case, we have already created a job so it just needs to be opened.	m.) Pick the job you want opened. Here you can see some obscure job names. Follow the NCPN protocol for naming jobs when you create one.
		
n.) This is the **main screen** of the selected job. The *Status Bar* and the *Status Line* are vacant because there is no survey running in this job at this time. **A main job screen is what you need to have open to start any survey session**.	**Note:** if your job has not already been created for you as part of the field preparation proceedures then you will need to create a new job in the controller. See section 3 on *Creating a Job* to get to this point of having a defined job already created/loaded in the controller as part of the pre-trip procedures.	

2.3 Camera function:

		
a.) Go to the *Windows* applications screen and open ***Pictures & Videos*** or use the shortcut key (Fn > 1) on the controller (Figure 5, item #5) and skip to c.)	b.) Tap on the ***Camera*** icon to open the camera function if not using the shortcut keys.	c.) The camera function is opened and is ready to take a picture. Here the controller case laying on a desk is in view.

		
d.) Tap ***Menu*** to open and check/set the resolution. Sometimes when the controller is reset the camera resolution will be reset to the lowest value.	e.) Set the resolution to **2048x1536** to get nice sharp pictures. We have had issues with the highest setting.	f.) After taking the picture this ***Media file*** screen appears. Use the drop-down list to indicate how you want the image associated with the collected survey data. Then tap ***Accept*** or press the ***Enter*** key to store it.

2.4 File Explorer and USB flash drive access

To access *File Explorer* navigate to the Windows home screen (*Windows* key > *File Explorer* > *Trimble Data*). This directory will typically contain at least these two folders: 1) The named *Root Directory* (i.e. NPS or Rover #), and 2) The *System Files*.

- The ***System Files*** directory contains all the files needed to operate the controller within the general survey program (i.e. geoid models, survey styles, feature code libraries, etc.).
- The named ***Root Directory*** contains all the files associated with a given job (i.e. Job files, media files/photos, and any linked files like previous survey data in a csv format). The root folder is where you will copy/paste files that are needed in referencing previous data sets, previous job files, and/or job templates.

The easiest way to transfer files between controllers is to use a USB flash drive. To find the USB flash drive, insert the flash drive into the USB port. Go to: Windows home screen (*Windows* key) > *File Explorer* > *My Device* > *Hard Disk* (the USB flash drive is recognized as a hard disk).

To copy files to the flash drive:

- **Highlight** the file(s) in either the *System Files* directory or the named *root directory*. **Tap and hold** on the highlighted file. Pick ***Copy*** when the popup menu appears.
- Tap ***Up***, and navigate to the same directory the job is in (*Trimble Data* > *{Root Directory}*).
- Tap *Menu*, scroll to *Edit*, and choose *Paste*. The file(s) will now be copied into the root directory. All data files associated with the job must be in the same directory as the job. Once your reference csv files have been copied into the *Root Directory* you will then be able to link to those files in the Job Properties screen described in section 3.1.2.

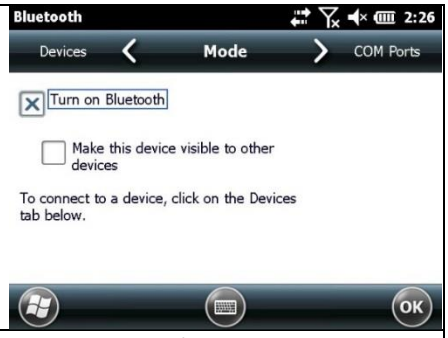
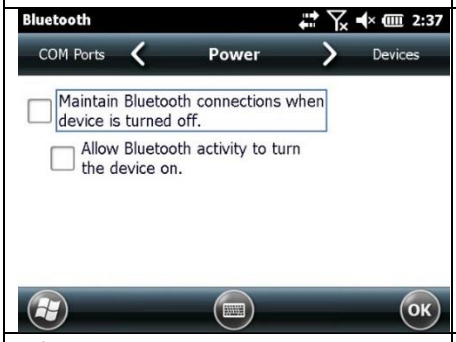
2.5 Bluetooth connectivity

There are three parts to the Bluetooth wireless system:

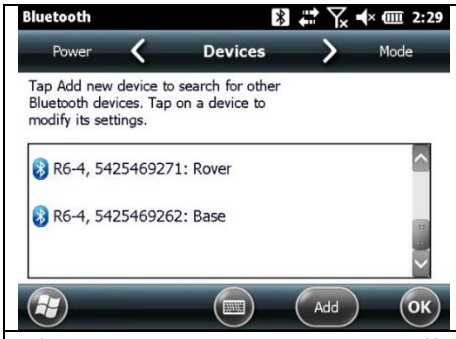
- Turning the Bluetooth function ON or OFF.
- Paring devices in the *Windows* environment.
- Assigning survey functions of paired devices in the *Trimble Access* survey application.

First, make sure the Bluetooth functionality is turned on and then make sure the receivers are known by paring them and finally assign the appropriate devices as either a GNSS base or GNSS rover. Press the *Windows* key again to put you back in the survey job.

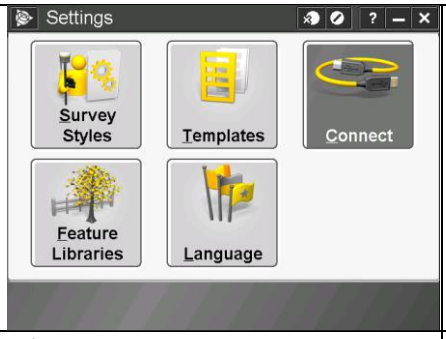
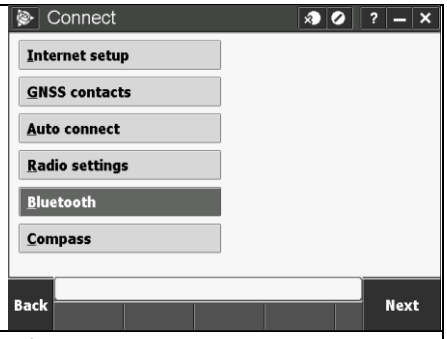
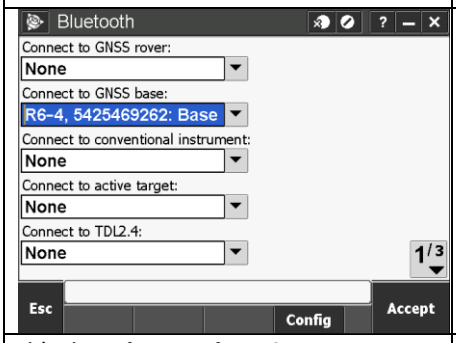
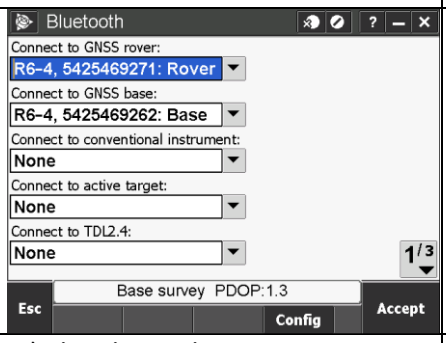
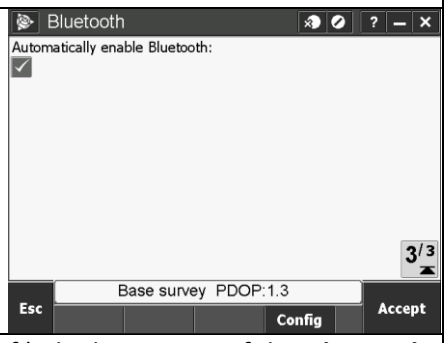
2.5.1 Turning the Bluetooth device On or Off:

		
a.) From a job screen, press the ***Windows*** key. Scroll to ***Settings*** and tap to open.	b.) From the *Settings* screen, tap ***Bluetooth*** to open.	c.) Scroll right/left to get to the ***Mode*** screen. Tap in the ***Turn on Bluetooth*** box to place an **X** there then tap ***OK*** or press ***Enter*** to turn it on.
		
d.) In the *Power* screen, make sure these are turned off (unchecked) to prevent the Bluetooth device from starting unnecessarily and causing power drain.		

2.5.2 Pairing a Bluetooth device:

	
a.) See *Turning Bluetooth On or Off* to get to the ***Bluetooth*** management screen. Scroll right/left to get to the ***Devices*** screen shown here. First check to see if your device is already paired by scrolling down to see the list of paired devices.	b.) Tap ***Add new device…*** if you need to pair a device. Make sure the device you want to pair is turned on. The controller should recognize the device and you can rename it there. You don't need to create a password and it is best to just leave this blank.

2.5.3 Assigning Bluetooth survey devices:

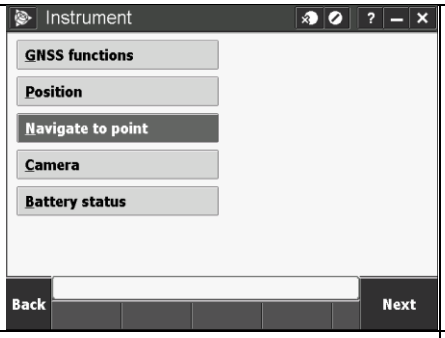
		
a.) Push the ***Trimble*** key and select ***Trimble Access*** to get to *Access* main page. Open the ***Settings*** menu by tapping on it.	b.) Open the ***Connect*** menu by tapping on it.	c.) Pick the ***Bluetooth*** option.
		
d.) The ***Bluetooth* assignment settings** screen. This tells the *Access* survey application which paired devices it should be communicating with for a specific function in the survey system. Paired devices will appear in the drop-down list next to the device function. Here, the base receiver is selected from the list of paired devices in the ***Connect to GNSS base*** drop-down list.	e.) This shows the rover receiver is selected from the paired devices in the ***Connect to GNSS Rover*** drop-down list. If there is more than one rover listed, make sure you pick the right one from the list. This is why its good practice to list the receiver's serial number in the device name (when pairing), so you can physically check the number on the bottom of your receiver unit. It can be rather confusing when your controller is paired with someone else's rover receiver. Tap ***Accept*** to set the device assignments.	f.) The last screen of the ***Bluetooth* assignment settings in Trimble Access** is this ***Automatically enable Bluetooth*** switch. If this is check-marked then the *Windows Bluetooth* device > *Mode* > *Turn on Bluetooth* option will always be on. Even if you go in and turn it off (uncheck the box in *Mode*) it will turn on again as soon as you exit. This switch means if *Trimble Access* is running the Bluetooth device will be turned on. I prefer to keep this option off (unchecked) to save power when I'm not actually surveying.

2.6 Using the controller as a "stand-alone" GPS device

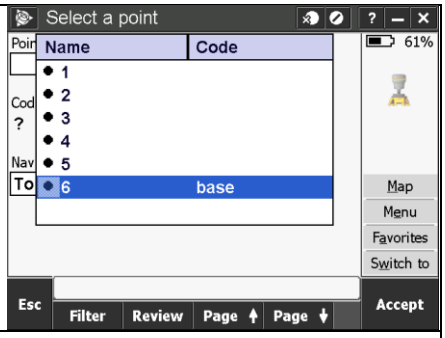
The TSC3 controller can be used as a traditional hand-held personal GPS unit. It is often used to navigate to a base point monument.



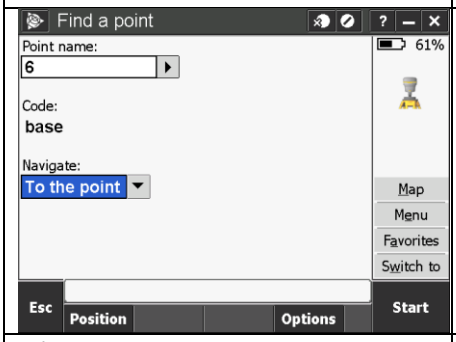
a.) From the main Job screen, open *Instrument*.



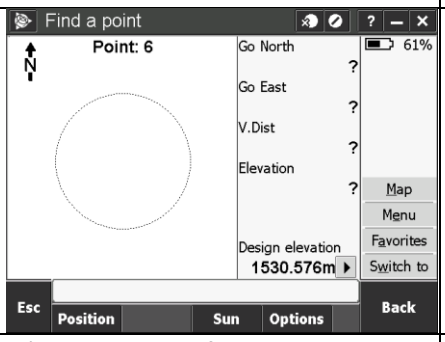
b.) Pick *Navigate to point*. The right LED light on the controller should start to blink green every 5 seconds, letting you know the internal GPS is functioning.



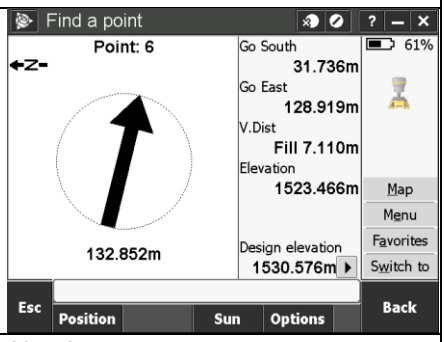
c.) You need to have a point keyed in or be linked to a file of points.



d.) A point has been selected. Press *Start* or the *Enter* key. You may see a message asking you to calibrate the compass.

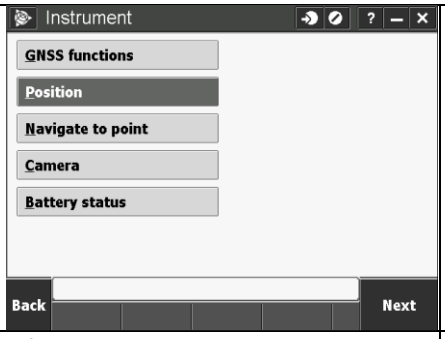
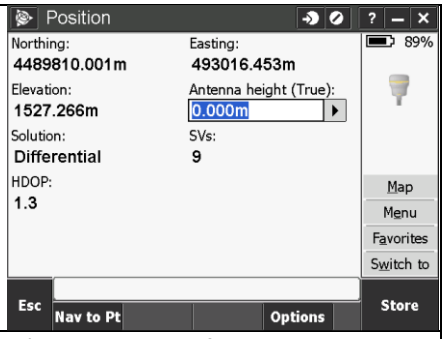
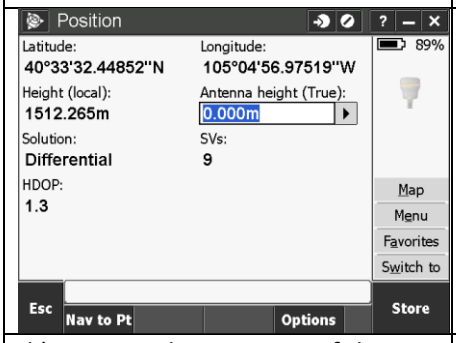


e.) It may take a few minutes to get its current position and calculate the direction you need to go.



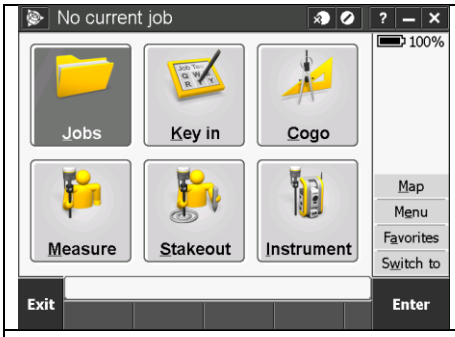
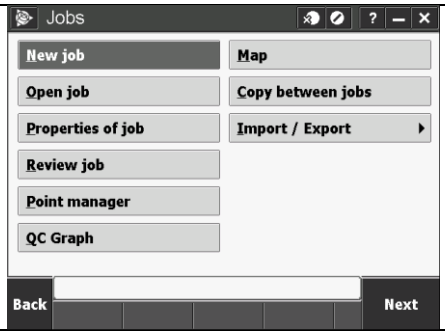
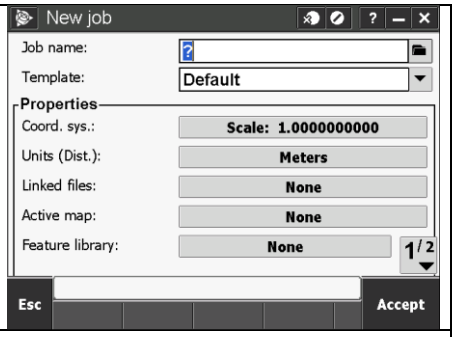
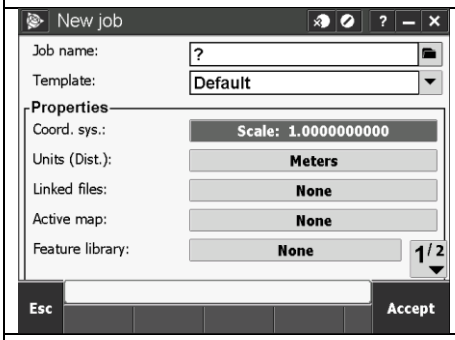
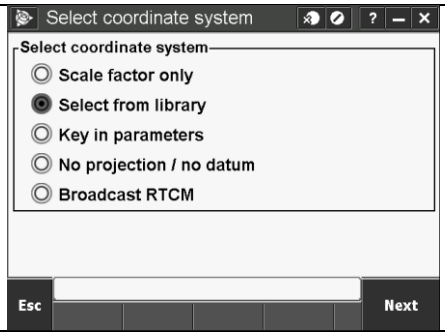
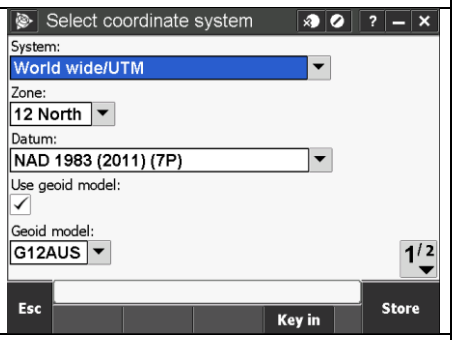
f.) It figured it out. The N compass needle points North. You need to go the in the direction of the large arrow relative to North. When you get near the point it will change to a + and circle diagram as shown in the *Stakeout a point* routine. Pressing *Esc* twice will close the stand-alone GPS function. When you start an RTK survey this will also close it.

2.7 You can also get the coordinates of your current position:

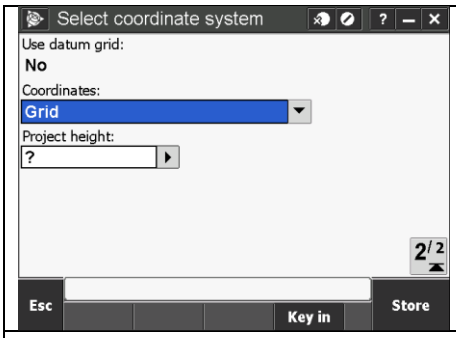
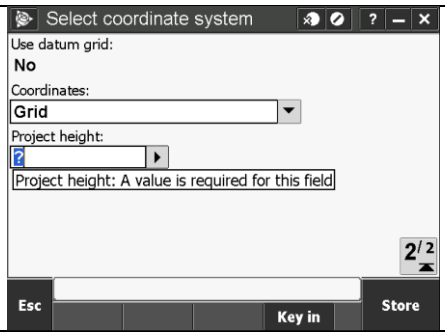
		
a.) From the main Job screen, open *Instrument*.	b.) Pick the *Position* option. The right LED light on the controller will start to blink every 5 seconds, letting you know the internal GPS is functioning.	c.) It may take a few minutes to generate your position. The undefined values (question marks) will populate with grid coordinate values.
		
d.) Tapping the *Options* soft key allows other display options for the position, These are the local geographic coordinates. Pressing *Esc* will close the stand-alone GPS function. When you start an RTK survey this will also close it.		

3 Creating a Job in the TSC3 Hand Controller

Trimble Access is the field surveying application software found on the TSC3 survey controller device. You need to have an ***Access* Job file defined and opened** to start any kind of survey. This section describes how to create an *Access* Job file. For sites that have been previously surveyed, the Job file is probably easiest and safest to create in the office before the field trip to avoid last minute surprises about missing data/missing files or incorrect project settings (i.e. datum and projections). However, for new surveys having no stakeout data, you can create the new job in the office if you know about it ahead of time or the Job can be defined at the site in the field during base startup.

<table>
<tr>
<td> 
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<tr>
<td>a.) The main job screen. Notice there is No Current job in the title bar. Tap Jobs or highlight Jobs and press the Enter key.</td>
<td>b.) On the jobs options screen tap New job.</td>
<td>c.) The New job screen will then appear. Name the job according to the NCPN format "Project+Site+year+rover# +person" (i.e. CanyQA2014r2HoJo).</td>
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<tr>
<td>d.) To set the job properties, Tap on the Coord. Sys.: entry box.</td>
<td>e.) The Select coordinate system options screen will apear. Select from library opens up the pre-defined coordinate system library.</td>
<td>f.) This screen is where you define the coordinate system. Use the drop-down lists to fill in the various boxes.

The values shown are the coordinate system settings that are used for all five of the NCPN Big Rivers Monitoring Sites (YAMPA, GREEN, CANY, BLCA, and CURE).</td>
</tr>
</table>

		
g.) This is page-2 of the Select coordinate system screen. The ***Coordinates*** (type) option is either *Grid* or *Ground*. Choose ***Grid*** for this setting to generate true UTM grid coordinates. Ground elevations will be computed using the Geoid model set on the previous page. The *Ground* setting means the grid coordinates will be computed at a scaled up ground elevation. These, then, are not UTM grid coordinates as UTM is defined at the ellipsoid height.	h.) A ***Project height*** must be defined. This is the message you get when you try to store the defined coordinate system without defining the project height. For RTK-GNSS jobs this can be any value. **Zero** is a good option if you don't know the average elevation in the area that you are working. Note: Project height is used to compute an elevation (and thereby a grid coordinate) of 2D points, which you won't have any running a RTK-GNSS system since this allows you to measure 3D points (x,y,z) within a tolerance of a couple centimeters.	i.) After Storing the job's coordinate system definition you will be back at this main job screen. This example job is called *junk*.

3.1 Adding stake-out information to the Job:

If this is a return trip to a known site then you will have coordinated points and possibly transect lines that you are looking to repeat survey measurements at. This is called "stake-out" data. This section describes various ways to add stakeout data to the job. There are basically three methods, one of which is hand entering all the data called "keying in". As you can imagine, this is OK for a few points but is not an acceptable method for many points. The other two methods involve getting data from files. The two methods for this are **data file *import*** and **data file *link***.

3.1.1 Importing data to a Job:

When using the data file import method, all data points that are imported into the current job are essentially copied into and made a part of the existing job's data set. Survey jobs that accumulate lots of data can be unwieldy to manage if all the stakeout data is imported/copied into the job and gets added together with the current survey topo measurements. Therefore, this method is not recommended for including previous stake-out data as a reference for the current field survey job. The other method, described below as linking, is the preferred method for accessing previous survey data from the current job.

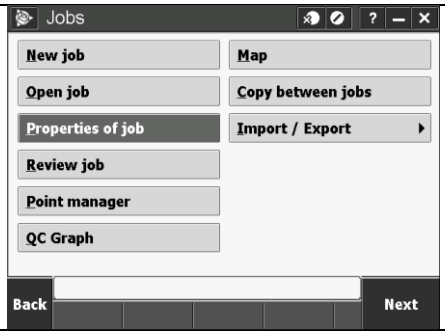
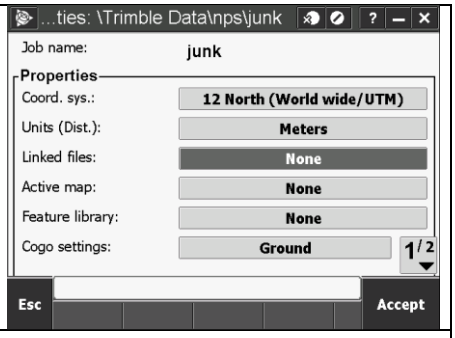
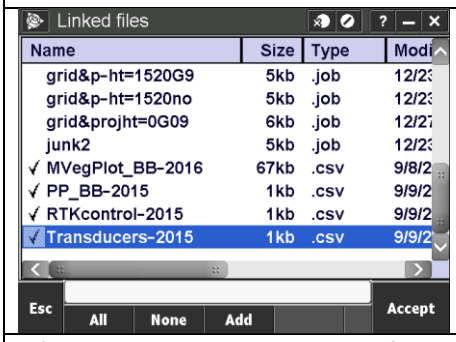
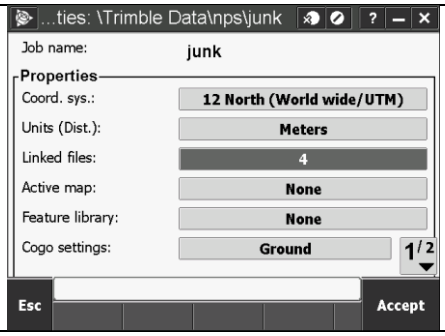
3.1.2 Linking a data file to a Job:

During a repeat survey there exists previous data such as control points, photo points, veg plots, transect lines, etc. These items usually need to be found by *staking out* because the purpose of the repeat survey is to gather data in the exact same horizontal location as previously done.

Terminology Note: *Stakeout* is a term used by surveyors (and the survey application software) to precisely locate a known point when performing a survey while *Navigate* is a term, generally used by everyone, when roughly locating a known point with a stand-alone GPS unit not involved in a precise surveying system.

There are two ways of accessing known (coordinated) data points in either *Stakeout* or *Navigate* mode. One is by importing the data into the job and the other is by *linking* data files. Linking files is easy to do but requires that the files be created correctly and available in the controller. This takes a bit more time and effort to set up than importing the data directly into the job but it makes the field work much more manageable by logically isolating data into subsets by type and location.

- Linking only those files having data of a certain type on your current transect or site will serve to keep the map less cluttered and the stakeout list much shorter and manageable. Linked files are usually CSV grid coordinate files and are generally created in the office and uploaded to the controller into the same root folder as the job. Files may be linked/unlinked from a job at any time during a survey. (Menu > Jobs > Properties of job > Linked files).

<table>
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<tr>
<td>a.) From the main job screen, open ***Jobs***.</td>
<td>b.) Pick the ***Properties of job*** option.</td>
<td>c.) Tap on the ***Linked files*** option. Currently, there are no linked files.</td>
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<tr>
<td>d.) Tap in the check-mark area for each .csv file you want linked to the job. You can link to jobs also but this can cause some unexpected problems if you are loading previous versions of an Access Job file. Tap ***Accept***.
Note: CSV files must be in PNEZD format with no header, just 5 columns of data.
• PNEZD means **P**oint name, **N**orthing (Y coordinate), **E**asting (X coordinate), **Z** (elevation), and **D**escription.</td>
<td>e.) You now see there are 4 linked files to this job. Tap ***Accept***. Now when you list points you will see all the points in the job as well as those in the linked files. The points in the linked files are not imported into the job until a function needs the coordinates. This has the advantage of keeping the job free of unnecessary clutter and copies of points that you don't need.</td>
<td></td>
</tr>
</table>

- Points within linked files are not imported into the current job until they are used for a job function such as *Stakeout*, or *Compute Inverse*. When a point is imported into the job from a linked file you will hear the controller make a “Chunk” sound. *Review* of the job will show the point with a small “C” icon next to it indicating it was copied into the job.
- Data in linked files can be viewed in the *Point Manager* and displayed in the *Map* view as shown in Figure 6 below. The blue colored data is from the linked file(s). The black colored data is currently in the job.

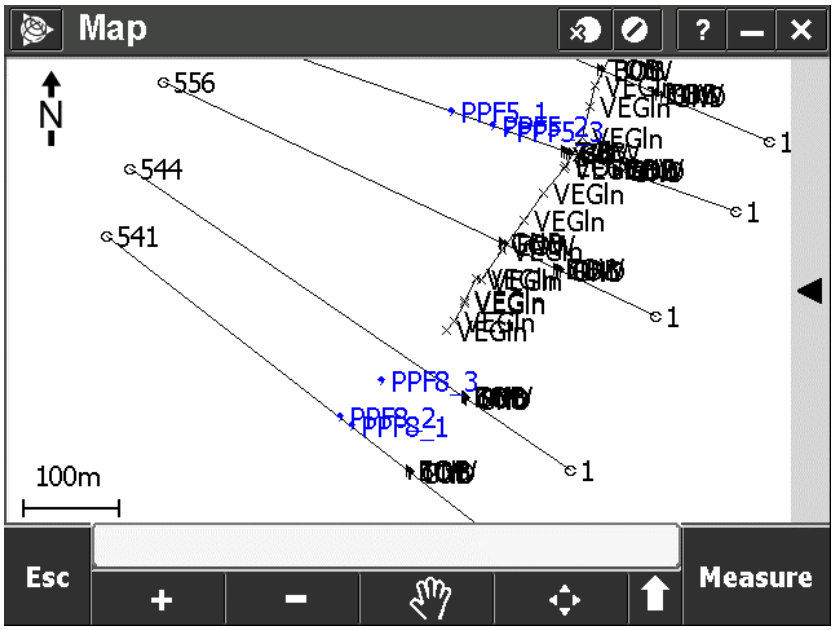


Figure 6 – General survey map view showing current surveyed data along with data from a linked file for reference.

3.1.3 Keying in data

As mentioned at the beginning of this section, points and certain types of data objects created by points can be hand entered by typing in the point name, coordinates, and description. It is recommended to have a paper copy of control point coordinates in case access to electronic files is lost. To key in points, go to: The *main menu* of the existing job > *Key in* > *Points*. Enter the Point name, Northing, Easting, Elevation, and Code as they appear on the printed copy. Leave the *Control Point* option unchecked even for control points. This makes it easier to manipulate in the office software later.

4 Step 1 - GNSS Base Station Setup and Assembly

Figure 7 shows all of the base station equipment unpacked and each item identified below:



Figure 7 – RTK base station equipment unpacked

Items in figure 6:

1. 42-watt solar panel with connecting cable
2. Extension rods for radio antenna
3. Tribrach base
4. Tribrach adaptor (removable mount)
5. Flat disc for mounting radio antenna rod on tripod
6. Long whip antenna
7. Short whip antenna
8. Antenna base (connects to antenna coax cable #13 and whip antenna #6 or #7)
9. Solar panel voltage regulator/battery saver
10. R6-4 base receiver dome
11. Short extension pole for base receiver (0.2m)
12. TDL-450 broadcast radio
13. Radio antenna coax cable with fixed antenna mount
14. Power/data cable for base receiver and broadcast radio
15. Marine battery with quick connect cables for base receiver power and solar panel
16. Heavy duty wooden tripods for base and radio antenna

The Basic RTK system setup connects the battery (power), broadcast radio, antenna, and GPS receiver using two cables: one is the combination power/data cable and the other is the radio antenna coax cable (alternate coax cable may be yellow in color). Figure 8 shows the base receiver and radio setup and all cable connections without being mounted on the tripods. The following sections describe how to assemble each of the components in more detail and mount on the tripods.



Figure 8 – Example of basic RTK base station system components and connections



Figure 9 – Base tripod with tribrach base mounted



Figure 10 – Base tripod anchored with tie-down straps

4.1.1 Base station tripod setup and receiver assembly

a) Set up the base tripod over the control point (i.e. "x" in a rock or rebar) and roughly level the tripod head by eye by adjusting the legs and tighten the thumb screws firmly. Screw the tribrach base (adaptor removed) onto the base of the tripod and level over the control point:
   - Roughly center the tribrach on the tripod head as shown in Figure 9.
   - Adjust the three tribrach thumb screws to be near the mid-point of their travel range. This is represented by a groove mark in the post holding the thumb screw. The top edge of the thumb screw should be near the groove mark.
   - Adjust the eyepiece reticle (cross-hair) to your eyesight to eliminate parallax error (sharp, crisp lines).
   - Roughly adjust the focus if necessary and center the tripod over the base point.
   - Using full body weight, press the tripod shoes into soft ground or verify solid setup on rock surface and finish leveling/setting up the tripod.
   - Anchor the tripod using either large rocks on the tripod shoes (shown in Figure 2) or using tie-down straps connected to a strap around the tripod head and anchoring them into the ground with stakes (Figure 10).
     - Note: this anchoring process should be done for both the base station tripod and radio antenna setup to insure that neither of the tripods get blown over in high winds or disturbed by wildlife.



Figure 11 – Base station receiver setup

b) Screw the stubby pole (0.2 meter) onto the tribrach adapter and screw the base receiver onto the stubby pole. Plug the combination power/data cable to the round port on the receiver (port#1). The connector is keyed, line up the red marks first then carefully but firmly push it in (pull the small wire loop to release the small prongs and remove it). Now attach this assembly to the tribrach base (as shown) and close the tribrach latch to lock it in place. The base receiver is now set up.



Figure 12 – Base station radio setup

4.1.2 Base radio and antenna assembly:

Set up another tripod within a couple meters of the base receiver. Lengthen the legs to nearly the max and spread them out pretty far to reduce the chances of the wind blowing it over. Strap it down with a tie-down kit if there is a chance of this. Roughly level the tripod head by eye by adjusting the legs and tighten the thumb screws firmly. Its only job is to support the radio mast so it doesn't need to be perfectly level and you can adjust it after you have the mast up. Note that the radio antenna can be mounted on anything (such as a pole lashed to a tree or fence post) as long as it is positioned relatively vertical and as high as is reasonable for the situation at hand. A tripod is necessary where there is no other way to mount the radio mast and always works. Other methods should be considered "make shift" or "less than optimal but it will work" approaches in case of a loss of a tripod.

In the large photo of Figure 12 the radio setup is shown with no additional antenna mast (so it fits into the photo). It is recommended to use at least one telescope pole (shown mounted in the inset photo) to raise the antenna. Antenna height is a big factor in effective broadcast reception at the rover. The choice of base point location will determine how effective the radio coverage will be. Low elevation base points may mean using a very tall (unwieldy) antenna mast which will require additional strapping/tethering for support (see Figure 3). There are two whip attachments, the short whip is shown. The long whip (5dB gain) sends the same transmit power but shapes the signal pattern flatter (ie – less vertical coverage) so the transmit power is concentrated in the horizontal direction perpendicular to the antenna axis. This

	works best for long distances. If you are working relatively near the base station and it is up higher in elevation, use the short whip.

Figure 13 shows an additional 42W solar panel charging system (PowerFilm product) which helps prolong the life of the base battery (12V AGM, deep cycle) when operating at higher wattage radio broadcast for a long time. At lower broadcast wattages it can keep the battery fully charged if it receives full sun (YMMV).The small square object is a voltage regulator to prevent overcharging. This setup typically provides enough charge during the day to maintain the battery well above 50% and eliminates the need for a generator or alternate power source to re-charge the base battery at night. This is especially important when having to operate in remote areas and when floating the river when transporting generators and fuel can be problematic and noisy.

Caring for the solar panel: Although these are really pretty tough they can be damaged by rolling them up improperly. The directions say to roll them up with the solar side facing out and not to be less than 4" diameter. Be careful of the wire pig-tail. When setting it up, connect the voltage regulator to the battery first. Then make the final connection between the voltage regulator and the solar panel.



Figure 13 – Base station battery and 42 watt solar panel charging system

5 Step 2 - Starting the GNSS base station

5.1 Start the base from a known point:

This section describes how to start the base survey session utilizing a control point with known coordinates.
Key points:

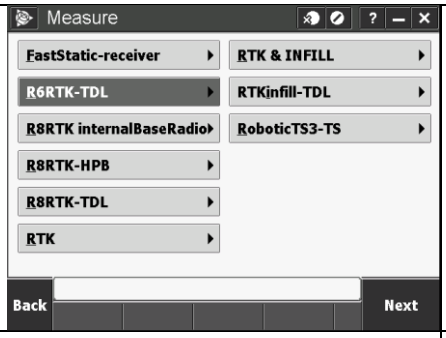
- The base and rover receivers for this system are identical units but we have assigned one to be the base and the other to be the rover to simplify the setup process (Trimble Access > Settings > Connect > Bluetooth). Each of the receivers also have printed labels on them for easy identification.
- The base height (height of instrument) and rover height (rod height) are measured to different places on the receivers respectively. The base is measured to the center of bumper and the rover is measured to the bottom of antenna mount.
- The base is normally set to log base data based on the parameters we have set in the survey style (R6RTK-TDL). The base receiver needs to collect data for at least 2 hours to be post-processed effectively using OPUS, preferably longer, but can't exceed 24 hours continuous.

Step-by-step process for starting base station using the Trimble TSC3 hand controller:

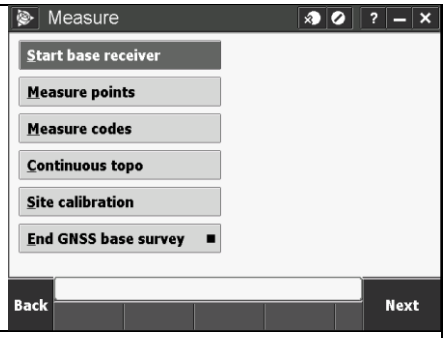
At this point the base receiver and base radio have been powered on. There is no transmit signal (Tx) light from the radio, only the green power light is on. Similarly, the base receiver has a steady green power light and a steadily flashing orange light indicating it is receiving satellite signals. The radio transmission light is not on. The following sequence describes how to start the base survey session, after which a rover survey session may be started.



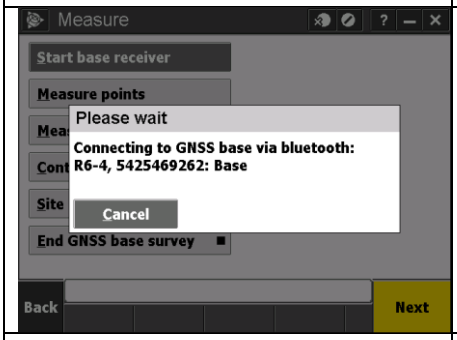
a.) The main job screen. Notice there is nothing in the status bar except the controller battery status and the status line is empty. Go to ***Measure***.



b.) Pick the survey style you'll be using. ***R6RTK-TDL*** is configured to work with the NPS base receiver and broadcast radio. More on survey styles elsewhere.

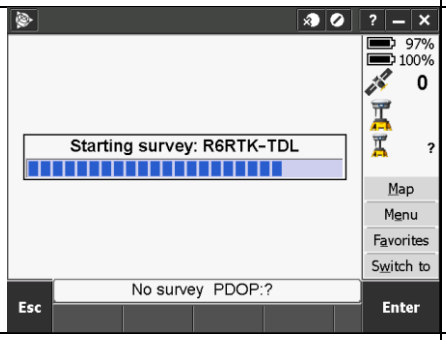


c.) Pick ***Start base receiver***. To initiate communication with the base. You need to be within Bluetooth range (generally 25ft.)



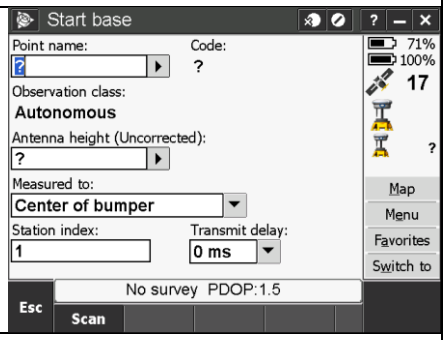
d.) You should briefly see this screen.

- If it hangs on this screen then the Bluetooth device in the controller needs to be turned on or setup (see section 2.5 Bluetooth connectivity).
  - Quick check: Is the blue light on the controller flashing once every 5 seconds? If not go to *Windows* > *Settings* > *Bluetooth* > *Devices* > *Mode*.
- If it says connecting *via cable* then the receiver needs RTK survey device assignment (*Trimble Access* > *Settings* > *Connect* > *Bluetooth*).

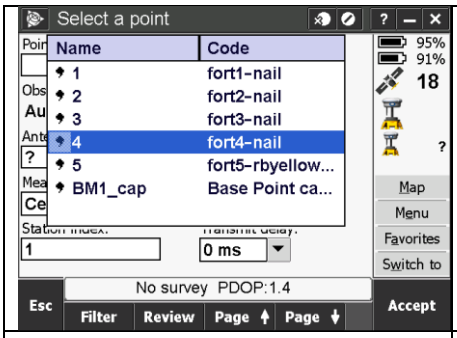


e.) If the receiver is not listed in the *Connect to GNSS base:* drop-down list then it needs Bluetooth pairing (*Windows* > *Settings* > *Bluetooth* > *Devices* > *Add new device…*).

You should also briefly see this starting base message and hear some connection sounds.

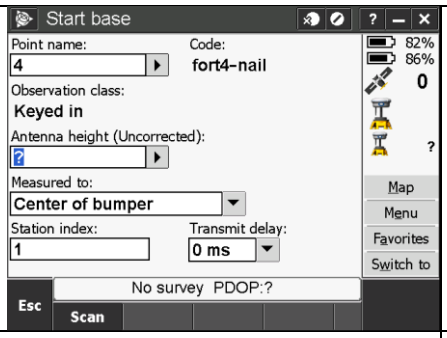


f.) When you have established communication with the base receiver you will be in the ***Start base*** screen. The status bar shows it's tracking 17 satellites and the base battery is fully charged (bottom battery icon). The highlighted *Point name* box is asking you to define the base point position (default is by *Point name*). You can pick different ways to define the point by tapping on the drop-down list arrow.



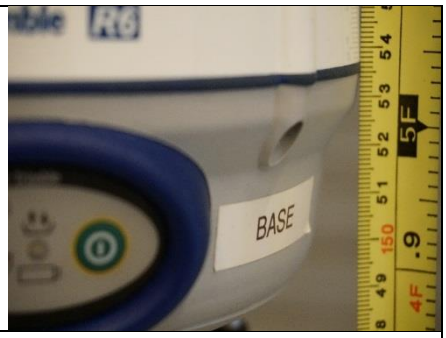
g.) **Note:** At this point, it is assumed you have a known (coordinated) base point. If you are starting from an unknown base point, refer to the part about starting from a "Here" position.

If there is a defined base point coordinate by name (from you either hand-entering it into the job via *Key in*, or from a linked or imported file) then you can pick it from the list of points. Tapping the drop-down arrow brings up a list of options on how to get a base point. Use the ***List*** option to bring up the list of named coordinated points.

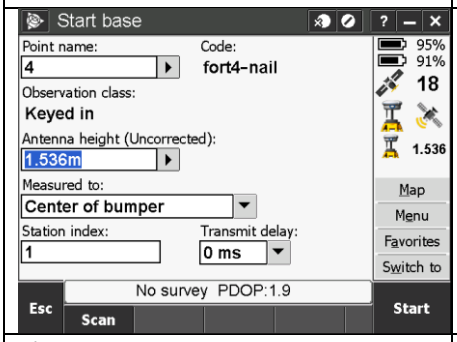


h.) After picking the base point from a list (or keying it in), the *point name*, *code*, and *observation class* will be filled in.

Next is to measure the antenna height. ***Antenna height (Uncorrected)*** means you are providing a raw measurement. You don't apply any modifications to this raw measurement. Notice the default *Measured to* point for the base receiver is ***Center of bumper***. The software will correct this raw slant measurement to a vertical distance to the ARP (Antenna Reference Plane).



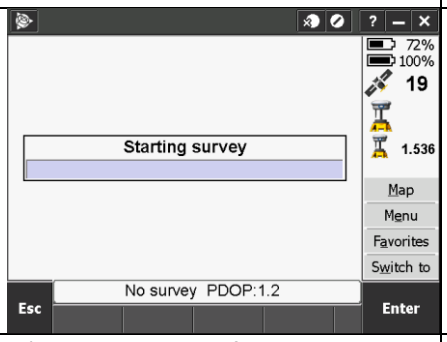
i.) Be sure to measure the base receiver height from the survey point (monument object) up to the **center of bumper** and enter it. In this case, it is 1.536m.



j.) The antenna height has been entered. Now the ***Start*** soft key becomes enabled because the required information is present.

Other information on this screen:

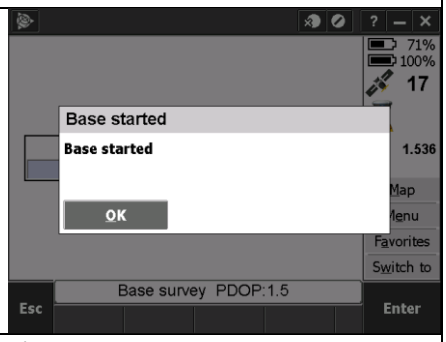
- *Station index* is the ID number assigned to this base receiver.
- *Transmit delay* has to do with multiple bases operating at the same time on this radio frequency. Leave it at zero.
- Verify that the information on this screen is correct and tap *Start* or press *Enter*.



k.) You should briefly see this message.

Notice the icons in the status bar area of the screen. These represent:

- Battery conditions: 1st is controller, 2nd is the device the controller is connected to, in this case the base receiver.
- Satellite information icon and number tracked.
- GNSS functions menu.
- Active base icon with base height.



l.) Then it should halt on this message until you OK it.

		
m.) After you OK it you will be returned to the main job screen. The base has now started and the status line at the bottom indicates a base survey session is in progress. You can now start a rover survey session. At this point it's a good idea to check the receiver and radio. • The green power light on the base receiver will flash off briefly every five seconds. This is your confirmation that it's logging base data. • The green radio light on the receiver will start blinking every second as it computes correction information. • The red TX (transmit) light on the radio will blink once per second as it transmits the correction on the broadcast frequency.		

NOTE: It is good practice to keep a log sheet of the base set-up (Figure 14). This includes control point used, base height measurement, start times and dates, radio transmit power, broadcast antenna height, and any other relevant issues to setting up the base station. When the survey is ended, make a note of the base file name (number) and end time. Check to see that the receiver is still centered over the base point and that the height is still the same. These notes will come in very helpful in the office if you have multiple base setups and/or base sessions as well as for future planning if you return to the same site repeatedly.

Transect Survey metadata

General data

Date:

Transect ID:

Details on getting to the transect:

Survey Specific data

Survey type: RTK RTK+infill RTN Fast Static Static Total Station (see other side)

For GNSS survey method

Base height measure up (HI): To: Bumper ARP

Base Start time: Base End time: Base File:

Base Point Description:

Base Radio: HPB-450 TDL-450 Trimark-III Transmit Power (W): Battery: Tractor Marine

Repeater: HPB-450 TDL-450 Trimark-III Transmit Power (W): Battery: Tractor Marine

On-transect Survey Start time: End time:

Rover/Controller: User:

Point range:

Notes:

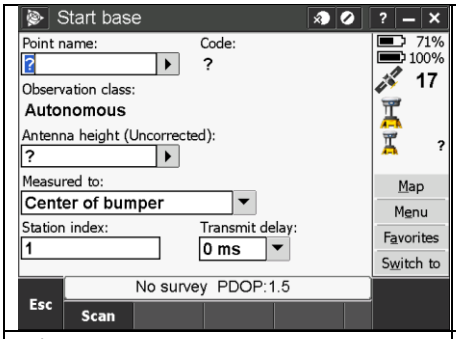
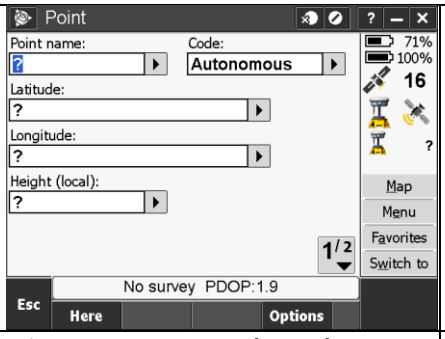
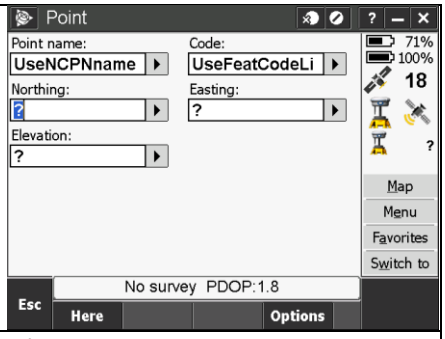
Figure 14 – Example of survey metadata sheet

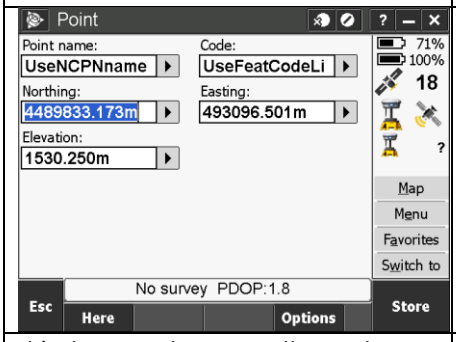
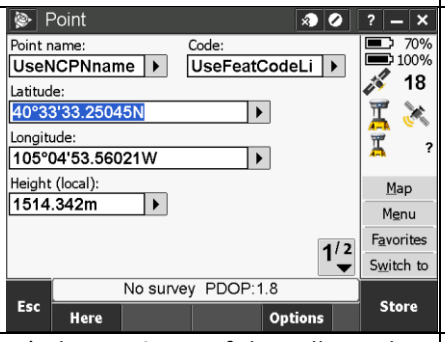
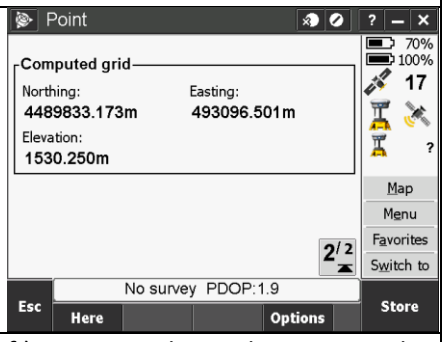
Radio transmit power:

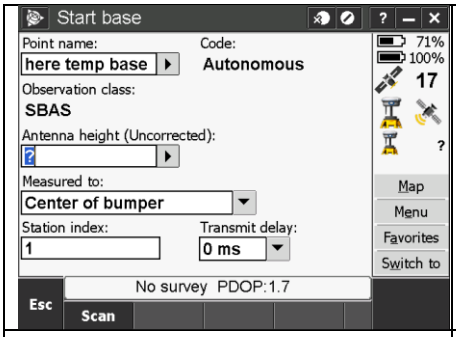
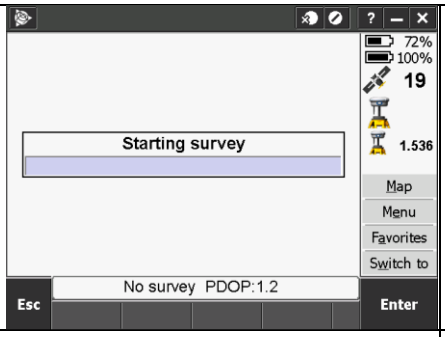
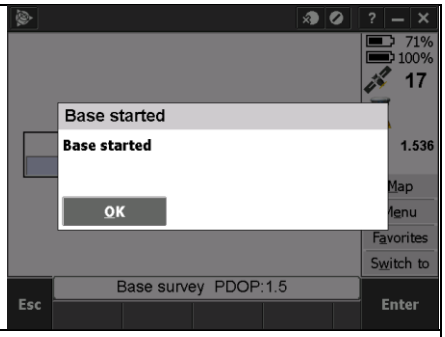
The TDL-450H radio has several transmit power settings. These range from 2W to 35W. With good base station placement, the radio transmit power can be kept relatively low. 8W is generally more than enough to handle most sites. The transmit power can be changed by using the arrow buttons to scroll through the menu. Current settings are marked with an asterisk. Scroll left/right to find the power setting. Scroll up/down to find the one you want. Press the power button to accept the change. The radio will last approximately a day at 8W with no solar charger.

5.2 Starting the base from a "Here" point:

If this is a new site and you have no known (coordinated) points then you will need to set up and start the base on an autonomous position called a '***Here***' coordinate. This is basically a GPS snapshot of your position about as accurate as a personal "hand-held" GPS unit. An RTK survey needs a base coordinate to function so this will suffice to get the survey going. Later on, in the office software, you can post-process this coordinate to get a better, more truthful, position using an online processing service. Because it's an RTK survey, all other points collected using this base session will also benefit from the post-process re-positioning of this point.

<table>
<tr>
<td> 
</td>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td>a.) From the ***Start base*** screen, tap the drop-down list for ***Point name*** and tap ***Key in***.</td>
<td>b.) This is the ***Key in*** (point) screen. This screen enables the ***Here*** soft key at the bottom left. The Point name is undefined and the Code is Autonomous by default.

The GPS satellite icon with the yellow wave symbols means the receiver is getting a SBAS position correction which improves the accuracy of the autonomous point.</td>
<td>c.) Naming and coding the new base point.
Name the point using the NCPN cheat-sheet to set the point naming convention for this new site.
Code the point by using the NCPN Feature Code Library (see Creating a Job).
Let the receiver sit running for a few minutes from when you powered it up in order for the receiver to be able to generate a reliable position/location.</td>
</tr>
<tr>
<td> 
</td>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td>d.) The coordinates will populate when you tap the ***Here*** soft key. Tapping it again will change the coordinates. Verify that the coordinates change only by a relatively small amount, say 50cm not 500m. The last Here position generated is what gets stored as the autonomous base coordinate.</td>
<td>e.) The ***Options*** soft key allows the 'Here' position to be displayed in geographic coordinates. These are the Local geographic coordinates.</td>
<td>f.) Page two shows the computed grid coordinates.</td>
</tr>
</table>

		
g.) Tapping ***Store*** or pressing ***Enter*** stores the last '*Here'* coordinate generated and brings you back to finish the base point definition so you can start the base. Enter the appropriate antenna height measured to the center of bumper as described in section 5.1 i and j then the ***Start*** soft key becomes enabled because the required information is present. Verify that the information on this screen is correct and tap *Start* or press *Enter.*	h.) You should briefly see this message. Notice the icons in the status bar area of the screen. These represent: • Battery conditions: 1st is controller, 2nd is the device the controller is connected to, in this case the base receiver. • Satellite information icon and number tracked. • GNSS functions menu. Active base icon with base height.	i.) Then it should halt on this message until you OK it.

6 Step 3 - Assembling the rover and starting an RTK survey:

6.1 Rover assembly

Figure 15-a shows the Trimble R6 rover survey equipment along with all the chargers and accessories packed in the pelican case for storage/transport in the field. Figure 15-b shows the minimum equipment that must be assembled to conduct a survey in the field and includes the following: adjustable rover rod, rover receiver, radio whip antenna, 2 rover batteries, two-piece controller mounting bracket, and TSC3 controller.

a)



b)



Figure 15 – Trimbel R6 rover a) pelican case containing rover survey gear and assessories b) rover survey gear unpacked

Figure 16 shows the rover gear assembled and ready to setup an RTK survey. The connection between receiver and controller is via Bluetooth wireless. The rover receiver accepts incoming RTK correction information from the base via the whip antenna.



Figure 16 – Trimble R6 rover gear assembled

Be vigilant about rover rod heights. Make it a habit to continually compare the setting shown on the controller to what the rod height is actually set at. See the part about measuring points for more info on rod heights.



- The scale printed on the rod is for rod heights measured to the bottom of the antenna mount. In the case of the R6 receiver it's also the bottom of the receiver.
- It is recommended to pin the rod height at one of the convenient locations using the attached pin (1.8m or 2m shown in Figure 17). Rod height mistakes are the most common surveying mistake made and are very difficult if not impossible to fix after the survey has ended and you've left the site.
- Fixed-height rods (2m is common) are available and go a long way toward preventing rod height mistakes, but the adjustable height rod allows us to work in places where a fixed-height rod would either make it very difficult or even prevent certain measurements.

Figure 17 – adjustable height rover rod with locking pin

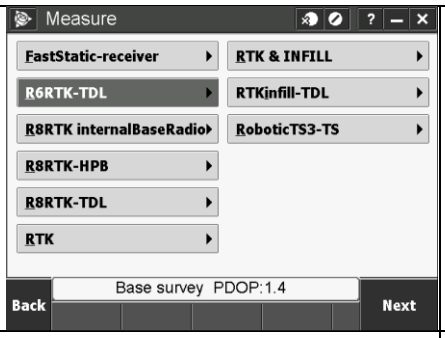
6.2 Starting the Rover session:

Once the base station is set up and started then a rover survey session can be started. This is the last step in getting the RTK survey system functioning. Collecting survey data can begin once a rover session is started. Any number of rovers can be used in an RTK survey which is what makes this method so powerful, as the work can be divided up between rover operators.
Key ideas:

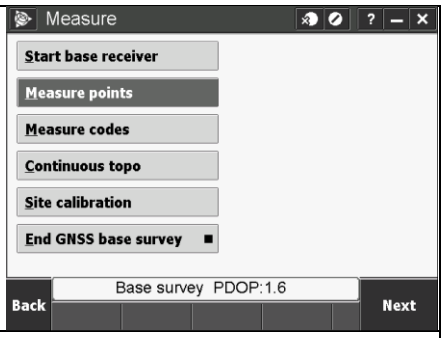
- Be sure to set the rover's controller to the correct job.
- The point name will be a hold-over from the last point name entered in any job. Be sure to change it to the correct naming format.
- Entering the correct point name does not ***set*** the naming pattern. Take a junk/temporary shot to set the naming pattern for the job. The NCPN cheat-sheet shows how to set the naming convention.
- Be sure to stake out a known point (preferably a control point) if this is a resurvey (see *Staking-out points*). This verifies the system is working correctly and that no blunders have occurred during job creation, equipment setup, or survey startup. If it's a new site then set an additional control point and have every rover measure it and then compare coordinates.



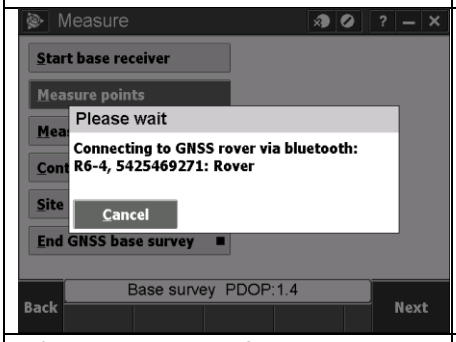
a.) Main job screen showing the base station in operation. Go to ***Measure***.



b.) Pick the **survey style** R6RTK-TDL (same as used for the base setup).

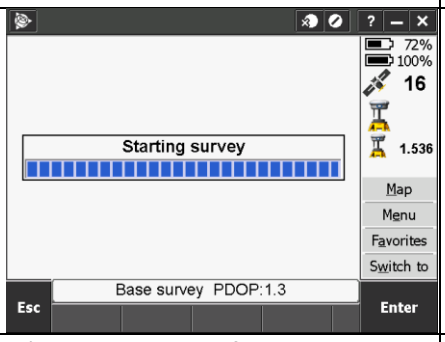


c.) Pick ***Measure points***.

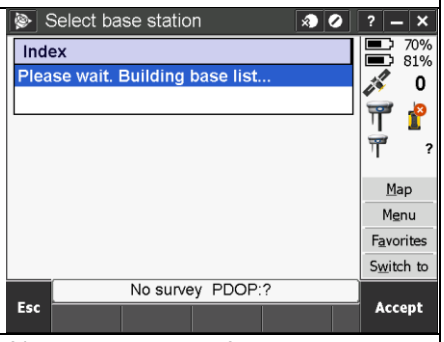


d.) You should briefly see this screen.

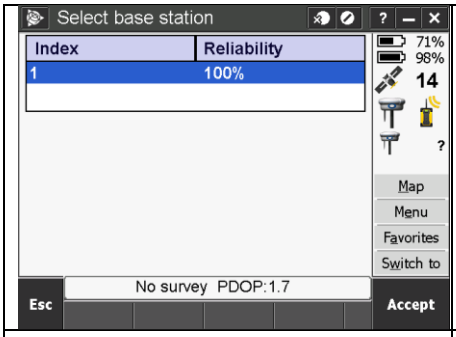
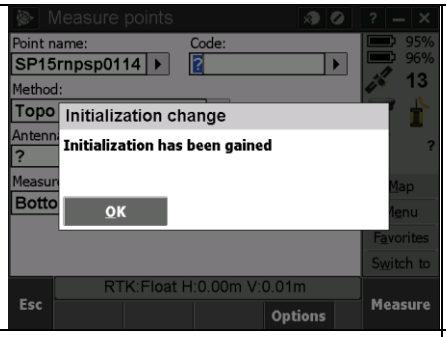
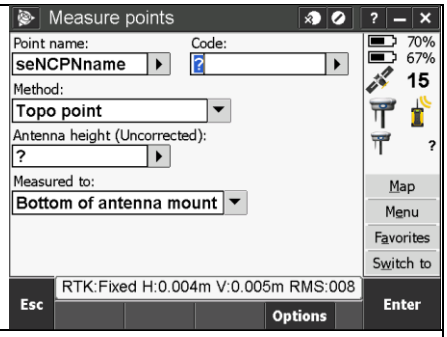
- If it hangs on this screen then the Bluetooth device in the controller needs to be turned on or setup (see section 2.5 Bluetooth connectivity).
  - Quick check: Is the blue light on the controller flashing once every 5 seconds? If not go to *Windows* > *Settings* > *Bluetooth* > *Devices* > *Mode*.
- If it says connecting *via cable* then the receiver needs RTK survey device assignment (*Trimble Access* > *Settings* > *Connect* > *Bluetooth*).
- If the receiver is not listed in the *Connect to GNSS base:* drop-down list then it needs Bluetooth pairing (*Windows* > *Settings* > *Bluetooth* > *Devices* > *Add new device…*).



e.) You should briefly see this message and hear some connection sounds.



f.) You should briefly see this message then be presented with a list of available base stations broadcasting on this radio frequency (next screen).

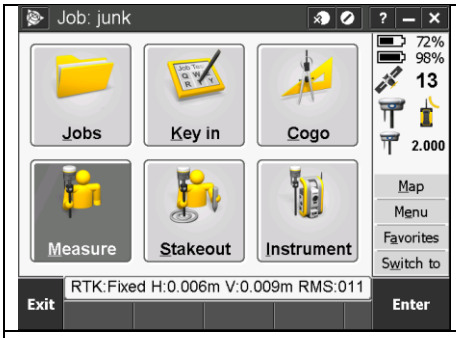
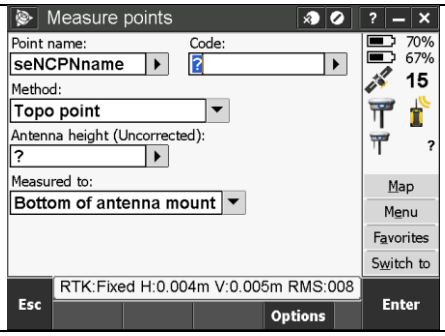
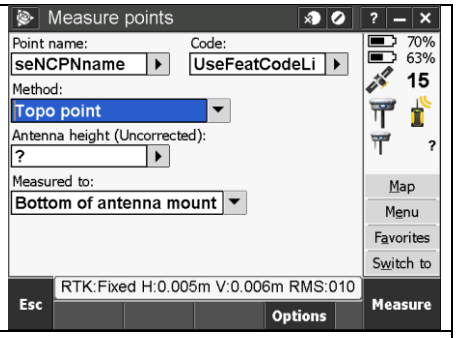
		
g.) This shows only one base station is detected (normally the case due to our remote sites and government radio frequency) and the radio reception is 100%. The index is the ID number assigned to the base in the survey style. If you see other base stations broadcasting on this radio frequency then you'll see them listed also. Make sure you pick the correct base ID. Tapping ***Accept*** or pressing *Enter* starts the rover survey session and returns you to the *Measure points* screen. You may briefly see another *Starting survey* message and hear a message saying '*waiting for information from the base*' as well as some more connection sounds as base information is imported into the job.	h.) The *Measure points* screen with an ***Initialization*** message. You should see this *Initialization gained* message for about 3 seconds if the rover receiver is upright and sky view is not obstructed.	i.) This is the ***Measure points*** screen. Refer to either the next section "*Measure points"* (section 7) or "*Stake-out"* (section 8) to continue. You can now see additional information, mostly indicated by icons, in the status bar area of the screen. These represent: • Battery conditions (1st is controller, 2nd is the device the controller is connected to, in this case the rover receiver) • Satellite information icon and number tracked • Base information icon • Active radio icon • Rover receiver icon and rover rod height (currently undefined). The status bar at the bottom shows that an RTK survey is in progress and has a fixed solution with the estimated horizontal and vertical accuracies and RMS. When conducting an RTK survey these values are usually less than 0.02m.

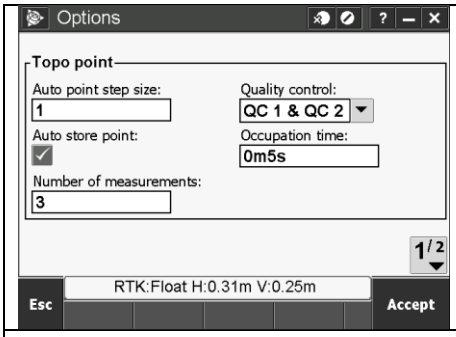
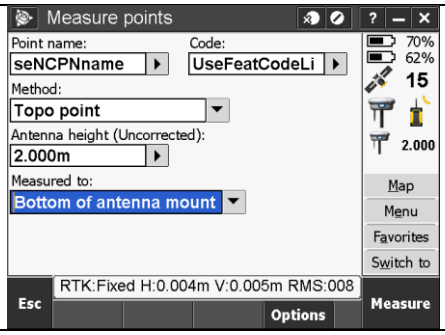
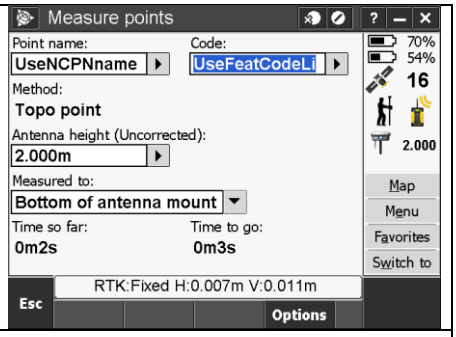
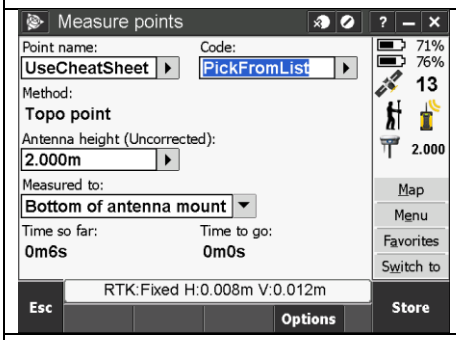
7 Step 4 - Measuring Points

This section covers an overview of how to collect survey data using an RTK setup and possible interuptions that can occur in the field. Once the base and rover receivers are set up and running, there is radio communication from the base, the rover receiver has initialized, and a fixed position solution at the rover is attained, then the actual task of measuring points can begin. The following sections describe how to measure points using the TSC3 controller and the guidelines for nameing conventions for point names as well as point code desciptions.

For a detailed desciption of field procedures associated with RTK surveying refere to the Standard Operating Procedure (SOP) #8 - *Field Preperation and Surveying Protocols*.

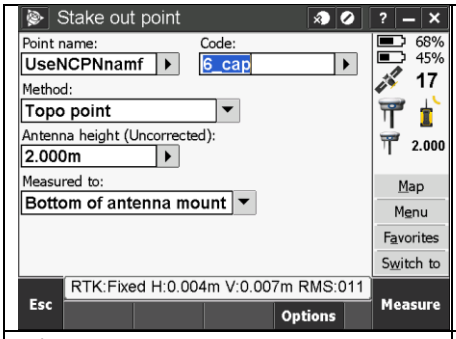
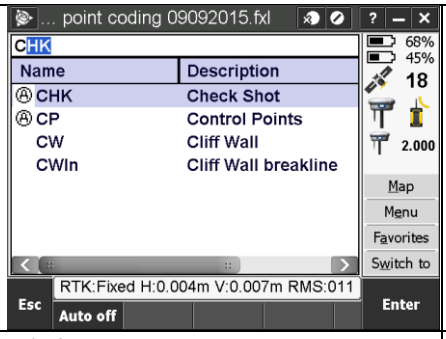
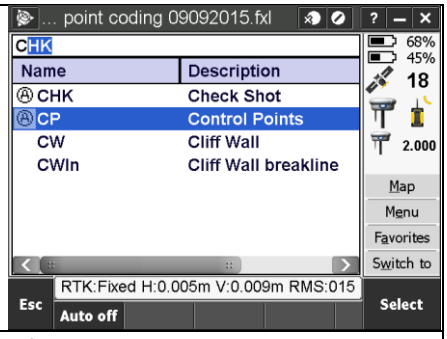
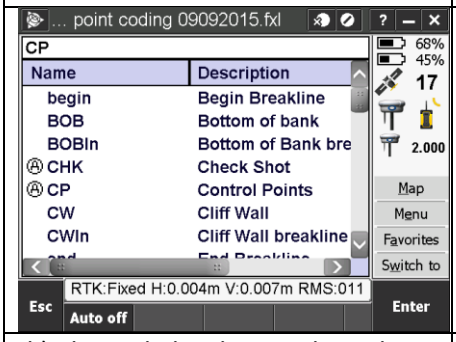
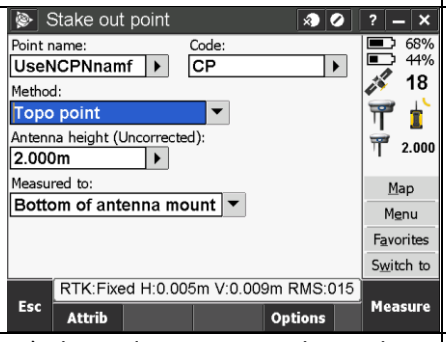
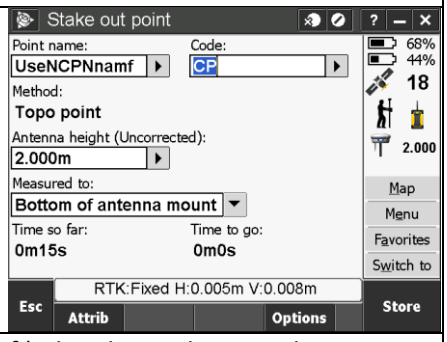
7.1 Measuring points:

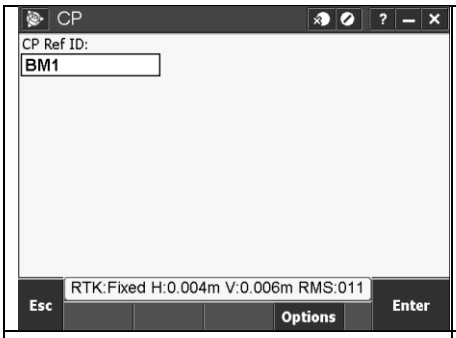
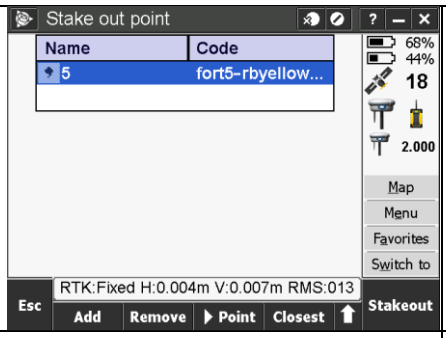
		
a.) From the main job screen you can see the status bar and status line show an active RTK survey is running with a fixed solution. To start measuring points select/open ***Measure***. Note: this screenshot should have undefined rod height for the rover (not 2.000) since we haven't measured our first point yet.	b.) This is the ***Measure points*** screen. • The point name is a hold-over from the last job or point entered in this job. Use the NCPN point naming convention (cheat sheet, see Appendix A) to set the point name correctly. • Use the *Feature Code Library* (associated with the job in Job Properties) to get the point coding correct.	c.) The ***Method*** determines only how long the shot takes before self-storing or being allowed to store manually. The default method is *Topo point*, which is commonly set at 5 seconds. You can change the amount of time required before storing a measurement by going into the *Options* soft key and changing the occupation time. I would not go less than 3 seconds, and this only if you have wide open sky, lots of satellites, excellent radio reception, very low RMS, very small residuals, etc. i.e. – perfect GNSS survey conditions.

		
d.) This is the first page of the *Options* screen (***Options*** soft key) showing settings for a *Topo point*. This is where you can enable or disable the ***Auto store point*** function. When this is **check-marked** and ***Accepted***, measured points will automatically store when the countdown clock expires. This is very useful for most topo work but I find it better to disable this function when measuring points that require higher precision and accuracy such as control points.	e.) This shows the Measure Points screen correctly filled out. The operator has: 1. Defined the *Point Name* 2. Defined the *Point Code* 3. Set the *rod height* (antenna height) 4. Set the *measure* point (default is *Bottom of antenna mount* for the rover) 5. Checked that the positioning solution is fixed and that the error estimates are within acceptable limits. Now measuring points can begin.	f.) The rover is placed on a point and plumbed using the target bubble attached to the rod. The ***Measure*** soft key is tapped or the ***Enter*** key is pressed to start the measuring process. The ***Time to go*** clock counts down from 5 seconds (for a *Topo point*) while the ***Time so far*** clock counts up as the point continues to be measured. The ***Store*** function soft key is currently disabled until the countdown clock expires and the positioning solution remains fixed and within acceptable tolerances.
		
g.) As the point is being measured the countdown (*Time to go*) clock expires and the ***Store*** soft key becomes enabled unless the "auto store point" option has been checked. The *Time so far* clock shows the point is being measured for 6 seconds and continues until the ***Store*** soft key is tapped or the ***Enter*** key is pressed.	**Note:** if the "auto store point" has been selected/checked in the options tab then the measurement will be auto stored after the required time has expired and the user will not need to enter/tap the "Store" key. Instead you will hear "Observation Stored" once the point has been measured/auto stored and you are then ready to move to the next point and take your next measurement.	

7.2 Point Coding (Feature Coding):

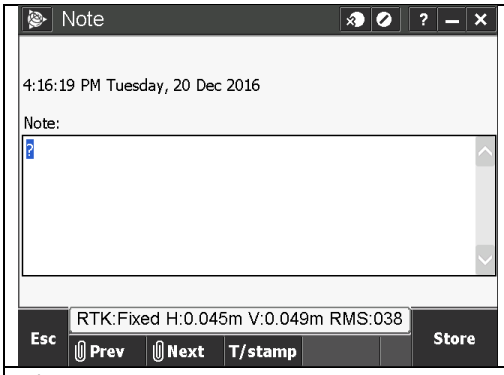
This section discusses how to use a ***Feature Coding Library*** which is associated with the file (Job properties). The feature code library is used to standardize the coding used by each surveyor in the field as well as simplify data processing back in the office. The feature code library allows the surveyor to enter/select a standardized code for each measurement by the type of data point that is being collected (topo points, control points, breaklines, etc.). A more detailed description of how this is utilized in the field is provided in the Standard Operating Procedure (SOP) #8 - *Field Preperation and Surveying Protocols*.

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<td>a.) This is the ***Stake out point*** screen. The curser default location is always in the *Code* entry box and the code defaults to the listed name.</td>
<td>b.) If there is a *Feature Code Library* associated with the file then pressing any letter key associated with a code in the file will bring up a list of those feature codes. In this case the letter *C* was pressed. The feature code library (.fxl) file is *NPS point coding 09092015* as shown in the title bar.</td>
<td>c.) The operator then either taps or scrolls using the up/down arrow keys to highlight the code from the list. Then tap ***Select*** or press the ***Enter*** key to actually pick it. Codes with *A* inscribed in a circle are codes with attributes.</td>
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<td>d.) The code has been selected and is displayed on the top line. Tapping ***Enter*** or pressing the ***Enter*** key will return you to the *Stake out point* screen and the code you picked will be inserted into the *Code* entry box.</td>
<td>e.) The code appears in the *Code* box and the point is ready to be measured. Notice the ***Attrib*** soft key is enabled because this point code has an attribute. You can enter it now by tapping the soft key or enter it after you measure when it prompts you. Tapping ***Measure*** or pressing the ***Enter*** key will measure the point.</td>
<td>f.) This shows the point being measured. *Auto store* is not enabled hence the 15 seconds noted for the current observation time that has elapsed. Tapping ***Store*** or pressing the ***Enter*** key will store the point.</td>
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g.) This is the point code attribute screen. The point has been measured but it will not store until the code's attribute is defined.	h.) When you store a staked out point, it is removed from the stake out list by default. Only the point *5* remains.	

7.3 Notes function:

The Notes function in the controller is very convenient and easy to use.

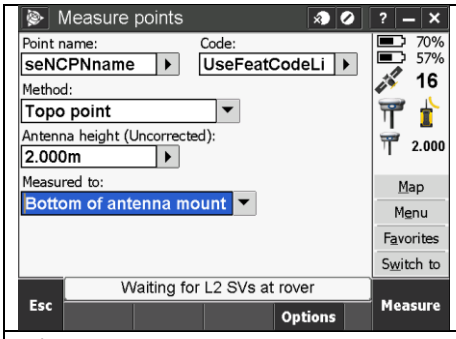
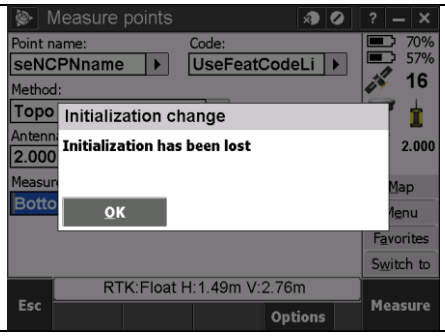
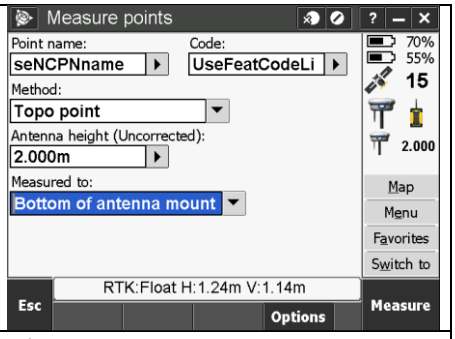
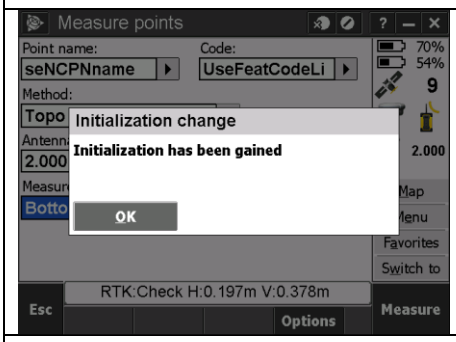
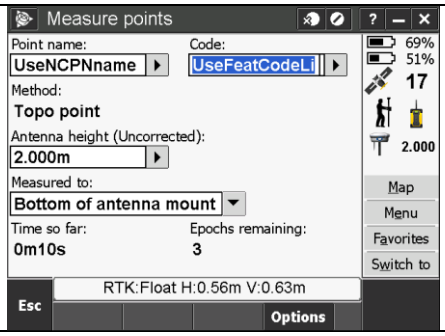
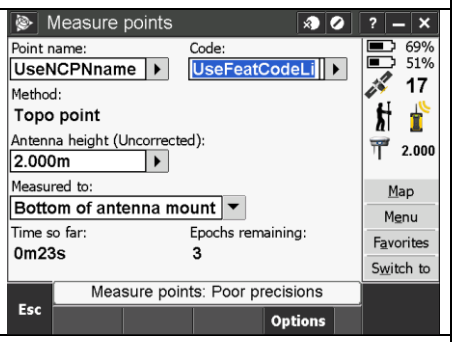


It's very convenient to attach notes to points as you are surveying. In the status bar tap *Menu* > *Key in* > *Notes* or *Favorites* > *Key in note*. This opens the ***Note*** screen. After you type a note and enter it, tap or press the ESC key to close the *Note* function.

7.4 Interruptions when measuring points:

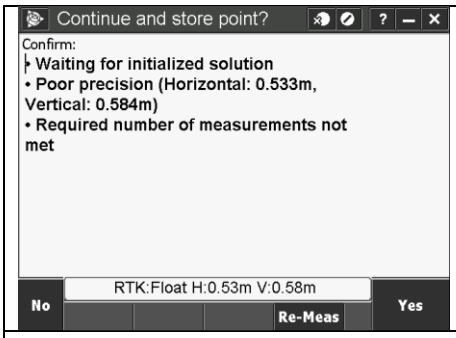
These are some examples of interruptions that can occur or prevent the measuring of points during an RTK survey and how to handle them. There are basically two sources for interruption problems: one is **satellite** related and the other is **radio reception** related. If the base point has been set to provide maximum sky coverage for the base receiver (always a priority) then the following satellite related issues are unlikely to occur when surveying in open areas with the rover. If/when you take the rover into vegetation that obstructs the receiver's sky view, or severely skew its sky view window (as being next to a towering canyon wall) then you are likely to experience satellite signal reception issues which manifest themselves with a ***Loss of initialization*** message.

7.4.1 Satellite signal reception issues:

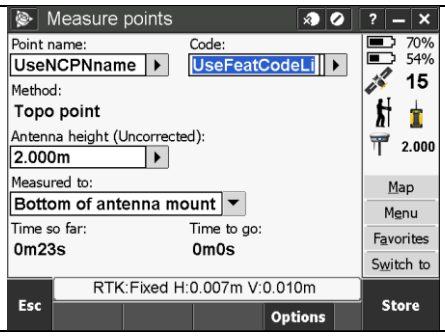
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<tr>
<td>a.) Status line message showing a problem. The operator is not presently measuring a point but the RTK: Fixed solution has been replaced by this message.</td>
<td>b.) Loss of initialization: You will see a brief message indicating Initialization lost. The Fixed solution will revert to Float. As can be seen the horizontal and vertical precisions have grown unacceptably large. Any number of issues can cause a loss of initialization.</td>
<td>c.) The Float solution continues but the precisions are getting better.</td>
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<td>d.) The receiver regains initialization and the user is notified. Audible messages also accompany the visual messages. The RTK: Check status will change to RTK: Fixed and the operator is good to measure a point provided that the precisions are acceptable.</td>
<td>e.) Here’s an example of losing initialization after a measurement has started. The solution status has gone to Float and the Store soft key is not shown because of this condition.

The countdown clock is removed and replaced with an Epochs remaining statement. An epoch is a time duration for a measurement; for RTK this is one second.

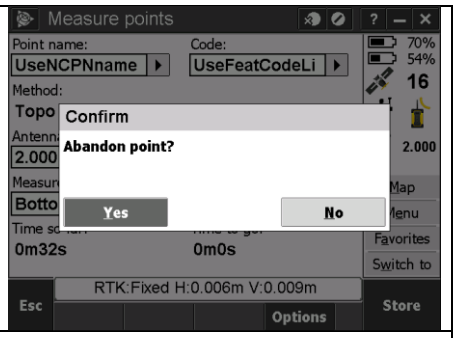
The horizontal and vertical tolerances shown in the status line are far above the acceptable limits.</td>
<td>f.) The solution has not improved at 23 seconds of measuring. 3 epochs still remain. I can still tap the blank soft key or press the Enter key to force the point to store.</td>
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</table>



g.) Here I've forced the store function of a less than quality point solution. This ***Continue and store point?*** confirmation message appears describing the problem and how bad the precisions are. If these conditions are acceptable for this point then tap *Yes* or press *Enter*. If not tap *No* or *Re-Meas*.



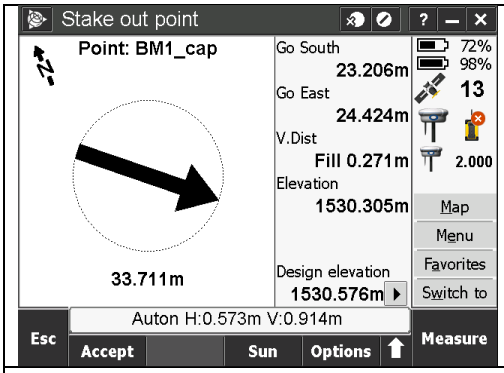
h.) In this case the measurement has been going on for 23 seconds and it appears that it's a good measurement by the precisions shown. However, for some reason I don't want to store this point. I'm going to **abandon** this measurement.



i.) Tapping the ***Esc*** soft key or pressing the ***ESC*** key will generate this ***Abandon point?*** message.

7.4.2 Radio reception issue:

If the base and rover receivers have adequate sky visibility then the only problem you are likely to encounter is loss of radio reception.



This screen shows a **loss of base radio reception**. When this occurs you will see the radio icon has a red circle with an X inscribed in it. The positioning solution will revert to *Autonomous* as shown in the status line and the precisions will become very poor. Also, the green radio light on the rover receiver will stop blinking. The only readily available solution is to raise the rod height to the max to get the radio antenna higher up and wait for a minute or two. Sometimes the radio will drift in and out and you may still be able to get a shot.

This problem is minimized by a combination of good base station placement to start with and taking notes on how the base radio is set up to overcome this condition in repeat survey sessions. If the base station is located out of line of site or a large distance from where the rover is being used the connection issue could be related to the radio signal not being transmitted far enough. This could be due to a low output wattage set on the base broadcast radio (5W instead of 35W) or the points being measured are located around a canyon corner where the radio signal is not able to be received. In the latter case the only option to continue surveying is either to move the base station or use a repeater radio if one is available. A repeater radio allows you to move to a location where the base radio signal is beginning to drop out and setup up an additional radio that will receive the base radio signal and re-transmit the signal using an additional broadcast radio.

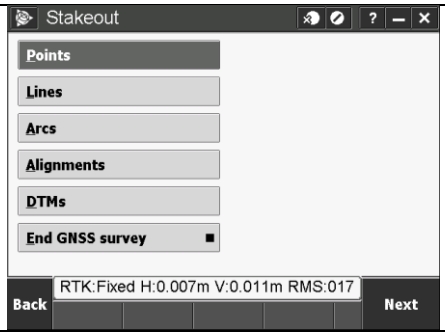
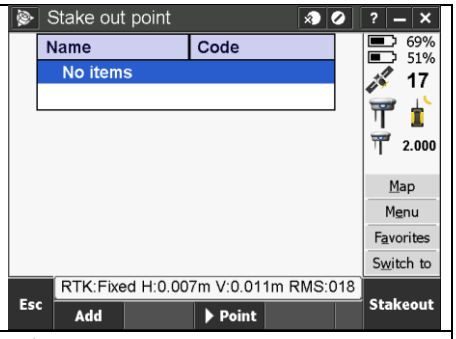
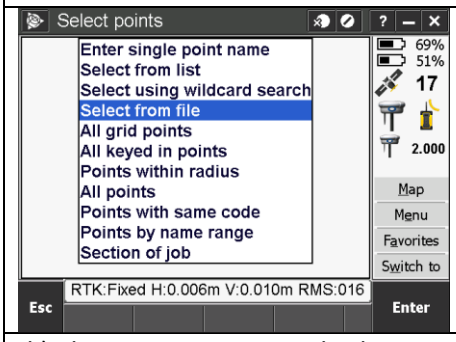
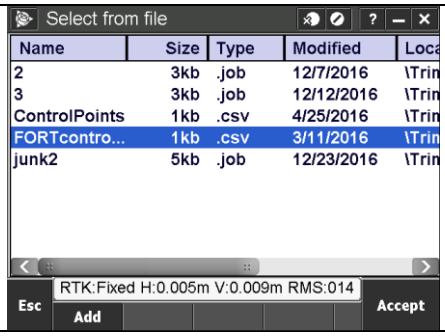
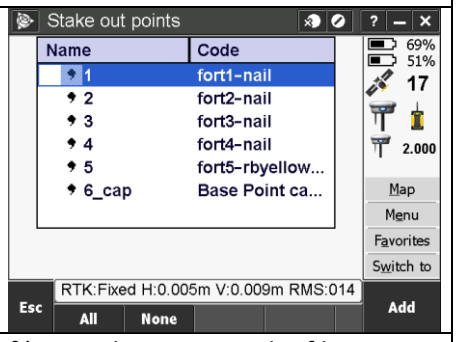
8 Staking out:

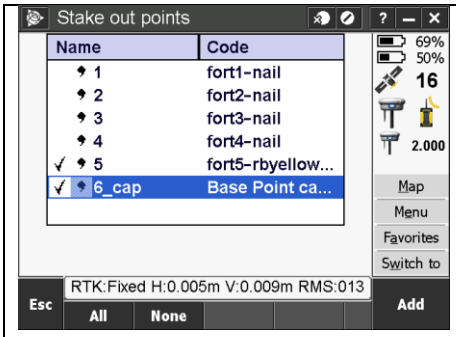
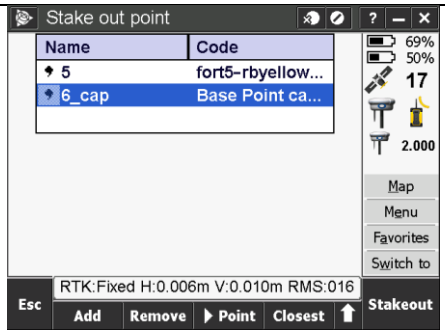
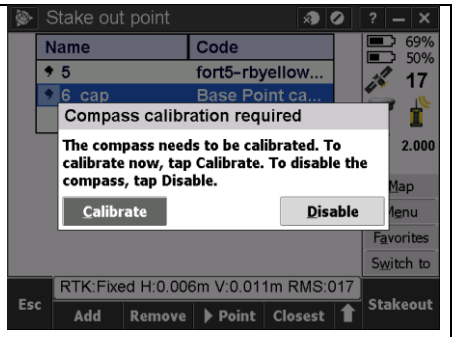
"Staking out" (also called *setting out*) is the process of determining where a point or object exists in the current coordinate system and then perhaps measuring and storing an additional record at that position. This section shows how to stake out two common objects, a *point* and a *line*, in an RTK survey.

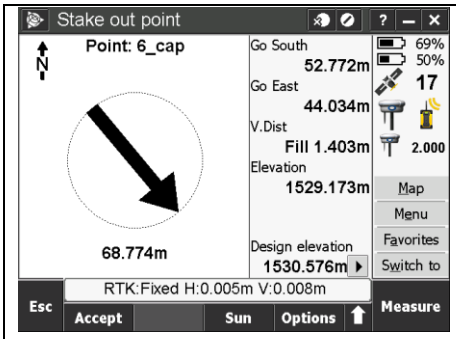
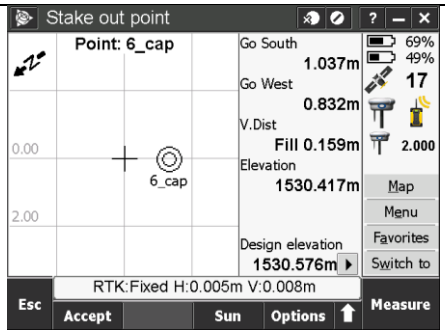
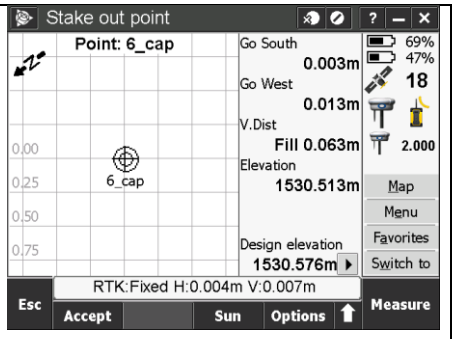
Key points:

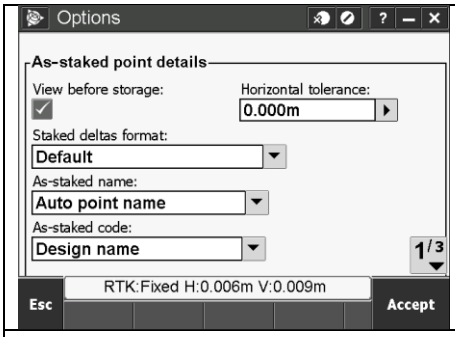
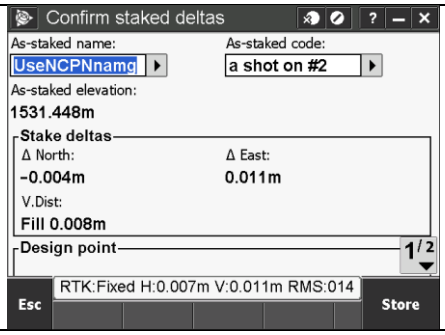
- Staking out a known point for the purpose of verifying that the RTK survey system is properly set up and functioning is vitally important and should be done as a matter of good field practice immediately after the rover survey is started. The staked point should match the known coordinates within a couple centimeters horizontally and vertically. If not figure out why not before proceeding, especially with any kind of stake out procedure. All rovers should stake out the same point independently and rover operators should compare 'As-staked' coordinate differences (*View before storage* option set to ON check-mark).

8.1 Staking out a point:

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<td>a.) The main job screen, pick ***Stakeout***.</td>
<td>b.) Pick the ***Points*** option.</td>
<td>C.) This is the Stake out points screen. Notice there are no points listed. Tap the ***Add*** soft key.</td>
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<td>d.) These are various methods to add points to the stake out list. Generally, we link files to the job so go to ***Select from file*** and tap ***Enter*** or press ***Enter*** key. See the part about linking files in Create a job if you need to do this.</td>
<td>e.) Now a list of available files is shown. Highlight the file you need and ***Accept***.</td>
<td>f.) Now the points in the file you selected are shown.</td>
</tr>
</table>

		
g.) **Check-mark the ones you need**. Optionally, you can tap the *All* soft key at the bottom, tap ***Add***.	h.) The points you check-marked from file listing are now added to the stake out list. • Highlighting a point and tapping *Stakeout* or pressing *Enter* will start the stakeout process for that point. Tapping *Closest* will start the stakeout process for whatever point on the list is closest to your current position.	i.) The internal compass won't remain in calibration because we do survey work in locations that are quite far apart from each other. As a result, this ***Compass calibration*** message pops up as soon as you try to navigate to a point. You can either disable it or follow the calibration procedure. The calibration procedure requires you to release it from the rod, turn it 360 in the face up position, roll it 360 end-over-end, and roll it 360 through face down to face up again.

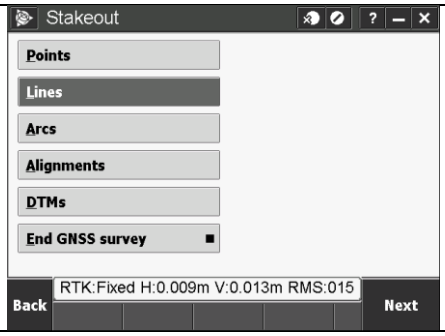
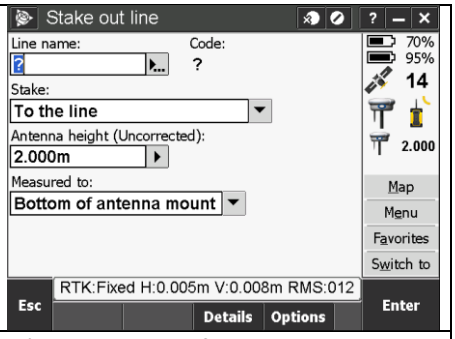
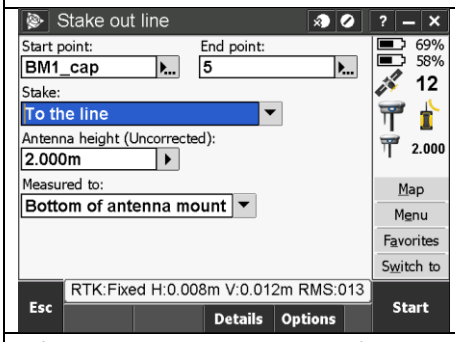
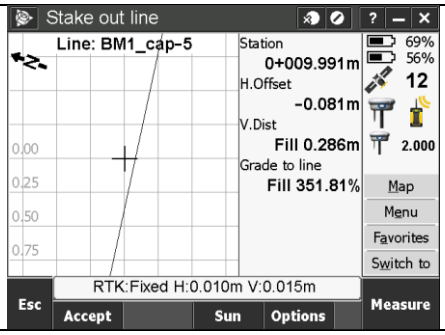
		
j.) If the rover is more than a few meters from the point then you'll see this big arrow display telling you how far you need to go and in what direction. Note the relationship to the North arrow.	k.) When you get close enough to the point the display will change to this. • Your location is the cross in the middle. It doesn't appear to move. This is called *Surveyor centered* (changeable in Options to *Target centered*). • The point location is the round circle object. It moves around as you do. • There is a compass direction shown in the upper left to help you know which way to move. Some operators prefer a small compass mounted on the rod. • Distances to the point are also shown to help you know how far to move in a direction. *Cut* or *Fill* are survey terms meaning 'down' or 'up' respectively. • When you have moved the tip of the rod to the stake out coordinate and plumbed it using the rod's target bubble, the distances to the point will be a few millimeters or a centimeter or so. This depends on the quality of the positioning solution shown in the bottom status bar.	l.) Here, the operator has positioned the rover rod on a survey cap monument. As can be seen, the horizontal positioning is acceptable at 3mm and 13mm. However, vertical distance is indicating a problem. It's saying I need to come up about 6cm to get to the point (Fill 0.063m). As it turns out this monument was run over by a tractor and squashed down into the ground about this much. Tapping ***Measure*** or pressing ***Enter*** will put you temporarily in the *Measure Points* screen (previously discussed) and will start measuring a point.

		
m.) The *Options* screen (Stake out point ***Options*** soft key). The ***View before storage*** option lets you see the relationship between the position you just measured and the known coordinates of the point.	n.) If *View before storage* is check-marked then this ***Confirm staked deltas screen*** appears when you try to store a staked out measurement. This allows the operator to see how close the measured point is and rename, recode, or escape (abandon measurement) if necessary. • Just like *Auto store* (unchecked) for measured points, this option is nice when you are wanting to see the actual details and have the option to cancel (Esc) or store the shot but for general topo work uncheck it if you don't need to see the details.	

8.2 Staking out a line:

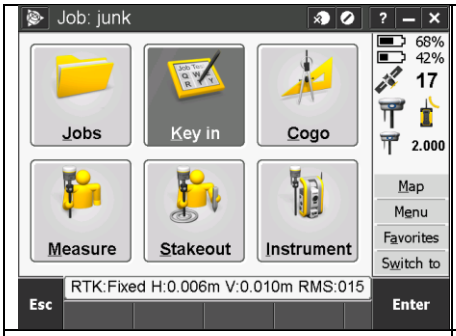
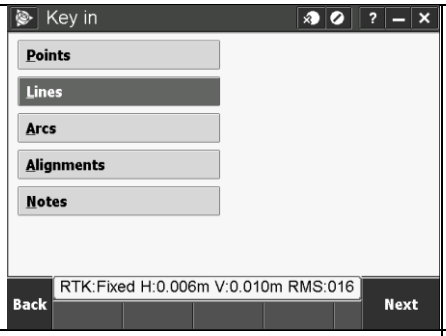
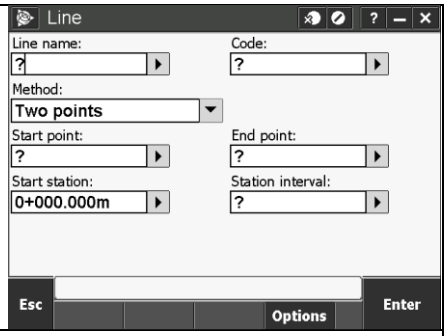
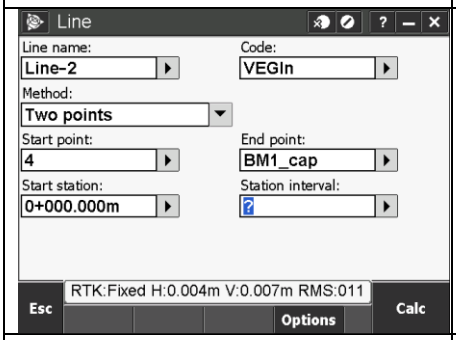
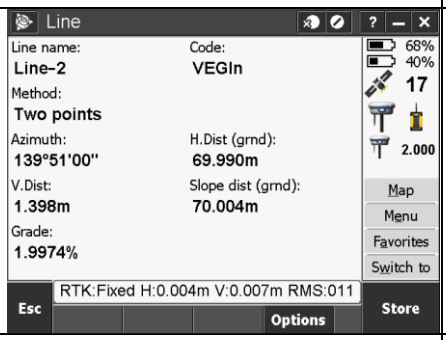
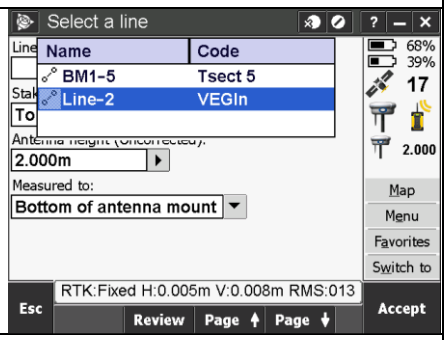
There are a few different ways to stake out a line. The two most commonly used ones are by *Line name* and by *Two points*. First we will discuss the Two points method.

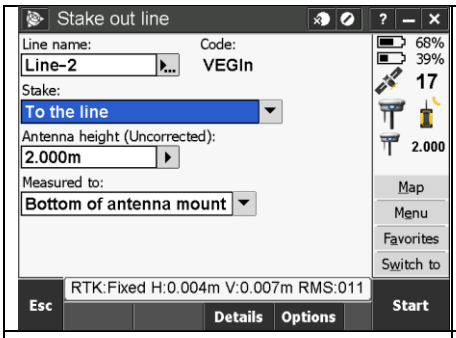
Staking a line by two points is faster to initiate but you will only be able to see the line in the stake out program. It will not be visible in the map.

<table>
<tr>
<td> 
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<tr>
<td>a.) The main job screen, pick Stakeout.</td>
<td>b.) Pick the Lines option.</td>
<td>c.) This is the default Stake out line screen (by Line name). To stake out by two points, use the drop-down list and tap ahead of the Two points method to place a check-mark there. That will open the Stake out line by two points screen (following).</td>
</tr>
<tr>
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<tr>
<td>d.) This is the Stake out line (by two points) screen. You can pick the start and end points by opening the drop-down list for each. Tapping Start or pressing the Enter key will start the stake out process.</td>
<td>e.) Here you can see the line on the display. The rover's position is indicated by the cross. H. Offset is negative if the rover is left of the line. The left or right side is predicated on the direction the line is defined from start point to end point.</td>
<td></td>
</tr>
</table>

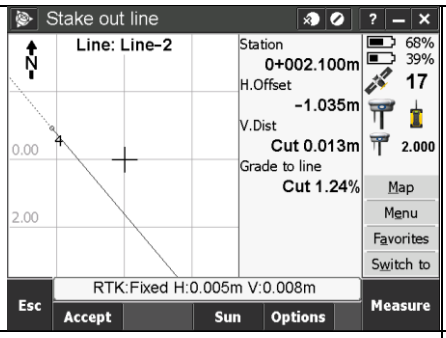
8.3 Stake out a line by name:

This method starts with the assumption that you need to create a *named line object*. This takes slightly longer to set up but you can see the line object in the *Map* view as well as in the *Stake out line* display window.

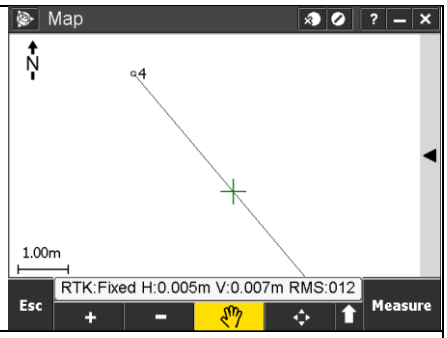
<table>
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</tr>
<tr>
<td>a.) The main job screen. Select Key in.</td>
<td>b.) Select the Lines option.</td>
<td>c.) The Key-in Line screen. You can always stake a line by two points without defining it as a line object in this key-in screen but you won’t be able to see it using the map function.</td>
</tr>
<tr>
<td> 
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<tr>
<td>d.) The line object has been named and coded. The line object is defined by two points and the stationing at the start point has been set to 0 (default). If you need to measure points at set station intervals then fill in the Station interval box. Tap Calc or press the Enter key to create the line object.</td>
<td>e.) This shows the created line object, its direction, length, etc. Press Store to store it and you will be returned to the stake out line’s Select a line screen.</td>
<td>f.) Tapping on the Line name drop-down list brings up all the known line objects. Tap on Line-2 to select it.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</table>



g.) The selected line is entered into the Line name box. Now the ***Stake method*** is highlighted. In this case, for topo measurement, I'm not concerned with where on the line I am as long as I'm on the line so I'll choose ***To the line*** from the drop-down list. If I needed to be at a certain spot on the line I would have picked *Station on the line*. Tapping ***Start*** or pressing ***Enter*** will start the actual stake out process.



h.) Here you see the actual stake process. You can see the line in the 'window' and one of the endpoints, point 4. The cross in the middle is where you are in relation to the line. Remember how the line was defined: Start at point ***4*** end at point ***BM1_cap***. Your current position is about 2 meters from the start point along the line and a little over 1 meter left of the line. If *H. Offset* is negative, you are left of the line. If *Station* is negative you are behind the start point. Since the line is a vector, the *V. Dist* means your current position is above or below the line. For our intent and purpose we don't really care where the line vector is vertically. If a measurement on the line is needed at this time then move right about a meter until the *H. offset* value drops to near zero.



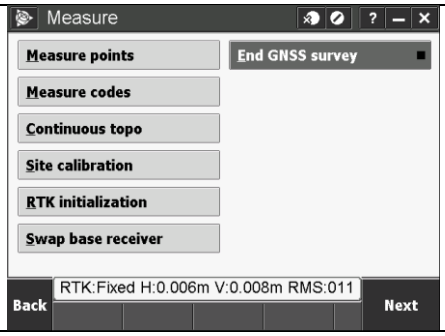
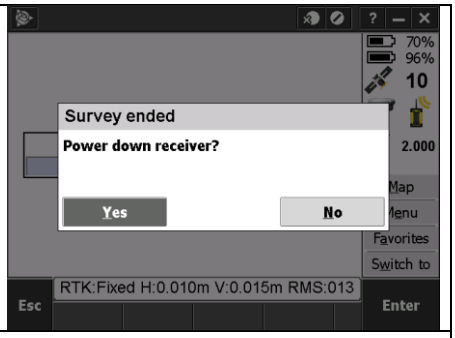
i.) This is the map function. Main job screen, ***Map*** from the menu bar. Since the line is a named object it will appear on the map. The map function does not give you any numerical values about your relationship position to an object. For tight tolerances along the line and stationing I would suggest using the previous method (Stake out line). For faster positioning many find the map function easier to use. However, the operator must **pay attention to the map scale** as the depictions of lines, points, position cross, etc. appear the same size at any scale. So you may be watching the line move in relation to the cross as you position yourself on the line and think you are on the line (as it appears here) only to find out later in the office that you were over a meter away because the scale was at something like 20m. I find the scale at .5m to 1.5m adequate for topo work. Here, the scale is at 1 meter and a reference bar is shown for comparison to other objects in the map window. It would appear that the rover's current position is within a couple of centimeters of the line based on comparison to the scale bar, acceptable for topo work.

The yellow 'hand' soft key is the current enabled map operation. The map view can be dragged along the line using the touch screen. The big 'up-arrow' soft key opens up other map options.

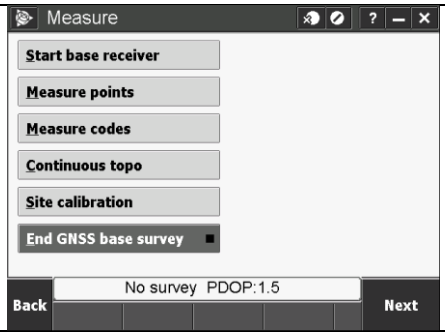
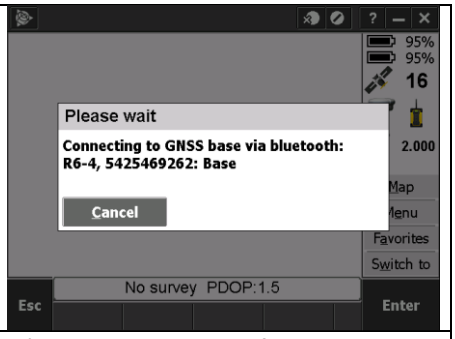
9 Step 5 - Ending the survey:

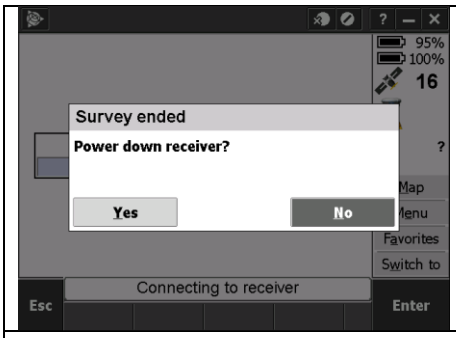
This is a two-part process. First end the rover session, then end the base session.

9.1 Ending the Rover session:

		
a.) From the main job screen, pick ***Measure*** to get to the options.	b.) Pick the ***End GNSS survey*** option.	c.) You will see a brief message saying *Ending survey* and then see this *Survey ended* message. Picking *Yes* will turn the receiver off. Picking *No* will leave the receiver running and receiving radio broadcast but the survey session has ended. The screen will return to the main job screen. Whether or not you power down, if you forget to measure something simply start another survey session and reconnect to the base radio.

9.2 Ending the Base session and retrieving the base file:

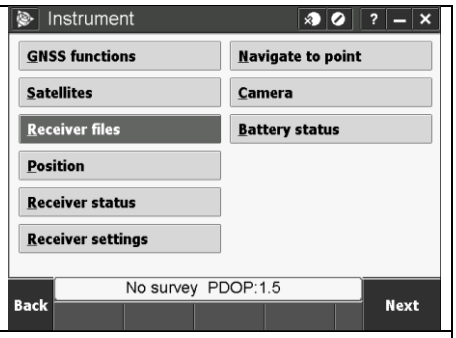
		
a.) The main job screen, pick ***Measure*** to get to the options.	b.) Notice the *End GNSS survey* option (for the rover) is no longer available. Pick ***End GNSS base survey***.	c.) You will see a brief message saying *Connecting to GNSS base via bluetooth*. It will hang on this screen if you are not within Bluetooth wireless range.



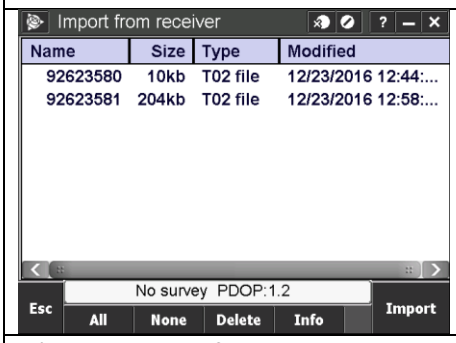
d.) You will then see a brief message saying *Ending survey* and then see this message. The default is *Yes* but you need to pick ***No***. This will end the base session but leave the receiver powered on so you can extract the base file it created. Base files accumulate in the receiver (up to the point of reaching storage capacity) and they can be retrieved later but because they are unreadable and the names are somewhat obscure it is better practice to get it now so it's immediately available to work with.



e.) After the base session has ended it will put you back in the main job screen. Note in your base log file when the base session ended. Go to ***Instrument***.

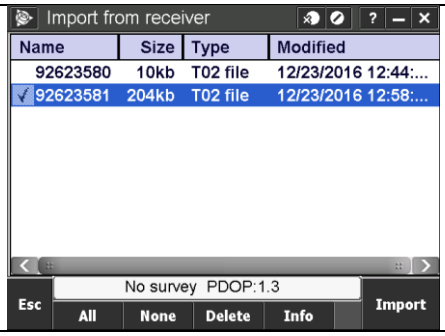


f.) Pick the Receiver files option.

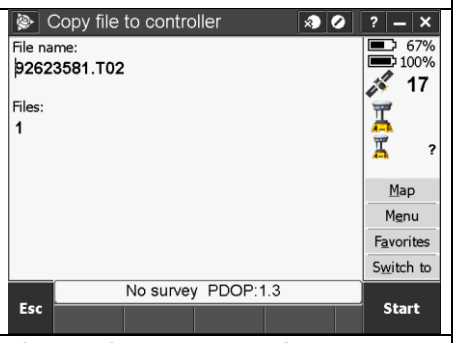


g.) This is a list of all the receiver files logged base data currently in the receiver. Every time the base is started it logs a file. Some of these may not contain relevant information. Look for files by date and by size. The 8 digit file name is composed of:

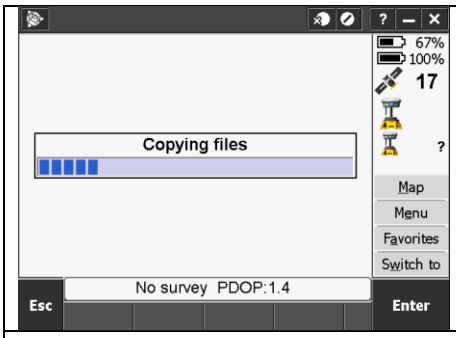
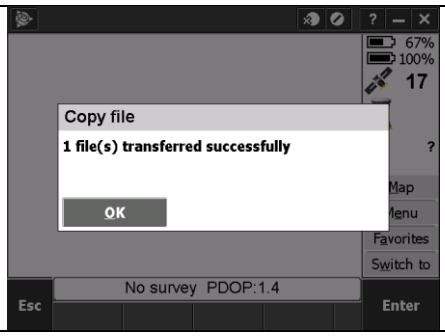
- First 4 digits are the last 4 digits of the receiver serial nuber.
- Next 3 digits are the day of the year.
- Last digit is sequence number of files created in a day, starts with zero.



h.) Check-mark the files you want to copy by tapping in front of the file name. Tap ***Import*** or press the ***Enter*** key.



i.) A confirmation list of the selected files you want to copy appears. Tap ***Start*** or press the ***Enter*** key to start the Bluetooth transfer. The base files will be copied to the root folder. Note the names of the base files and maybe the sizes in your base log so you know which files go with which base point.

		
j.) The selected file(s) will start to be copied to the controller. Keep the controller near the base receiver and don't unplug or turn off the base receiver until the transfer is finished. It can take several minutes for a large file.	k.) This notice will appear when the transfer is complete. Tap OK and you're done. You can now power down the base receiver by pushing the power button for about 4 seconds or from the controller by answering *Yes* to the power down question again.	

Appendix A: Survey Coding Cheat Sheet

This is an example of the surveyor's "Coding Cheat Sheet". Its printed on approximately 5x7 inch front and back and lamanated.
This helps the field surveyor to properly name files and pick codes. This is created from the Feature Coding Library (.fxl file) associated with the job.

NCPN Survey Code Library		
Controller file names:	"Project+Site+year+rover# +person"	
Example:	*CanyQA2014r2HoJo*	
Pt Names:	"Site+YY+rover#+pt# "	
Example:	*QA15r2p0001*	
Point ID	**Pt Code**	**Attributes Required (ID/Distance/Time Ref)**
Transect Start/End	TxStart/TxEnd	transect #/ID, stationing
Cliff Wall	CW	
Top of Bank	TOB	
Grade Break	GB	
Bottome of Bank	BOB	
Ground Shot	GND	
Tagline Meter Mark	TAGm	Tagline location (optional)
Sand Cap	SC	
Edge of Water	EOW	
Submerged shot	SUB	
Thalweg	THL	
Vegetation Plot	VEGplot	Plot ID/#, Plot type
Cliff Wall Breakline	CWln	
Top of Bank Breakline	TOBln	
Grade Break Breakline	GBln	
Bottom of Bank Breakline	BOBln	
Ground shot Breakline	GNDln	
Sand Cap Breakline	SCln	
Edge of Water Breakline	EOWln	
Submerged shot Breakline	SUBln	
Thalweg Breakline	THLln	
Begin breakline	begin	
End breakline	end	

NCPN Survey Code Library		
Controller file names:	"Project+Site+year+rover# +person"	
Example:	*CanyQA2014r2HoJo*	
Pt Names:	"Site+YY+rover#+pt# "	
Example:	*QA15r2p0001*	
Point ID	**Pt Code**	**Attributes Required (ID/Distance/Time Ref)**
RTK Base	RTKbase	ID of base station point
Control Points	CP	CP# or ID
Right/Left Head Pin	RHP/LHP	Transect ID
Tansducer Eye Bolt	TransBolt	Transducer ID
Tansducer Reference Mark	TransRef	Transducer ID
Transducer WSE	TransWSE	Transducer ID, date, time
Photo Point	PP	PP Type, PT ID
Water Surface Elevation	WSE	
High Water Mark	HWM	
HWM Breakline	HWMln	
Large Woody Debris	LWD	
LWD Breakline	LWDln	
Temporary point	TMP	PT ID for temporary point
Check Shot	CHK	PT ID for check shot

Appendix B: Packing list

Base station gear:



Base station setup:

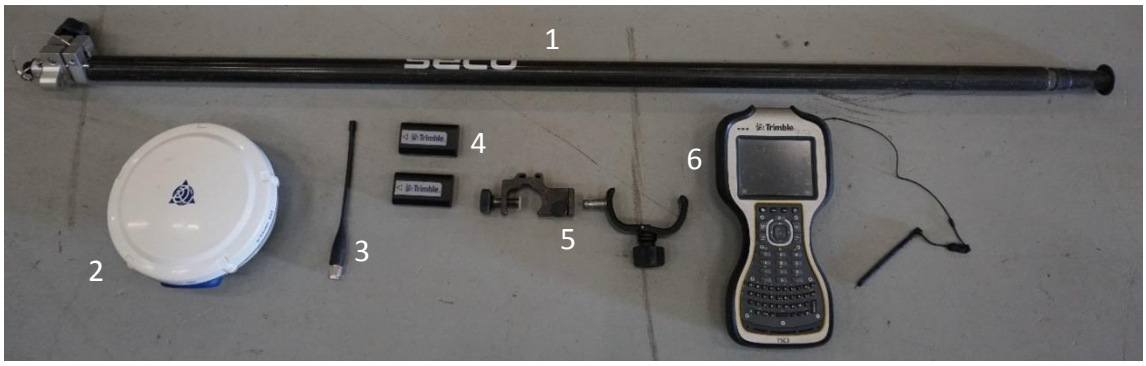
1. 42-watt solar panel with connecting cable
2. Extension rods for radio antenna
3. Tribrach base
4. Tribrach adaptor (removable mount)
5. Flat disc for mounting radio antenna rod on tripod
6. Long whip antenna
7. Short whip antenna
8. Antenna base (connects to antenna coax cable #13 and whip antenna #6 or #7)
9. Solar panel voltage regulator/battery saver
10. R6-4 base receiver dome
11. Short extension pole for base receiver (0.2m)
12. TDL-450 broadcast radio
13. Radio antenna coax cable with fixed antenna mount
14. Power/data cable for base receiver and broadcast radio
15. Marine battery with quick connect cables for base receiver power and solar panel
16. Heavy duty wooden tripods for base and radio antenna

Not shown but often necessary: A means of securing the base receiver, base radio antenna, and solar charging panel from being toppled by strong winds. There are generally two methods; weigh it down or tie it down.

- In areas where there is only rock; A set of six 24” – 30” bungie cords to strap rocks to the tripod legs as ballast to help prevent wind topple and hold down the solar charger. (Photo example shown on page 3)
- In areas of sufficient soil depth; A set of six tent pegs and a tie-down kit, 3 lb. hammer, and a set of four smaller bungie cords for use in holding down the solar panel with 4 tent pegs.

Appendix B: Packing list (cont'd)

Rover gear:



For each rover setup:

- Rover rod (adjustable height model shown, with flat topo tip)
- Rover receiver
- Receiver radio antenna
- Receiver batteries (you'll need at least 2 per rover)
- Rod mounting bracket (2-pieces)
- Survey controller (TSC3 controller)

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

Standard Operating Procedure (SOP) #17

Trimble Business Center Office and Field QA/QC Operating Instructions

Version 1.01 (January 2021)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	1/30/2021	L. Gommermann	Added appendices A – D	To provide additional details for survey processing	1.01

1 Overview of Trimble Business Center (TBC) Program

1.1 Online Tutorials

The following online tutorials might be helpful in learning the ins and outs of TBC and general RTK surveying practices.

- https://youtu.be/KLCDQ8yafY0 (Best Practices for Minimizing Errors during GNSS Data Collection)
- https://youtu.be/O-oXxe6hGuA (Frontier Precision - NAD83, Datums, and Geoids)
- https://youtu.be/HnWNhyxyUHg (Intro to coordinate systems and UTM projection)
- https://youtu.be/MvBIFqLhEhU (Using the Trimble GNSS Online Planning Tool)
- https://youtu.be/XBMZlFS-Lmk (Post-Processing GNSS Data with Trimble Business Center 3.00)
- https://www.youtube.com/playlist?list=PLRzg5z9U-U91vgISnxmVaiZSzYHK3UDSs (Trimble Technical Workflows by California Surveying & Drafting Supply)

1.2 Initial TBC Settings and Options

The options menu (File > Options) is used to set some of the characteristics of how TBC looks and works for you.

On the left side is a menu structure for the options. The ones you will probably want to modify are the first three in the General options list and the *Improvement Program* option.

To turn off the nag for the ***Improvement Program***, open this option and select the ***No*** radio button.

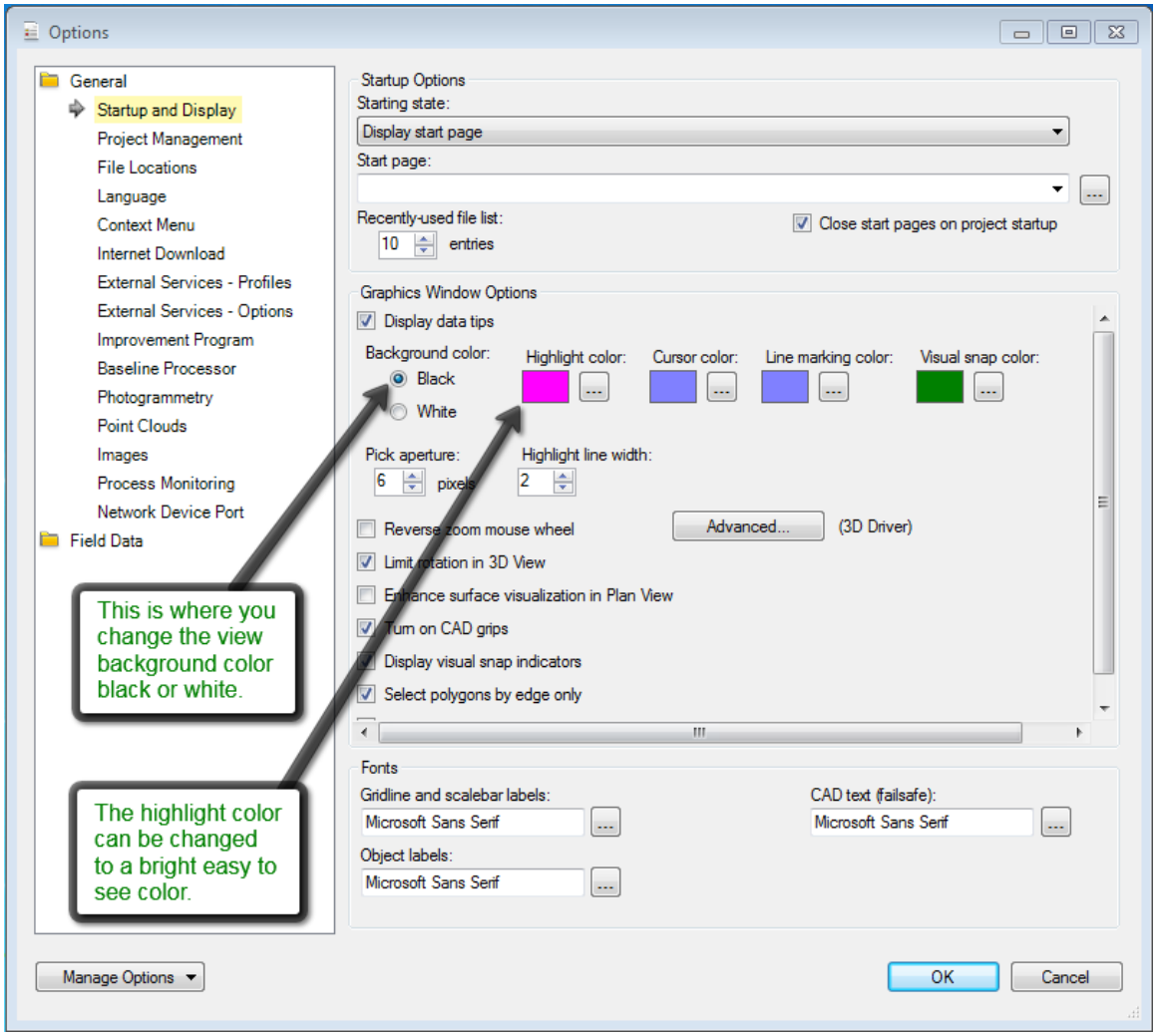


*Figure 1 – This is the **General Options** menu showing the Startup and Display options. NOTE: This indicates a black view background has been selected which is what I prefer. However, I have done the screen captures for this presentation using the white background.*

1.3 Project Management

The next category in the *General Options* menu is ***Project Management***. This category contains five file path settings and some switches. The first three file path settings are discussed below. The other two paths are left at the default setting.

When TBC is installed on your computer, it creates a default folder/directory called *Trimble Business Center* in the Documents directory of your user account. The path may look something like this: *C:\Users\YourUserName\Documents\Trimble Business Center*. So, the default location for several of the project management options will be this *Trimble Business Center* folder. We now look at the effects of modifying paths and settings. Any changes made in TBC's *File* > *Options* menu are persistent and will remain until you change them.

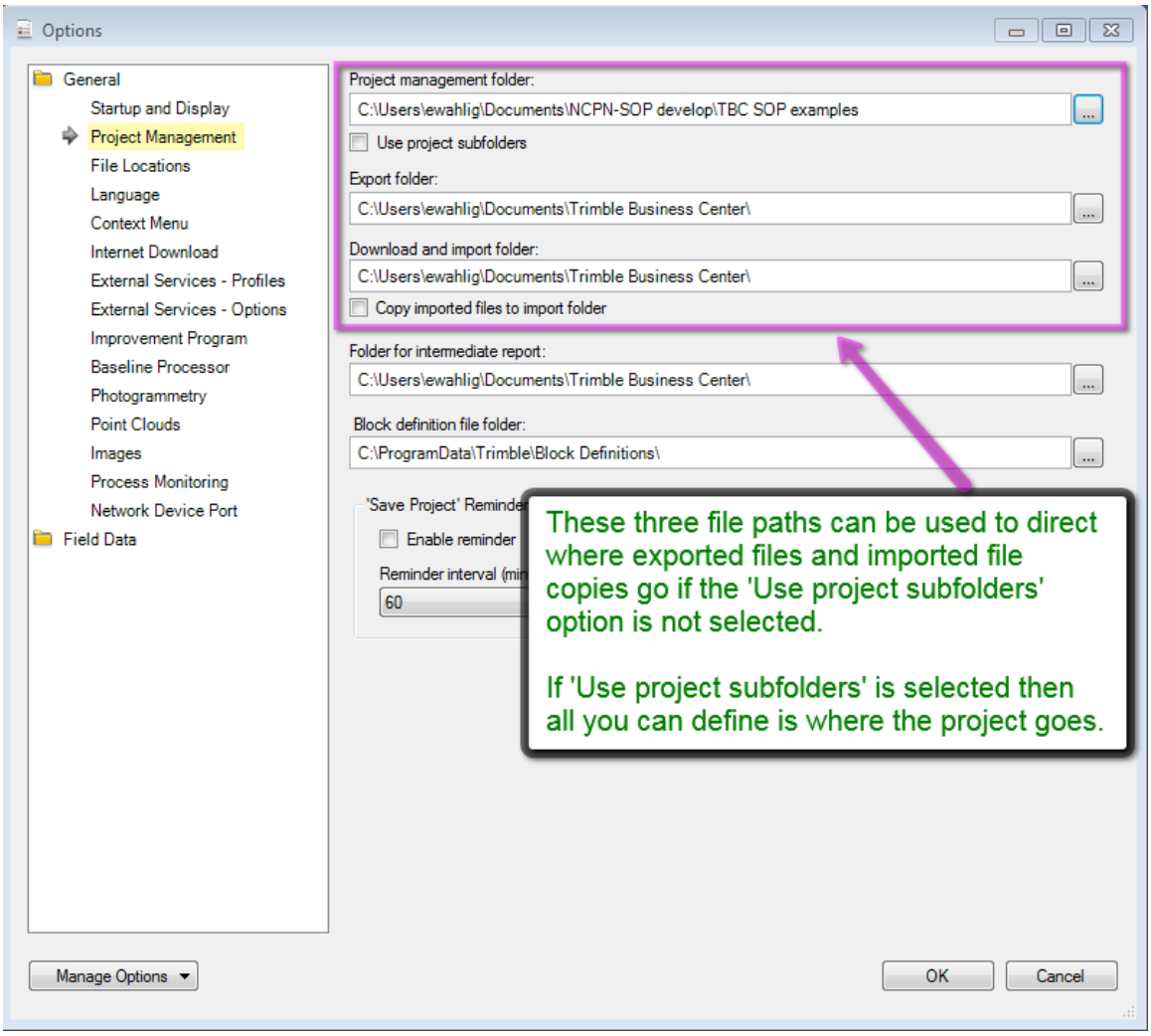


*Figure 2 – This is the **General Options** menu showing the Project Management options.*

The first location option is the ***Project Management*** folder path. This is where the TBC project will be stored. If you are working on several projects from one trip then set this to that folder/directory to avoid having to keep setting the path when you save projects.

Note - The '***Use project subfolders***' option is enabled by default. It is intended to help manage large projects having lots of files from various sources. For the type of survey work we do, this option tends to create subfolders for every job file which contain only the job file, a redundant copy of the feature coding library, and possibly a subfolder of images if any were taken with the controller. If you like this file management system then leave it enabled. If you prefer to have more control of the file structure and like to have your files organized/grouped by type of data then disable this option. Disabling this option will then enable the ***Export folder*** and the ***Download and import folder*** paths discussed below. **This setting is project specific and must be set before a project is created. Once the project is created it can't be changed.**

The second location option is the ***Export folder*** path which is enabled if you disable the '*Use project subfolders*' option. This is where file exports from TBC will go. You can change it to your preferred location but, it will eventually happen that you will forget about this path when you create a project and export a data file and wonder where it went. This is where you find where it went.

The third location option is the ***Download and import folder*** path which is enabled if you disable the '*Use project subfolders*' option. This can also be set to your preferred location and, as mentioned, if you don't see your job files being imported (if you enabled the '*Copy imported files to import folder*' option, check this path to see where they are going.

Basically, enabling the '***Use project subfolders***' option ensures the data from a project stays together with the project at the expense of creating a lot of folders and subfolders with some redundant files. Disabling this option allows more control of the file structure and naming at the expense of sending the project or project data to a previously set path if you forget to change the path before importing/exporting data because these path settings/switches are persistent.

2 Starting a new project:

Go to *File* > *New* or from the start page select *Start a new project*. You will be presented with a Template selection list for the new project.

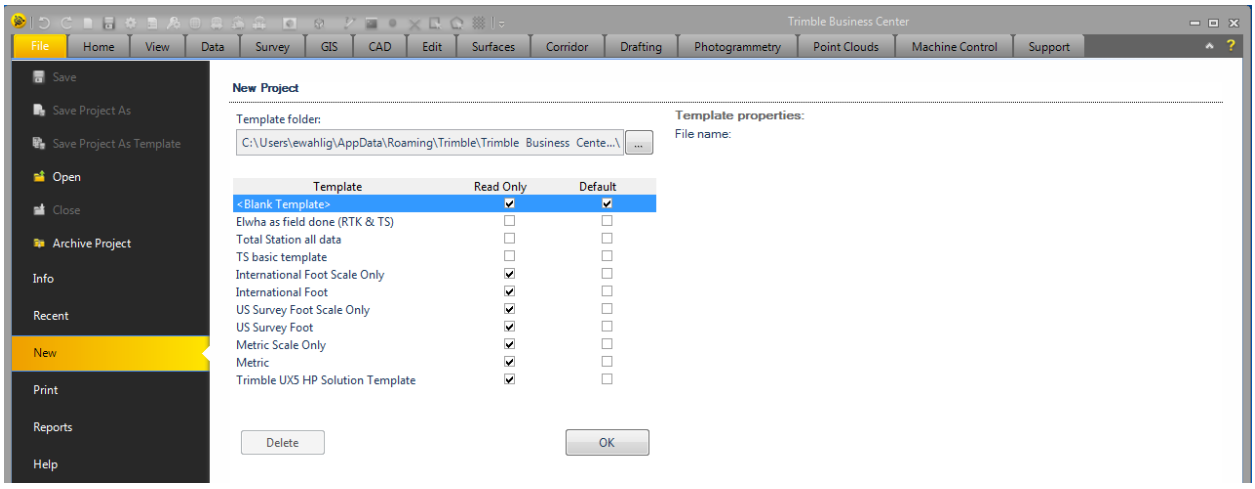


Figure 3 –New project screen showing template options.

Select ***Blank Template*** and then ***OK***. This will create a new project with default coordinate system and datum transformation definitions. You will then be presented with the new survey home screen showing the survey plan view as seen below.

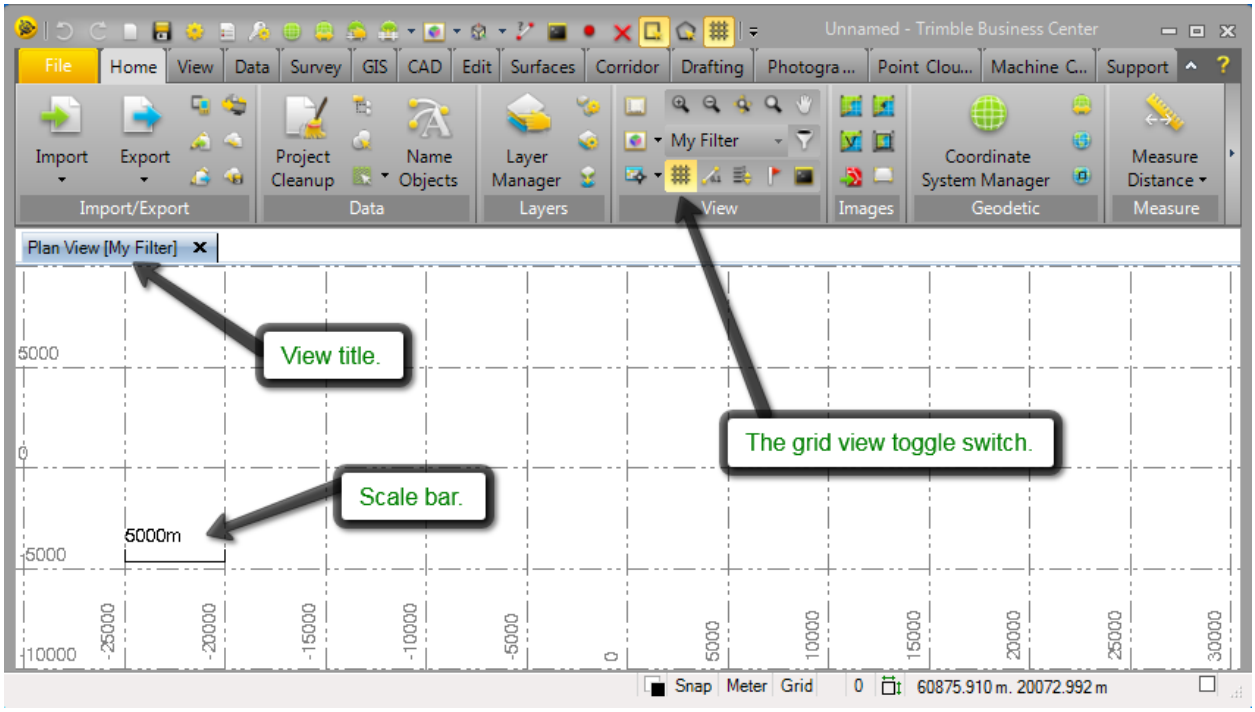


Figure 4 –New project home screen.

This is a new project showing the standard plan view. There is no data in the project. Notice the grid ordinate is in the center. New projects look the same but the grid position may be quite different depending on the coordinate system definition. The coordinate grid can be turned on/off by clicking on the grid icon.

Next we look at some of the Toolbar icons and adjust some project specific settings. Below in the TBC toolbar showing some of the most often used functions. You may want to add the inverse function as has been done here.

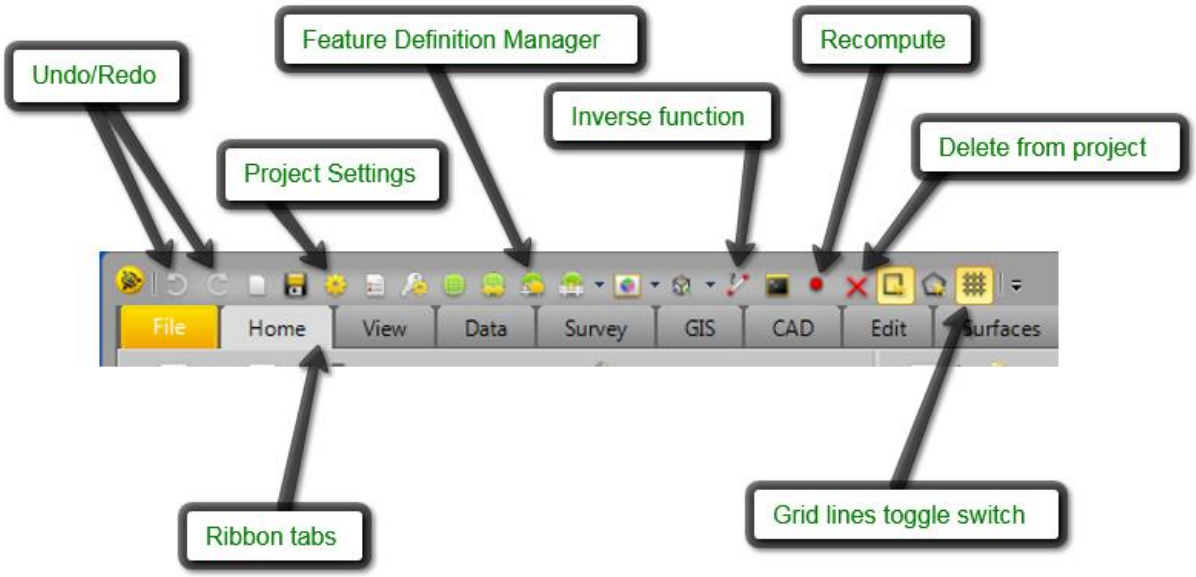


Figure 5 – General TBC toolbar showing common icons used within the program.

To set some project specific parameters and understand what coordinate system is used in a 'Blank Project', click on the *Project Settings* icon. This will bring up the ***Project Settings*** dialog below and allow you to see what the current settings are as well as edit some of the information as it pertains to your project. The menu on the left side in the figure below is indicating the *General Information* folder is open and being shown. Notice that some entries are written in blue. Any values written in blue are changeable. Sometimes, what is written in black or gray in one dialog can be changed by opening the correct dialog to address that value.

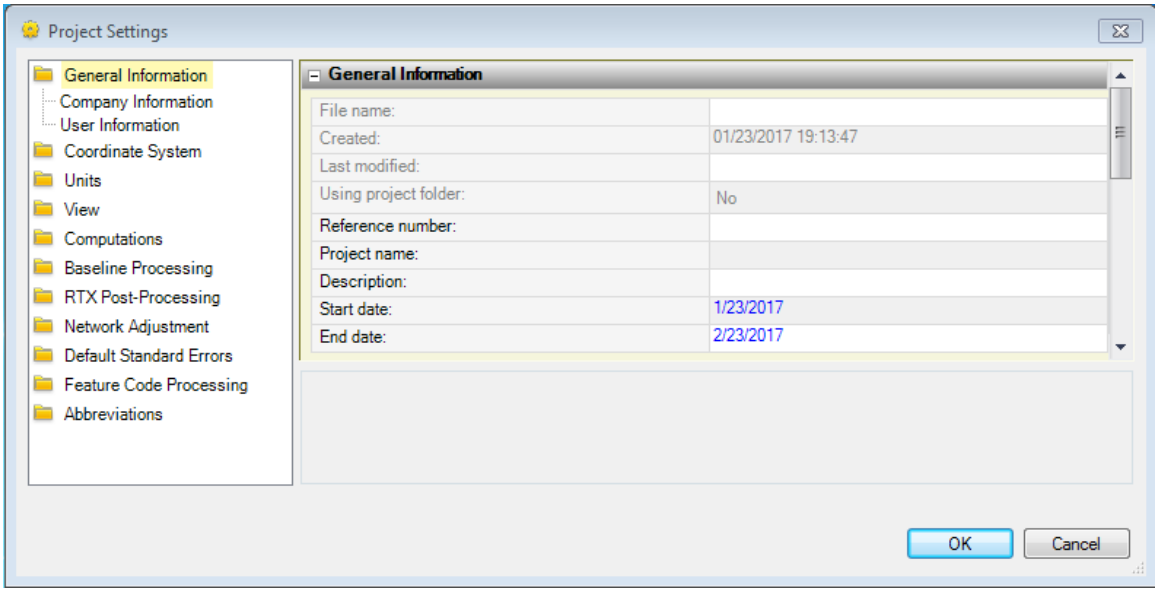


Figure 6 – TBC project settings window.

This is the *Coordinate System* dialog. We'll take a minute to discuss the coordinate system defined by the Blank Project template as this will help you know what to look for when you import data from a field survey.

The *Coordinate System* folder has been opened to show the current coordinate system summary. Notice it has a default Coordinate system group and no datum transformation. The default projection is Transverse Mercator.

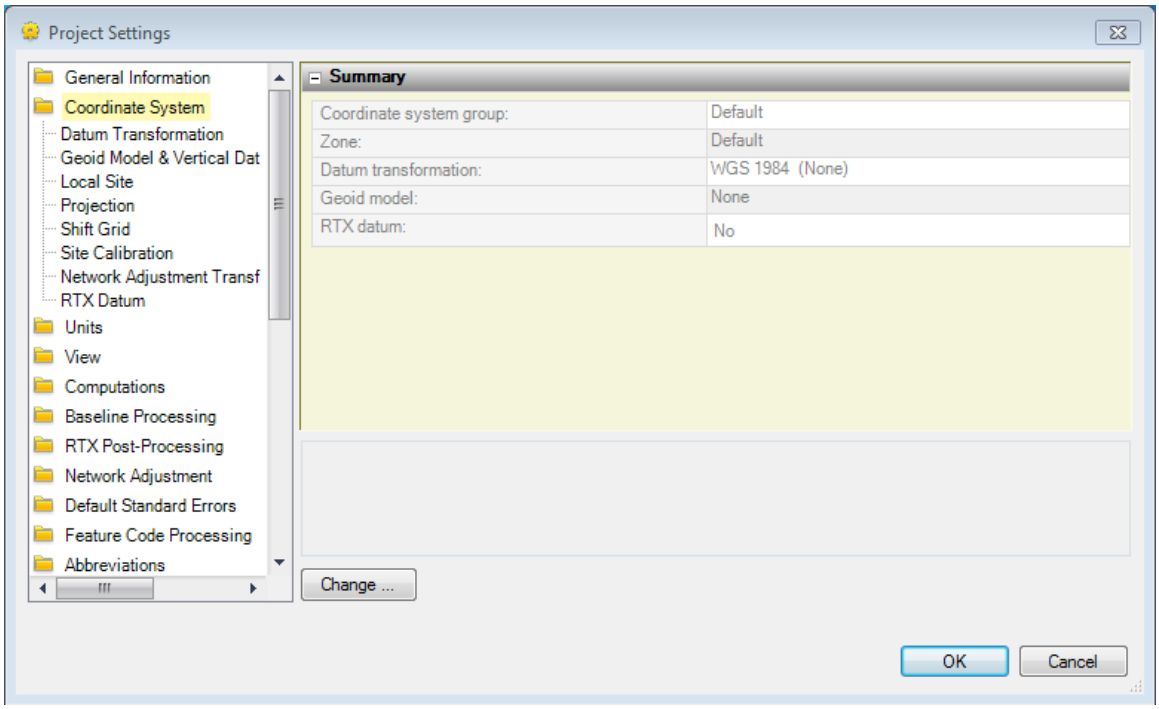


Figure 7 – TBC project settings window showing the coordinate system settings and options.

This shows the *Datum Transformation* defined by the Blank Project template. There is no transformation method as WGS84 is a world-wide geocentric model not a locally defined model. Local datum transformations are defined by either a three or a seven parameter transformation.

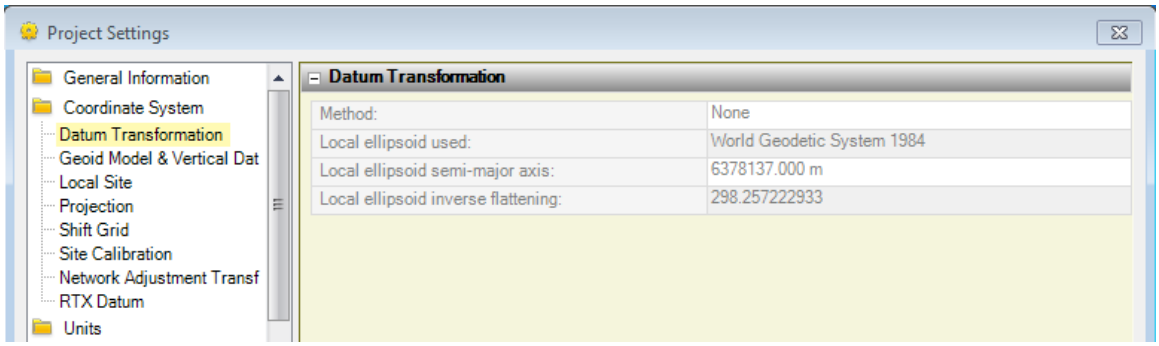


Figure 8 – TBC project settings window showing the coordinate system dialog and Datum Transformation options

This shows the Geoid model and vertical datum used. There is neither a geoid model nor vertical datum defined.

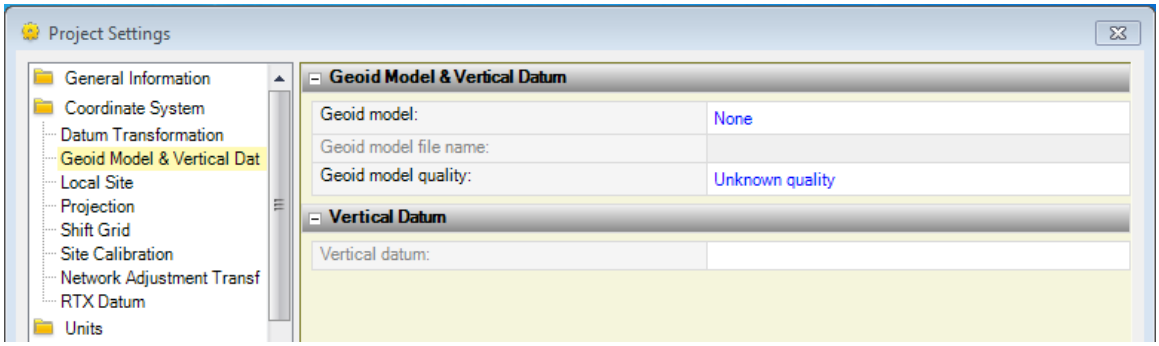


Figure 9 – TBC project settings window showing the coordinate system dialog and Geoid Model & Vertical Datum options

This shows the default TM projection used by the Blank Project template. This definition is why you see the grid in the plan view when the coordinate grid toggle switch is on. The ordinate is centered because there is no coordinate data in the project yet.

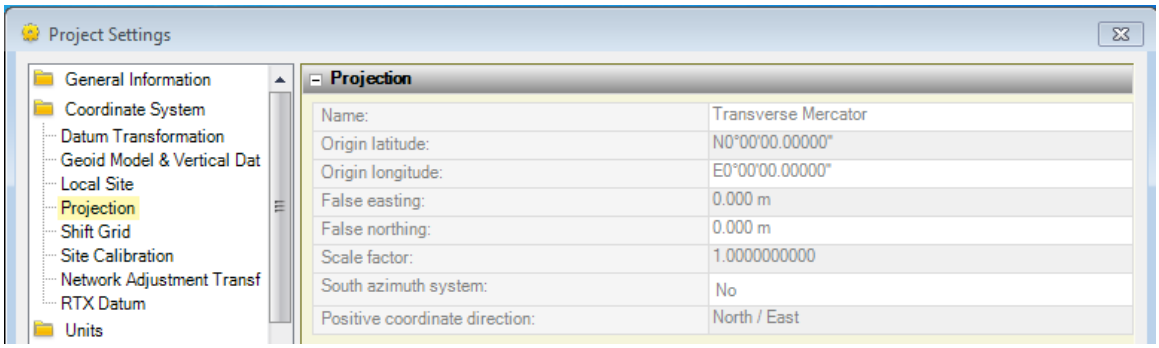


Figure 10 – TBC project settings window showing the coordinate system dialog and Projection options

This brief look at the coordinate system should help you become familiar with what changes may or may not take place when you import data files into a TBC project. We will return to this topic later on.

So far we have opened the TBC application and used the Options dialog to change certain application settings and we've opened a blank project. We will now need to change some project specific settings.

Project specific settings are what can be stored as part of a template to be used when you open a new project. Open the Project Settings dialog and click on the *Units* folder in the menu then open the *Coordinate* dialog.

This is the *Coordinate Units* dialog. Changing the coordinate order from the default Easting, Northing (X,Y) readability to the Northing, Easting (Y,X) readability will help with workflow. 5000, 5000, 100 grid coordinate definition often used for total station work. In this system you can see that the X and Y coordinates can get confused very easily. The other settings here are OK.

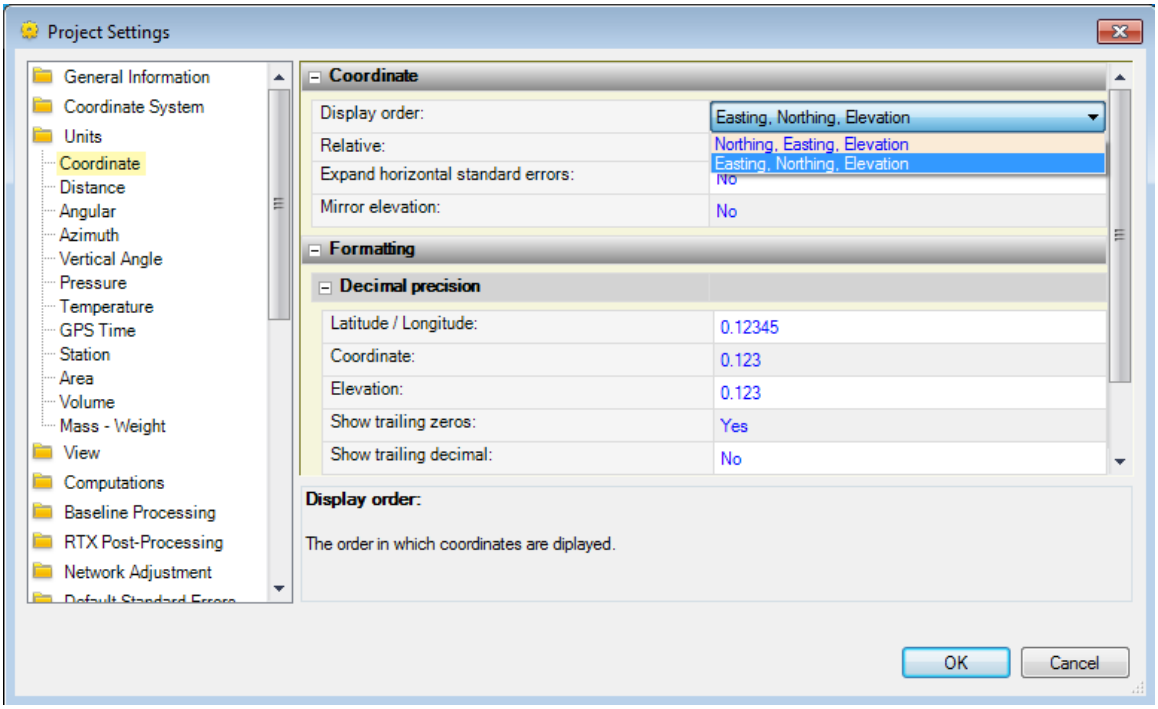


Figure 11 – TBC project settings window showing the coordinate units dialog and options.

This is the *View Points Spreadsheet* dialog. Change the Attributes and Descriptions to ***Show***. You can also change the Local and Global coordinates to show in the spreadsheet as well if you like.

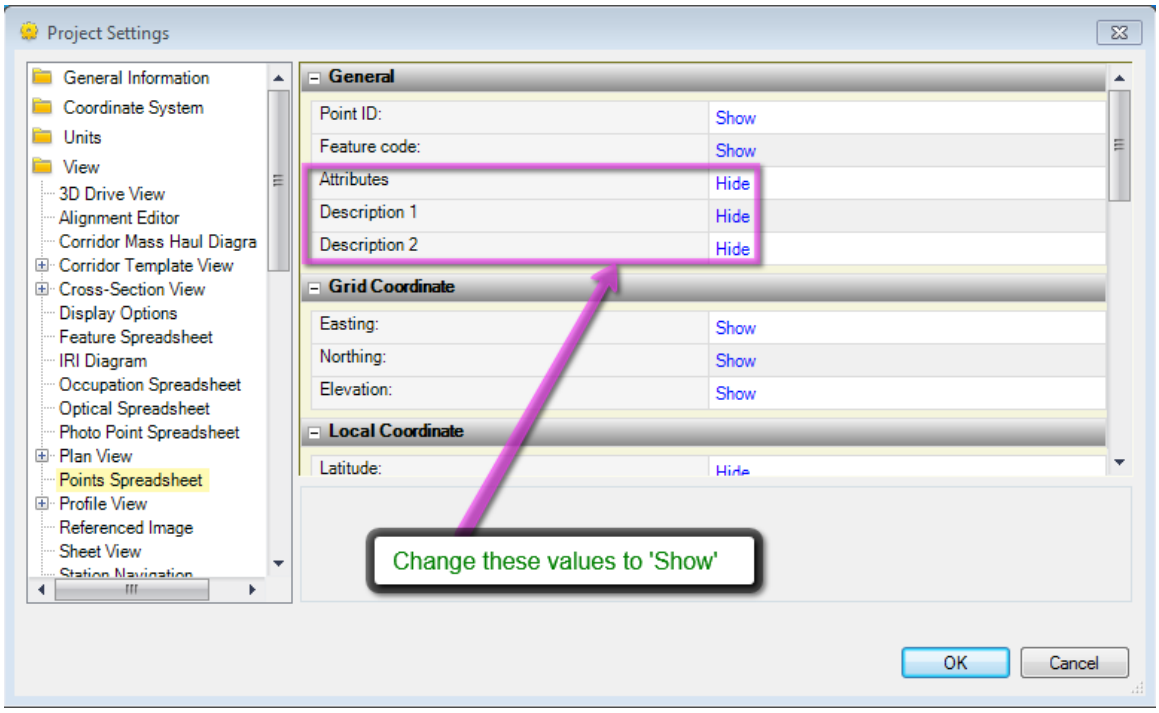


Figure 12 – TBC project settings window showing the points spreadsheet dialog and options.

This is the *View Vector Spreadsheet* dialog. If you are using RTK you will be using this. You will want to see how long certain measurements took. You will probably want to de-clutter the spreadsheet view by hiding the features that our equipment doesn't support such as the default shown Tilt information.

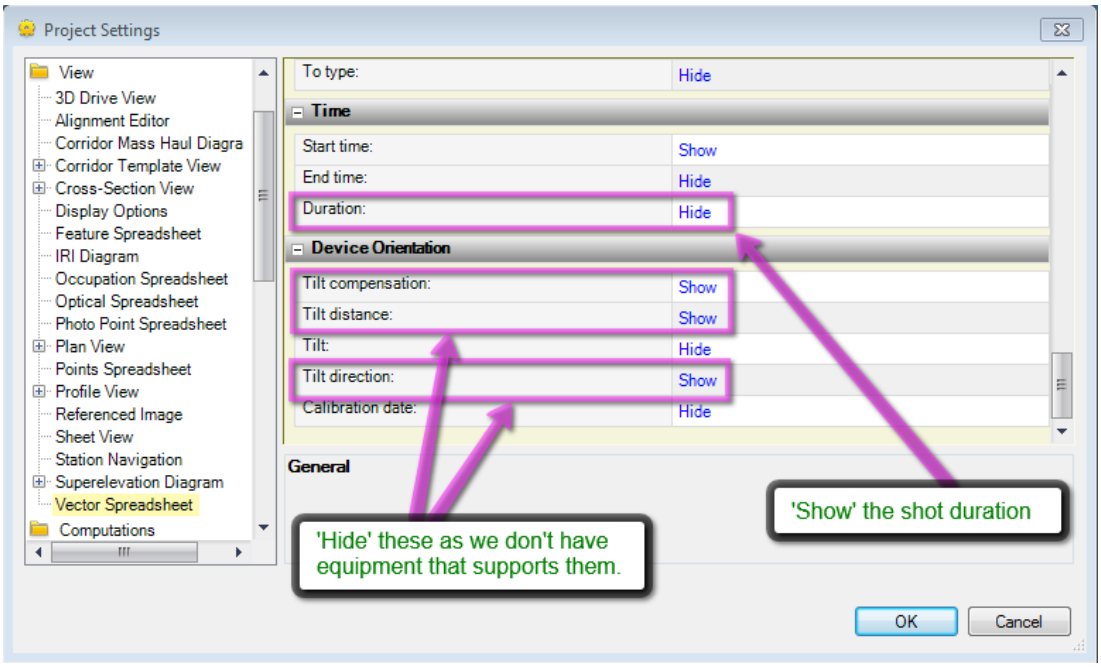


Figure 13 – TBC project settings window showing the vector spreadsheet dialog and options.

There are two function *Panes* you will need to use quite often. These are the *View Filter Manager* and the *Project Explorer*. These are initially free-floating but can be docked. Open the View tab to see the Manager and Project Explorer panes buttons.

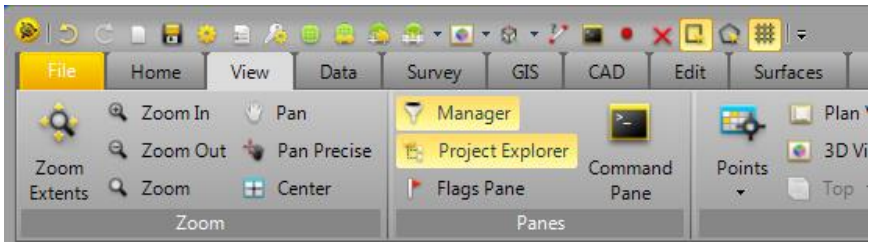


Figure 14 – TBC view toolbar and optional panes for project and data management.

Here, both panes have been opened. They are in floating mode by default.

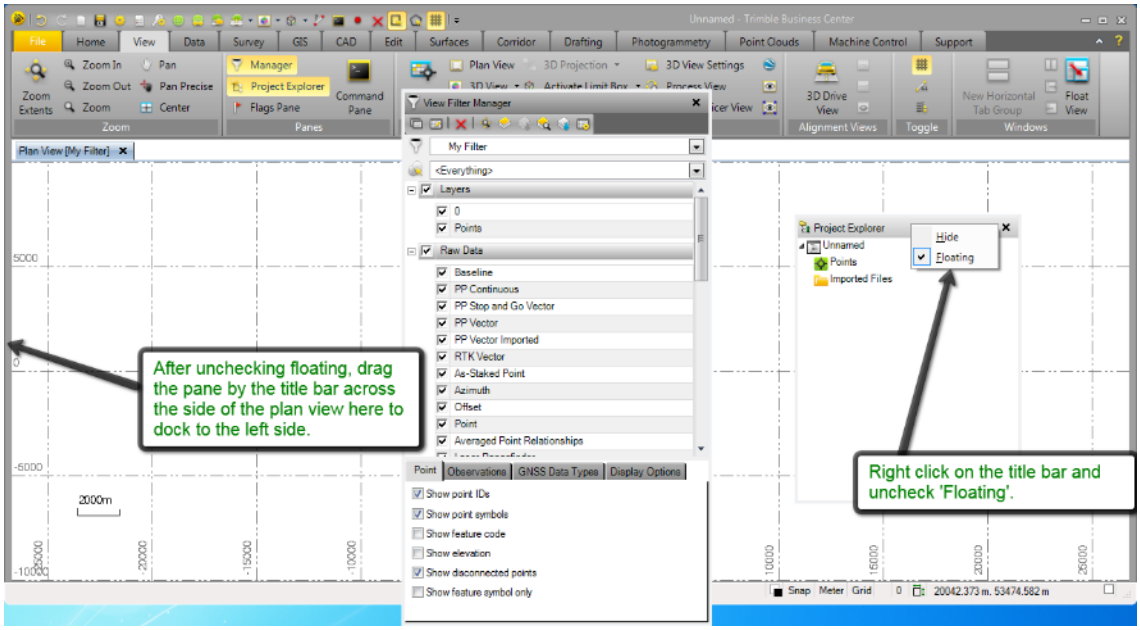


Figure 15 – TBC project showing Project Explorer and View Filter Manager panes active.

Now they have been docked to the left side and will stay with the application wherever you move it. Also, they are not laying on top of the plan view. This pretty well sets up the application so you are ready to use it.

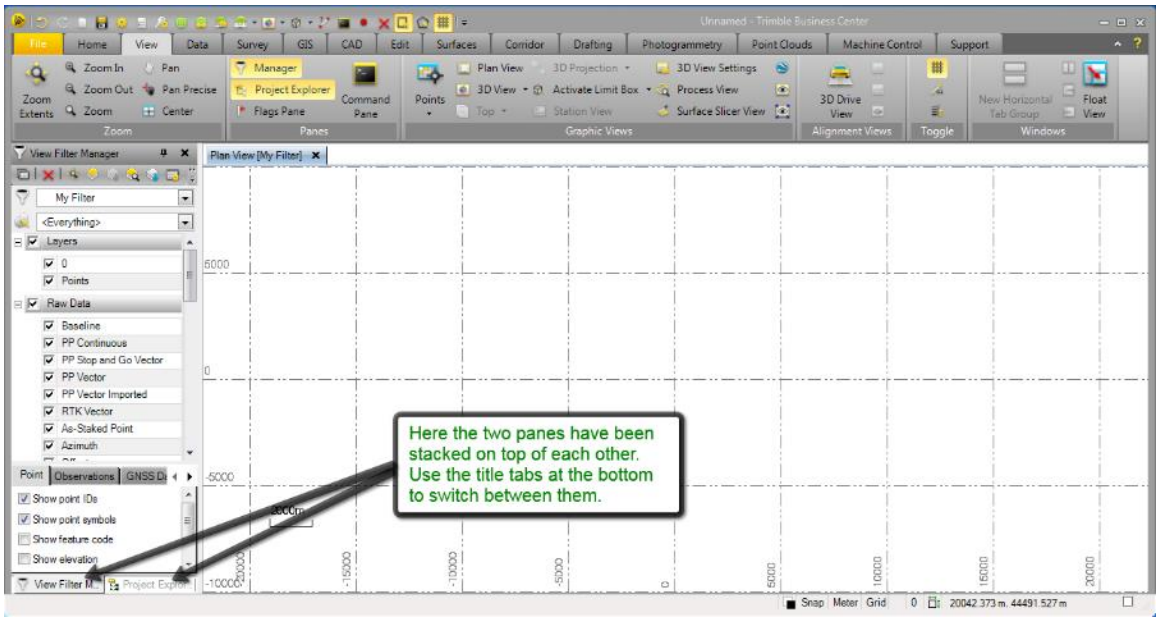


Figure 16 – TBC project showing Project Explorer and View Filter Manager panes active and docked along the left side of the screen.

2.1 View Filter Manager

In the above screen shot, the *View Filter Manager* pane is shown visible (its "on top" of the *Project Explorer* pane). The top box is the *View Filter* selection. The default here is "My Filter" so use that for now. The next box is the *Selection Set* and the default for that is "Everything" so use that for now.

Below that there are four categories of data: ***Layers***, ***Raw Data***, ***Flag***, and ***Photogrammetry***. The order of these four categories can be repositioned in the pane. I prefer to have the Layers first, the Raw data second, the Flags third and the Photogrammetry last as we currently don't use it. Click on the category heading and then right click and select 'Move up' or 'Move Down' to reposition.

There are four items in the *Project Explorer* that affect your ability to see data in the *Plan View*. These are ***Filter***, ***Selection Set***, ***Layers***, and ***Raw Data***. These are very useful for isolating problems or clearly viewing certain data. However, they can be frustrating to use at first. Here is a check list of figuring out the 'Why can't I see this data or these points in the Plan View?' question.

The first thing to do is generate a *Points Spreadsheet* so you can see by a listing of the points just what survey data is or is not currently in the project. If the point has coordinates, you should be able to see it.

2.1.1 Filter

There are initially two filters, one is the default 'My Filter' and the other is 'All'. All is locked so you won't be able to do anything with it. Use the default 'My Filter' for now until you understand how to use filters.

2.1.2 Selection Set

Using the drop-down arrow for the selection set will show the list of job files in the project. Selecting one or more of these will show only the data from those jobs in the *Plan View*. So if you are wondering why you can't see certain data, this may be the reason.

2.1.3 Layers

If you turn off (uncheck) layers you won't see data on those layers in the *Plan View*. So if you are wondering why you can't see certain data, this may be the reason.

2.1.4 Raw Data

If you turn off (uncheck) raw data types you won't see data of that type in the *Plan View*. So if you are wondering why you can't see certain data, this may be the reason.

Now, on to how you use these things:

- Turning off the *RTK Vector* data type in the *Raw Data* category is very helpful to de-clutter the *Plan View*.
- Turning off all *Raw Data* and then turning on just the *As-Staked Point* type will easily allow you to isolate As-staked points for point type conversion. See section 4.1 for more details on how to convert "as-staked" points to regular topo points.
- Turning on or off layers will de-clutter the screen and allow you to see selected layers.
- Selecting a job will allow you to see just the data from that rover.

3 Connecting and Importing a Trimble Access job file:

Now that you have TBC setup and configured how you want it to look and where to store files you are ready to import your survey data. Importing an *Access* job file from the controller into a TBC project will change the project's coordinate system to that of the incoming file's coordinate definition if it is different and if there is no data in the project already (blank/empty project). So this is normally what will happen when importing your data. If the project is not empty and the two coordinate systems are different, you are presented with a message asking how you want to handle this situation.

We generally connect the Trimble TSC3 controller to a computer via a mini-USB cable as this is the quickest method. Microsoft's *Windows Mobile Device Center* should initiate when you make the cable connection and turn on the controller. You should see a 'Connected" message in the lower left of the home screen as shown in the photo below.

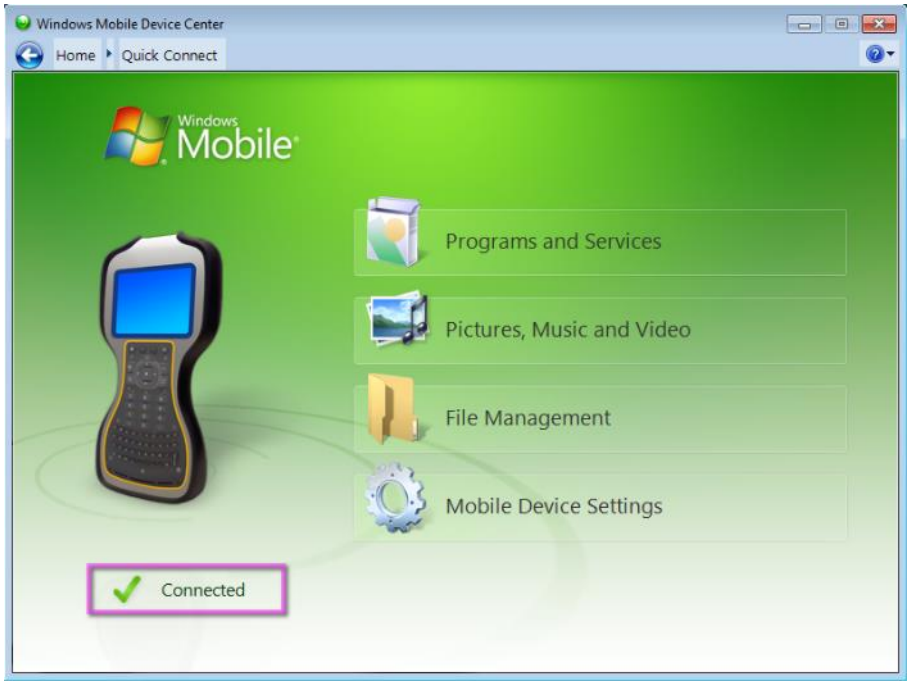


Figure 17 – Windows mobile device center main page

Can't connect?

If you are having trouble connecting, the first thing is to check is the *Enable Advanced Network Functionality* option found in the controller's *Windows* environment settings.

On the controller, press the *Windows* key and open: Settings > Connections > USB to PC. Either enable or disable the advanced network functionality option by tapping in the box.

a) 

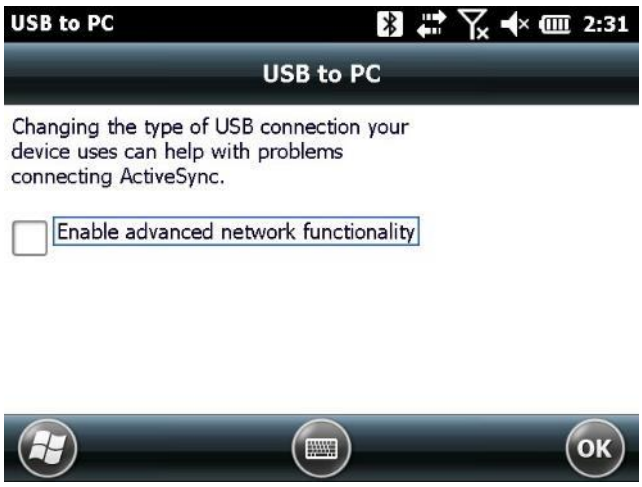
b) 

Figure 18 – TSC3 hand controller USB to PC connection settings.

3.1 Controller files Upload/Download using Windows Mobile File Explorer

To get copies of the files on the controller without having Trimble Business Center (TBC) open on the computer you can use the window mobile file explorer. If you just want to copy the survey data from the controller(s) onto the computer then you can just use the file path feature in Windows Mobile Device Center to navigate to the home directory on the controller and copy/past the files you want.

To do this, while the controller is connected to the PC, go to *File Management* > *Browse the contents of your device* in the *Windows Mobile Device Center* screen as shown below.



Figure 19 – Windows mobile device center file management option.

You should now be pointed at the *Trimble Navigation Limited TSC3* controller device. You need to get to the home directory in the controller that has all the data files. Open the device icon and go to *Trimble Data* and **open the root folder** (rts-1 shown here, yours will be named differently).

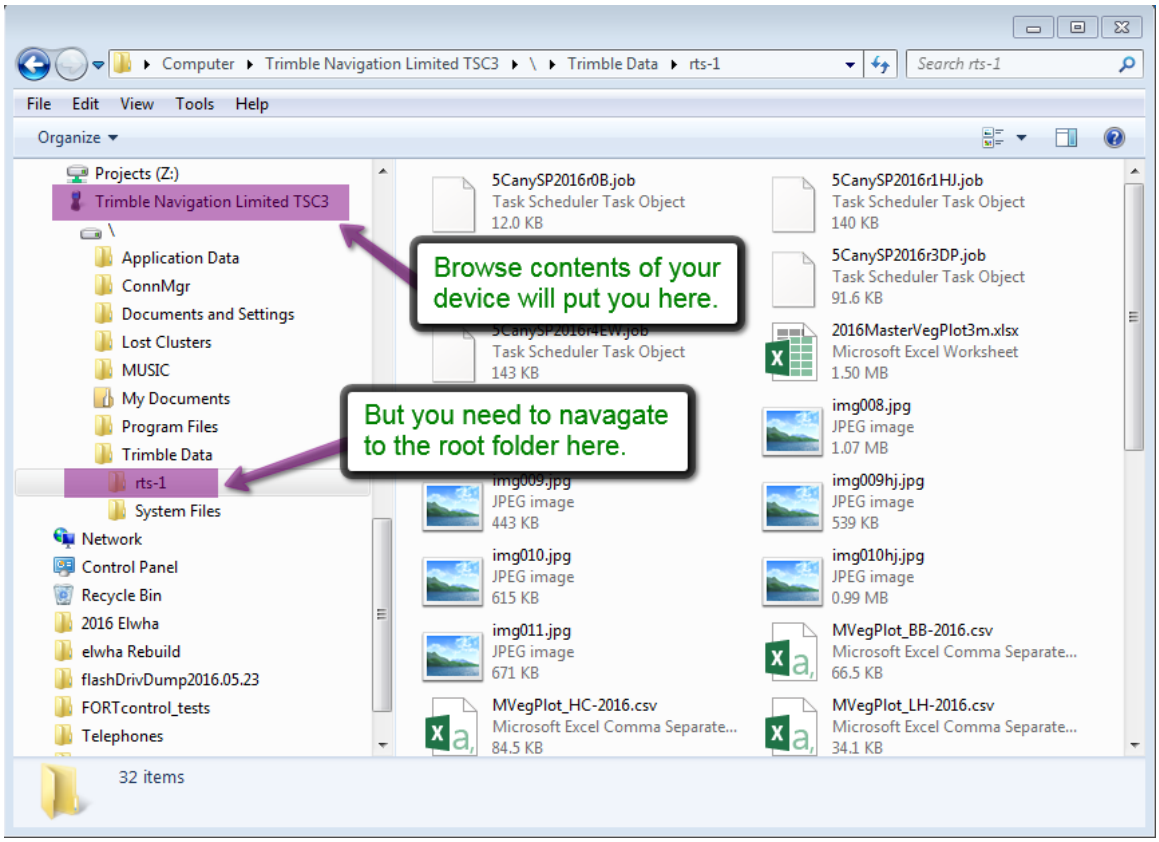


Figure 20 – Using windows mobile file explorer to navigate to Trimble survey data files.

You should now see all the JOB files, CSV file uploads, and any JPG images you took with the camera. This is the data file repository for survey work done in a *Trimble Access* job file.

You can now select by the usual methods to copy and paste the files on your computer.

3.2 Controller Upload/Download by directly importing job files into TBC

When you are field checking the data (field QA/QC) then directly importing the job files into *Trimble Business Center* (TBC) is the fastest way to quickly evaluate the data.

First, open a copy of TBC and choose *Start a new project*. Pick *Blank Template* and *OK* as it is shown below.

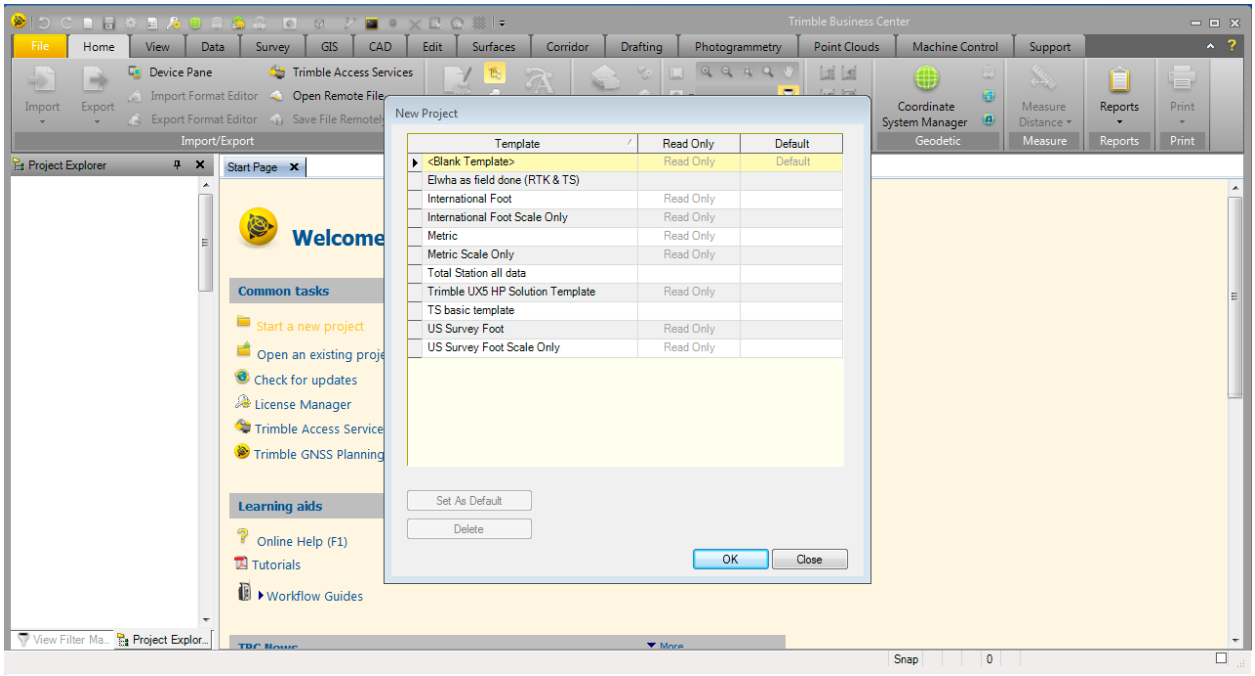


Figure 21 – Starting a new TBC project using the blank template selection.

You should now be in a new unnamed project. Connect the controller to the computer using a mini-USB cable. This should bring up a *Devices* pane in the project as shown below.

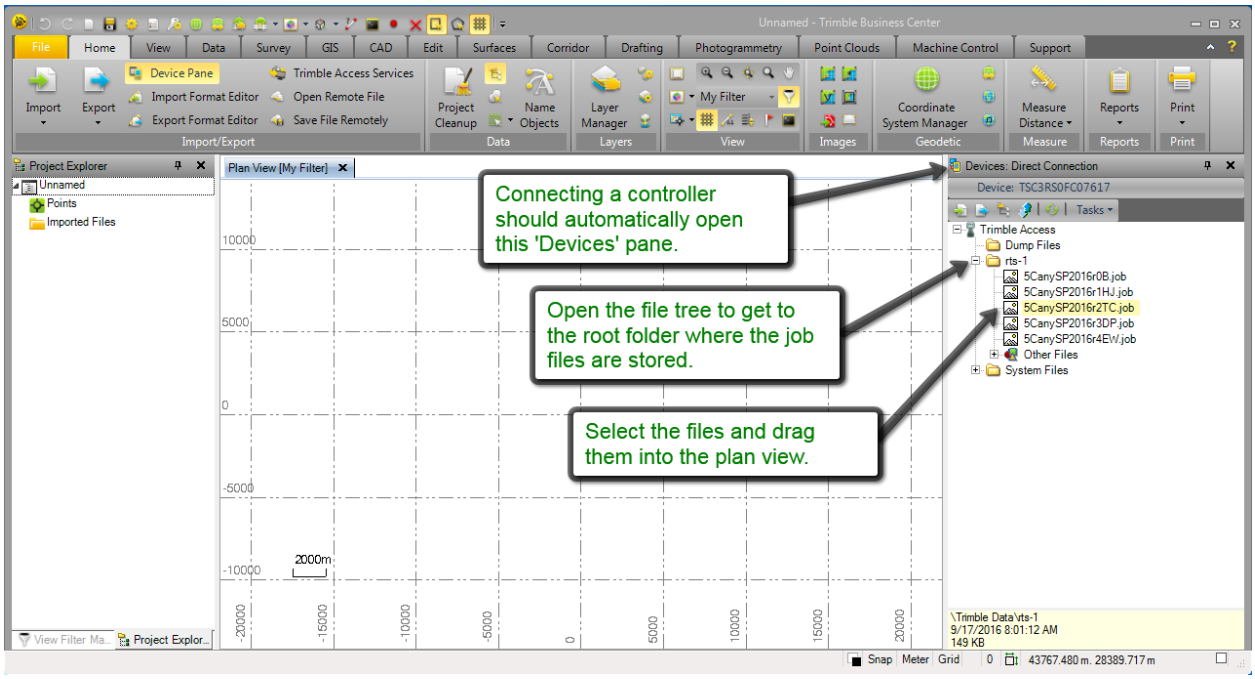


Figure 22 – Connecting to the hand controller within TBC for downloading survey data.

Locate the files you want and drag them into the plan view in the project or double click on the file to select and import the data. This will import them and some associated files. It will also change the project's coordinate system to that of the incoming job file.

You should now see the points from the file in the plan view as shown below. You should also see the RTK vectors as blue lines emanating from the base point to each recorded survey measurement. The points without blue vectors are from the linked CSV control/reference file(s) (i.e. transect end points).

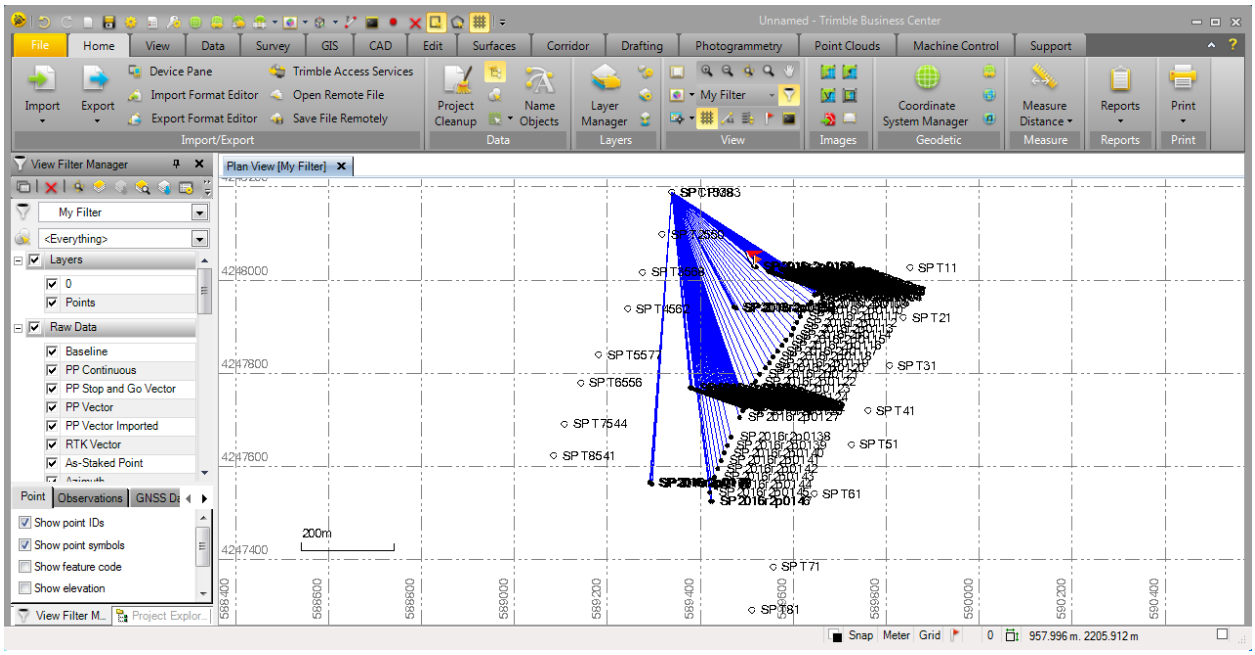


Figure 23 – TBC project showing recently imported survey data from the hand controller.

This rover file shows 3 types of data: a series of survey shots indicating a vegetation line running northeast-southwest, two transects running roughly east-west with a small part of another one at the bottom, and transect alignment/end points (small circle icons without vectors) on the east and west sides which came from a linked CSV file in the field controller. Notice also the red flag (error).

At this point if we open the "project settings" icon you can check to see what project settings were imported with the JOB file. This view of the project settings shows that the coordinate system from the job file import has replaced the previous default coordinate system. The geoid model is also copied from the imported job file. If you opened the *Datum Transformation* you would see a seven parameter transformation method where the blank project had none. You can close out of the project settings. Now let's look at the imported data.

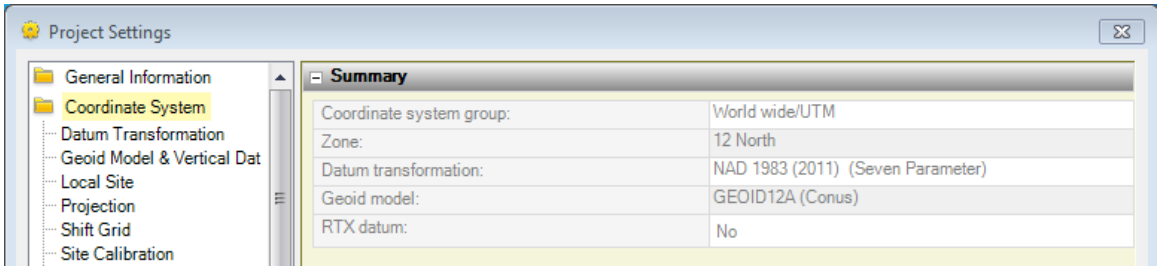


Figure 24 – TBC project settings and reviewing the imported coordinate system from the hand controller survey job.

The figure below shows the project *Explorer* pane with two points highlighted. The *Show elevation* and *Show feature code* options have been checked (turned on) in the *View Filter Manager*.

You can zoom in to see close-ups of any area using any of the "zoom" icons on the TBC ribbon panel or using the scroll wheel on your mouse. The coordinate grid view has been turned off for clarity. The scale here is 20cm as noted by the scale bar. To pan around the area you can use the "pan" icon or hold down the right mouse button and pan the screen.

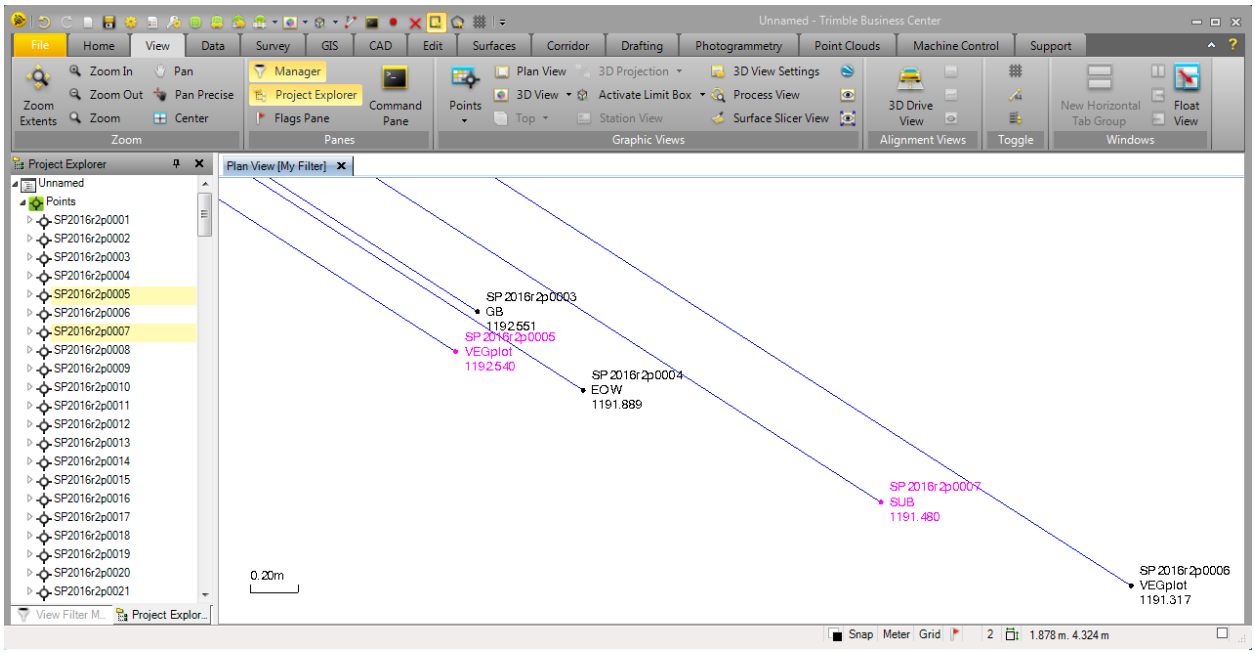


Figure 25 – TBC project showing surveyed points along with the project explorer pane open.

You can select a point by clicking on it to highlight it or select a range of points by using the left mouse button and creating a box around the points you want selected within the plan view screen. Right clicking then brings up a list of point commands. In the figure below, the *Properties* command has been selected and the **Properties pane** displays.

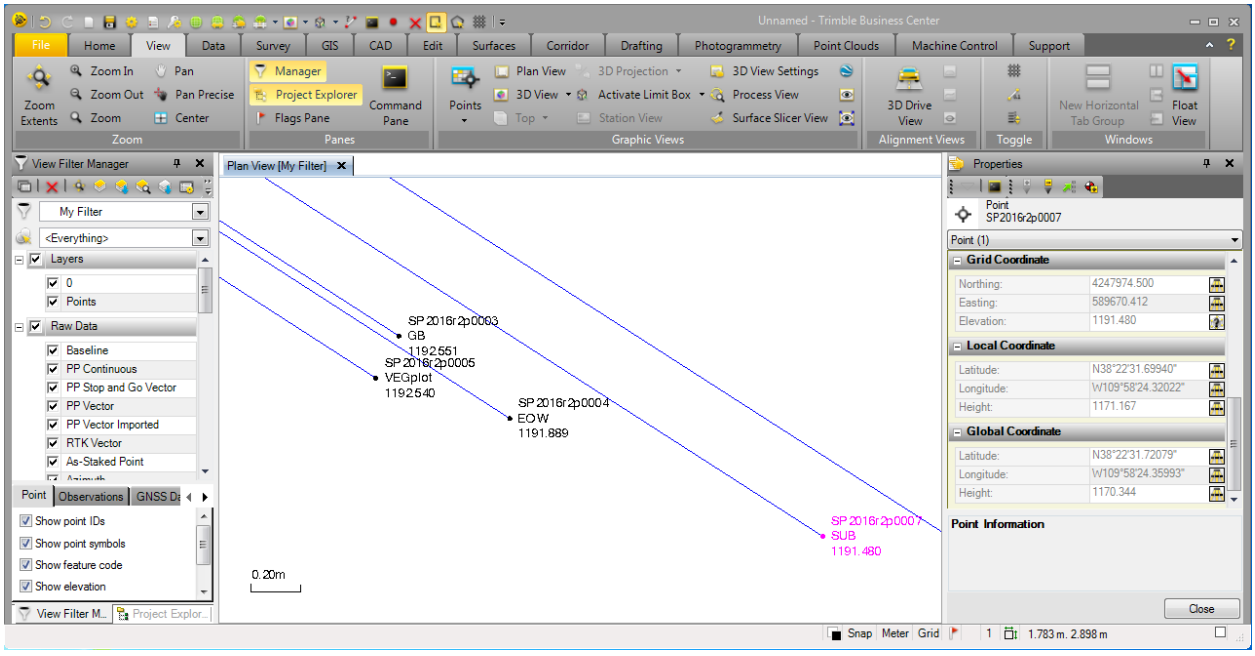


Figure 26 – TBC project showing surveyed points along with the view filter manager pane open.

The pane has been scrolled to the bottom to show the three coordinate sets for the point. These are *Grid* coordinates, *Local* geographic coordinates, and *Global* geographic coordinates. The Global coordinate is the WGS84 coordinate. The other two are derived from the datum transformation and the projection defined in the project settings.

Alternately, you can get a detailed list of all your surveys points using the point spreadsheet icon as shown in the figure below. The following figure shows an example of the Points Spreadsheet view. The yellow highlight shows the selected points.

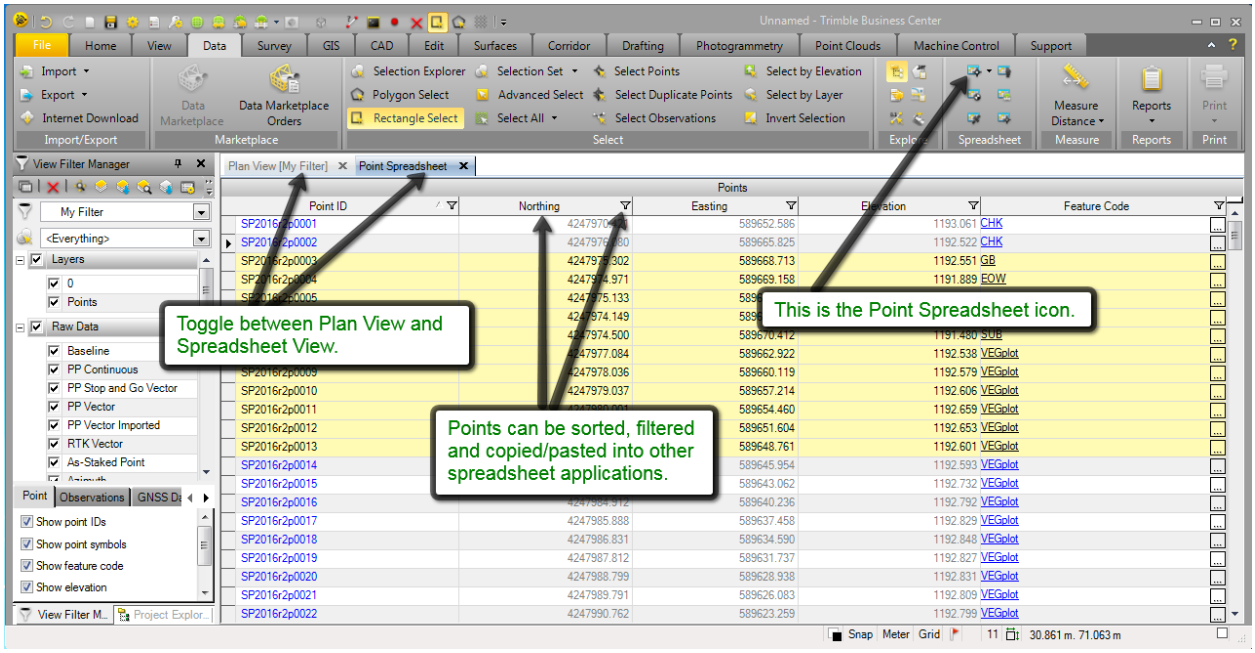


Figure 27 – TBC points spreadsheet view.

Using the point spreadsheet you can select a range of points of interest and then switch back to the plan view screen to see them in plan view. The figure below is an example of the selected range of points shown in the previous Spreadsheet view now shown in the Plan view.

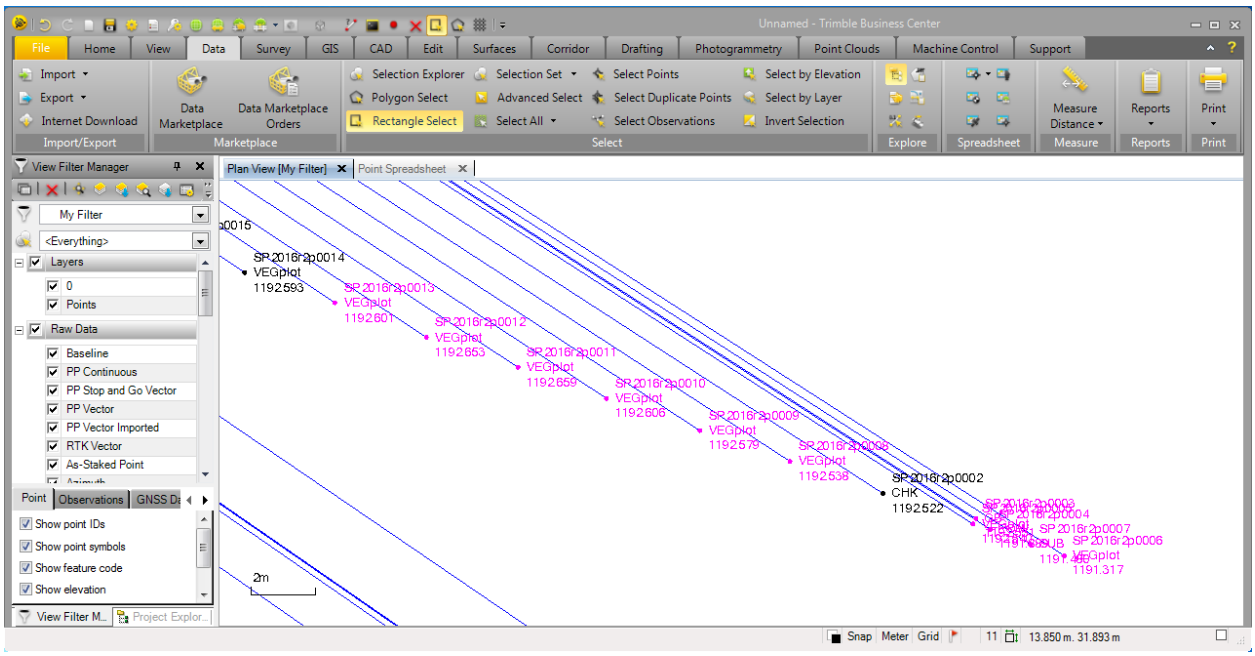


Figure 28 – TBC plan view showing selected survey points.

Once you have confirmed that the data has been properly imported and generally looks "OK" you are ready to import additional survey data if needed. In the same manner as described above, we will also be downloading any base files as well as any other job files from other rovers that have collected data at this site so we can comprehensively evaluate all the survey work to see if it meets the requirements before we move on to the next site.

3.3 Error Flag Investigation

After importing your survey data from your hand controller you want to check if there were any errors associated with your survey points. If you have error flags you will see a flag symbol in the status bar as shown in the figure below. You may see red, yellow, or orange flags on points after you import them into the project.

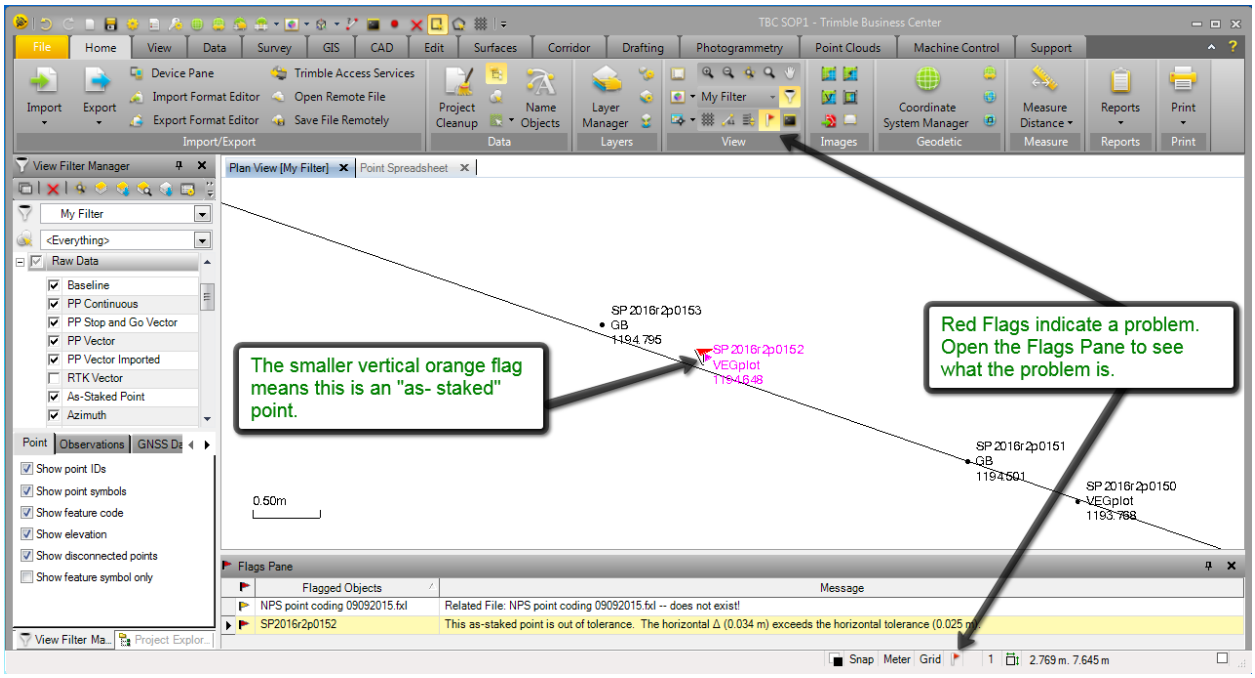


Figure 29 – Viewing and accessing the flags pane for identifying errors.

Open the ***Flags*** pane to see what errors exist. In this case you will see there is a small vertical orange flag at the same point. This means the point has an 'as-staked' classification. The error is stating that the point measured is out of (default=0.025m) tolerance compared to the known coordinates of the point/object being staked. Evaluating the error we see that the measured point is 0.034m out of horizontal tolerance. As long as the "as-staked" points fall within the acceptable range for the type of survey work being conducted (<0.05m for veg plots) then these error flags will disappear once we convert the "as-staked" point to regular survey points.

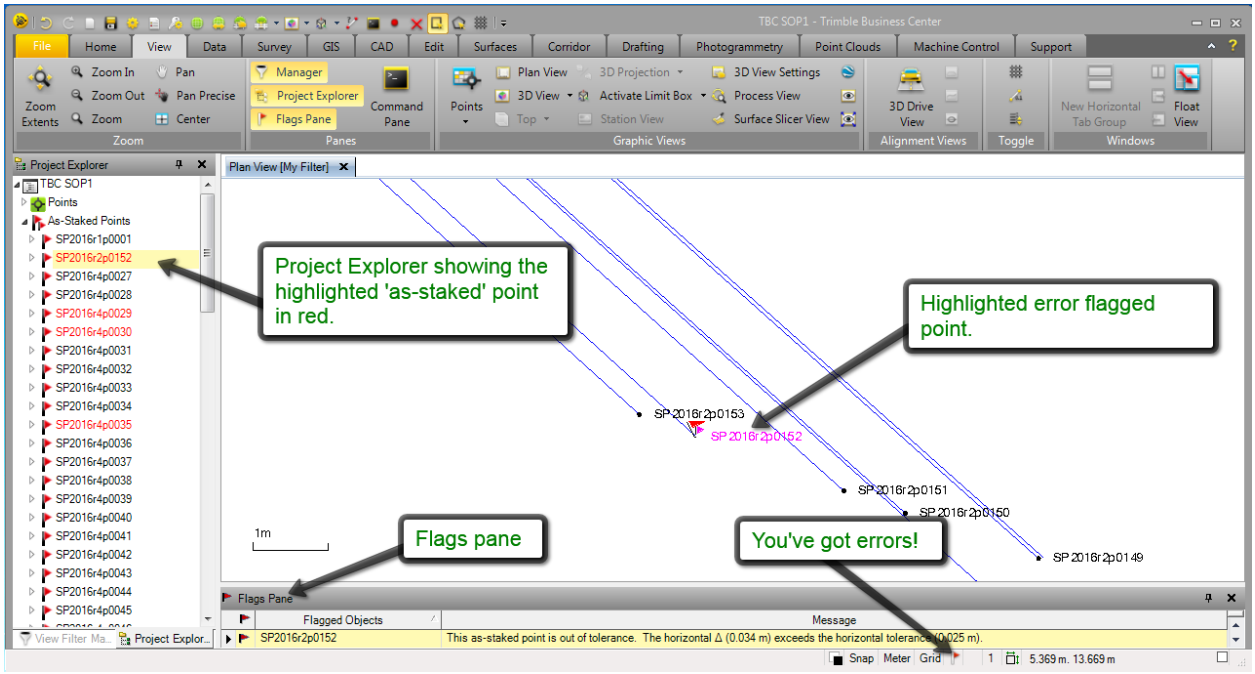


Figure 30 – As-Staked survey point with error flag.

After all of the survey data has been downloaded from each of the controllers and error flags checked you are now ready to organize the survey data and begin the QAQC process. Once you have all your original survey data downloaded from all of the controllers you need to make sure you save the TBC project with all of the original data. This allows you to always be able to get back to the original downloaded project data if needed. The following is the suggested file naming convention: RiverSitenameYYYY_download_CurrentDate (i.e. CanyMC2016_download_09302016).

4 Survey Data Organization and QAQC in the Office

Once you have downloaded the original survey data from the hand controllers you are ready to organize the data into various data layers and conduct some QAQC before finalizing and outputting the project data for analysis. The first step in organizing the data is to make sure that all points collected "as-staked" are converted to a regular survey point.

4.1 Converting "As-Staked" points

Converting "as-staked" points is a two-step process that basically puts a copy of the point on the *Points* layer and then deletes the original "as-staked" value. The easiest way to do this is using one of the two methods described below:

1) *To convert "as-staked points", in the Project Explorer pane:*
   a) Open the *Project Explorer* pane and open the *As-Staked Points* list by clicking on the side arrow.
   b) Select all the "as-staked" points in the list, then right click and pick *Convert As-Staked Point*. Copies have now been made. You may notice the point names now have a "-1". The point spreadsheet will show two points, the original and a copy with the "-1" appended to it.
   c) Right-click again and pick *Delete* to get rid of the as-staked originals.
   d) Click on the red *Compute Project* button (red dot) which appears in the status bar at the bottom of application window. All the as-staked point copies will be placed into the *Point* raw data type and will re-appear with vectors in the Plan View. You should not see any *As-Staked* points in the *Project Explorer* pane or any orange flags in the *Plan View*.
2) *Alternatively, To convert "as-staked points", in the survey pane:*
   a) ***Turn on all the layers*** *by check-marking the Layers category.*
   b) ***Turn off (uncheck) all Raw Data*** *and in the View tab on the ribbon, Zoom Extents. You should see nothing in the Plan View. If you see anything such as lines, turn off that layer.*
   c) ***Turn on only the As-Staked Point*** *raw data type by check-marking it. Now you see only points with orange flags in the plan view. Select all the as-staked points by pressing Ctrl+A or select all, right-click and pick Convert As-Staked Point. Then right-click again and pick Delete to get rid of the as-staked copies. Now click on the red Compute Project button. Now all the as-staked points have been copied to the Points layer and the as-staked originals deleted.*
   d) *Turn on all the raw data again by check-marking the Raw Data category header and any layers you turned off.*

You may notice several of the red error flags have disappeared as well. If you have any remaining errors there will be a flag button in the status bar at the bottom. This will open the *Flags Pane* and you can review the remaining errors and determine if they affect the survey data.

4.2 Layer the data (should not need this if the feature coding is working correctly)

The next order of business is to sort the survey data by layering it. This helps to see what types of data have been gathered and if there is missing data of some type. Open the *View Filter Manager* to see the existing *Layers* category. It helps to turn off the *RTK Vectors* in the *Raw Data* category by un-checking it.

Click on the *Data* tab in the ribbon and open a *Point Spreadsheet* and a *Vector Spreadsheet* in addition to the *Plan View* which is already open. If you are running a total station you will need an *Optical Spreadsheet* as well.

If the feature coding is not working properly or if you end up with points that are not getting layered appropriately you can use the following process to manually layer the data. Using the *Point Spreadsheet*, sort the data by clicking on the *Feature Code* column heading. Drag down the left column (boxes) to highlight all data that is of like type. For example all EOW coded points will go on the EOW layer. Right click and select *Properties* to open the *Properties Pane*. The layer property will say Points in blue. Click in the Layer box and open the drop-down list and select the layer you want, in this case EOW. Then click anywhere on the *Point Spreadsheet* to make the change. Repeat this for the obvious changes (i.e. Veg plots, Veg line, transect endpoints, etc). It helps to turn off the layer once you have re-layered a set of points so you can see what's left. Put all the ground topo data (GND, GB, TOB, BOB, SUB, etc.) on the Topo layer. You should now be left with relatively few points to assign a layer.

4.3 Data grouping:

Often there are several types of data and several sources of data in the same TBC project. Grouping data either by source or by type (or both) is quite helpful when performing initial field QA/QC evaluation. So far, we have looked at only one source of data (a field file from one rover). Below is the same project containing measured data from several sources; these are from four rovers, a base receiver, and the control/reference points to manage the survey. You can see these sources in the Project Explorer under the Imported Files directory as shown below.

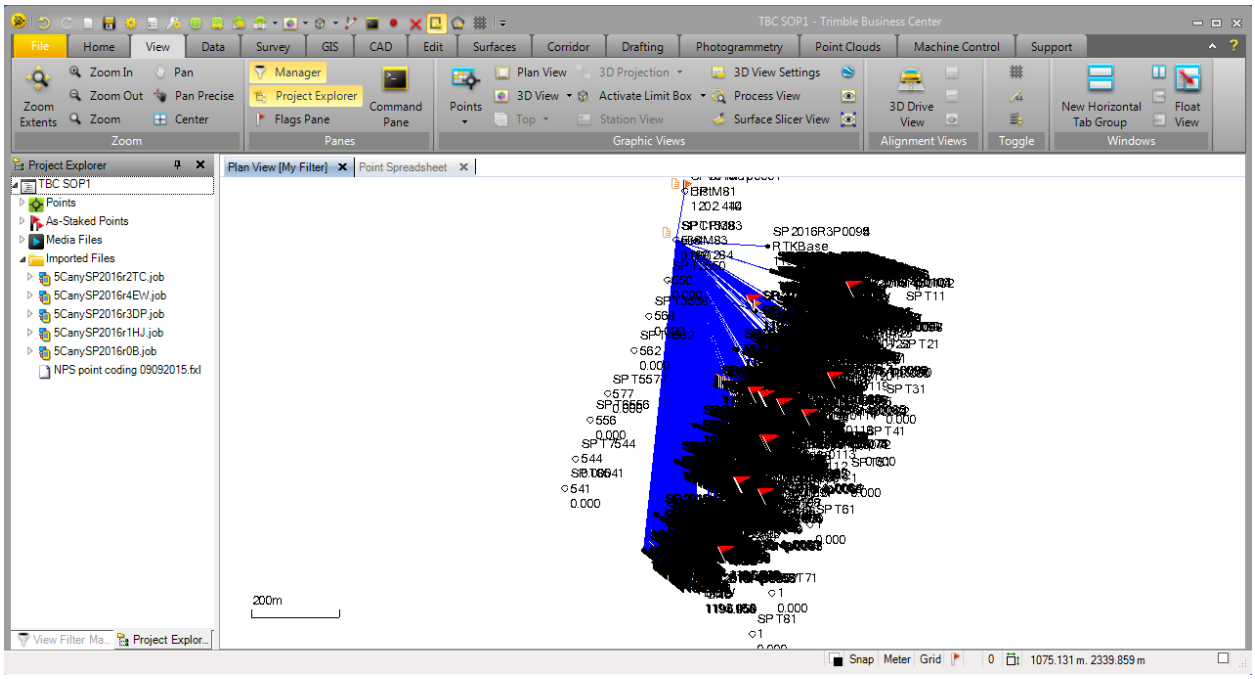


Figure 31 – TBC project showing survey data imported from numerous controllers.

There are basically three ways to group data, these are **layering, source**, and **Selection**. First we will cover layering.

4.3.1 Layering:

All points come into a TBC project on the *Points* layer by default. The defined layers (other than default) will be automatically created by the *Feature Definition Library* upon import if one was used during the field work. This file comes into the TBC project from the controller by association with the job file in the controller.

To check this, open the *View Filter Manager* and scroll down to find the *Layers* category. (This *Layers* category can be moved to the top of the list by right-clicking on the *Layers* title bar and selecting *Move Up*). If you uncheck the *Points* layer all the points in the project will disappear from the plan view.

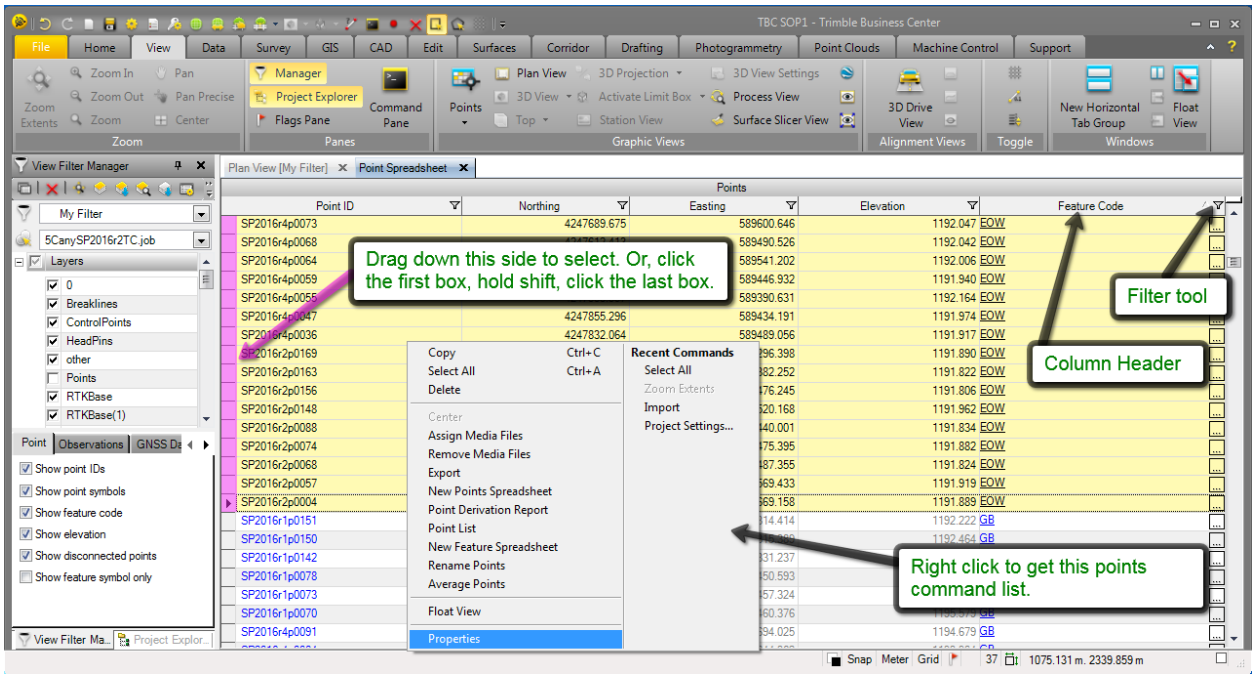


Figure 32 – Using the TBC points spreadsheet to identify and select data by feature code.

Open the *Point Spreadsheet* and click on the *Feature Code* column header. This will sort the points by code. Now you can select by finding points with the same code. You can use the filter button in the column header (use *Custom*) but it's just as easy to select by group if they are sorted.

Scroll down the right side to find the first point of the group you want to layer. Using the left side of the spreadsheet click in the box preceding the first point of the group and drag down the left side to select all the points with the same code. Right-click to open the points commands and click *Properties* to open the point properties dialog.

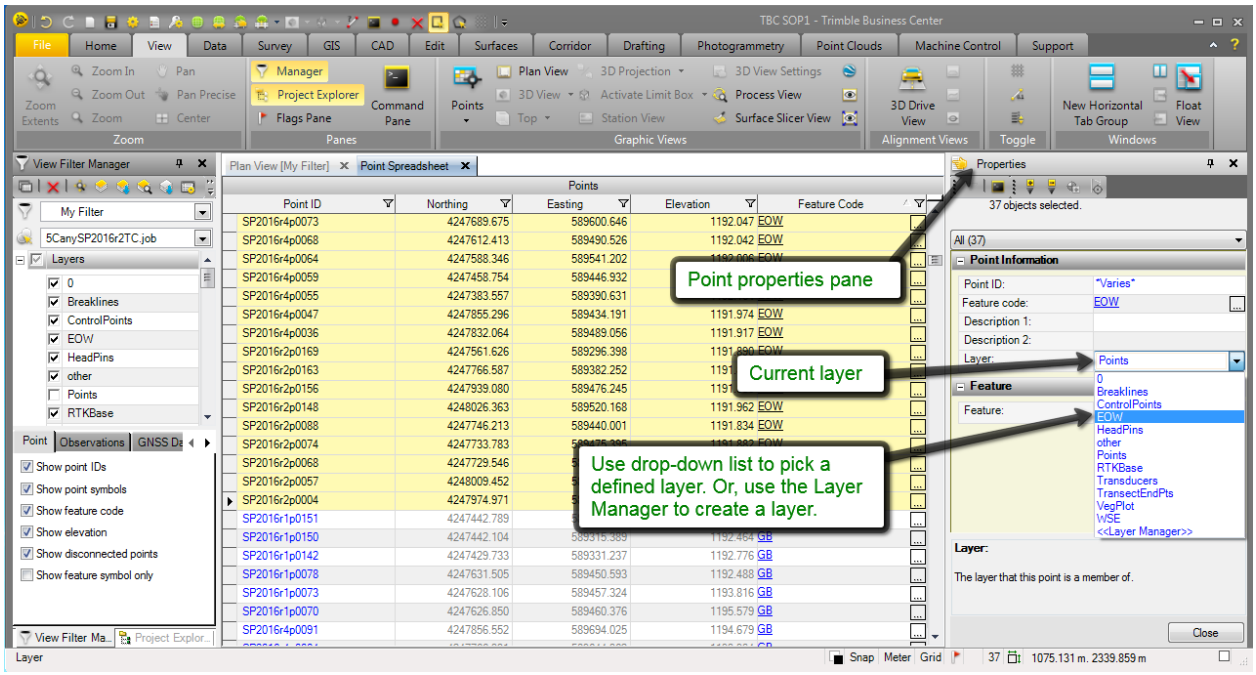


Figure 33 – Selecting data and assigning it to a given layer.

You should see an information box called *Layer*. The entry is currently *Points*. This means all the points you selected are currently on this layer.

Open the drop-down list to show the different layers available and select the layer you want and click on it. This will put all the selected points on the layer you selected. The points still remain selected (highlighted). Open the plan view and click in it to de-select the points.

4.3.2 Select by source:

The easiest way to isolate the data from one source is to isolate it by source. To do this, open the *View Filter Manager* and click on the drop-down arrow to open a list of the source files. Check mark the one you want and OK it as shown below. Now you should see only the data contained in that file.

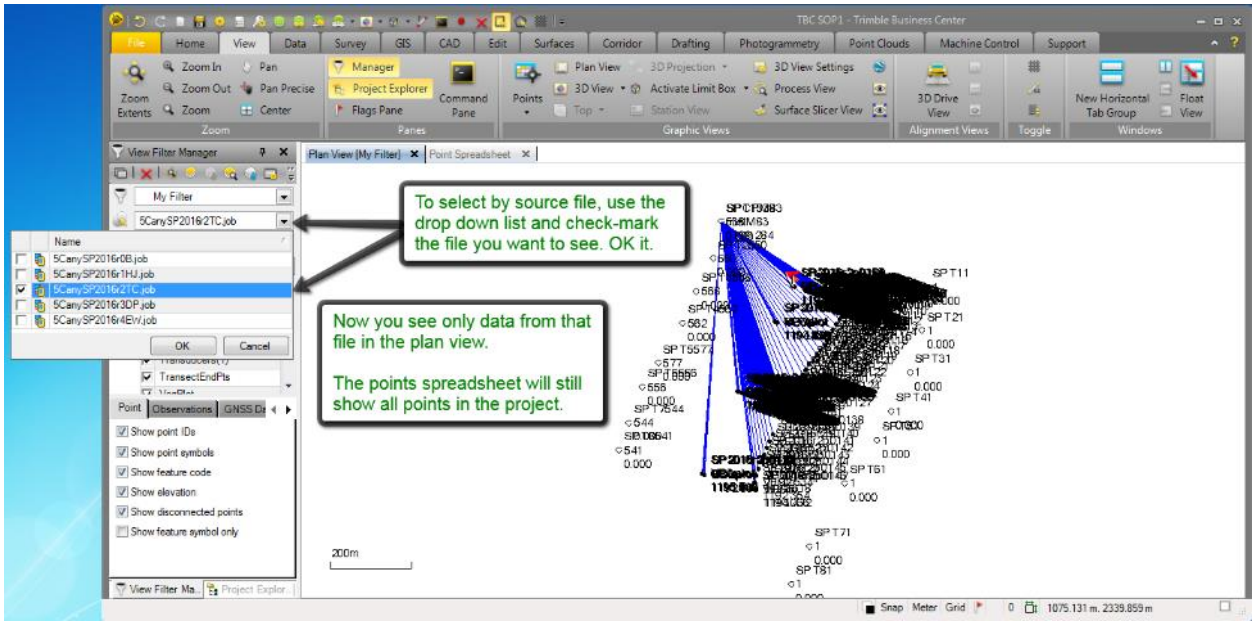


Figure 34 –Using the view filter manager to select survey data by source type.

4.4 Saving the Original Downloaded Survey Files

Once you have all your original survey data downloaded from all of the controllers and organized/layered you need to make sure you save the TBC project to create a copy of the original data. This allows you to always be able to get back to the original downloaded data if needed. The following is the suggested file naming convention: RiverSitenameYYYY_download_CurrentDate (i.e. CanyMC2016_download_09302016)

4.5 QAQC of Survey Data

Prior to QAQC of the survey data you want to save a copy of the original survey project with a new name so that you are always able to go back to the original project data if needed.

With the original project file loaded in TBC, select *File-Save Project As* and rename the project as follows: RiverSitenameYYYY_processed_CurrentDate (i.e. CanyMC2016_processed_11212016)

The first step in the QAQC process is to make corrections to the survey data as noted from field notes. For example, where an incorrect rod height is documented in the field notes, locate the appropriate point number in the TBC project and make the needed correction to the rod height that was recorded for the shot. After all the field note corrections have been completed then you need to confirm that all the required survey data was collected and recorded properly. Not all survey errors will be noted in the field notes and often there are additional corrections that will need to be done (i.e. unknown point code used, incorrect point naming, codes

left blank, etc.). In order to determine what might need corrected lets first look at the minimum required survey data that should be present for all surveys.

4.5.1 Minimum Required Survey Data

The following are the minimum required survey data points that should be collected for all surveys being conducted regardless of if they based on transects or full 3D topographic mapping. Each of the following data points should be identifiable in the TBC project and included in the various survey layers.

- Control points (i.e. Base station setup) and check shots (Rebar or "x" in rock)
- Photo pts (overview and feature)
- Transducers (TopBolt, RefMark, WSE)
- Veg Plots
- Topo Points (with appropriate coverage)
- WSE
- Vegetation (extent) line mapping

4.5.2 Survey Data along a Transect (Cany and Island Park):

For a transect inspection, you are looking to see if current data has been collected at all the plots on the transect and at changes in slope along the transect. You should also see at least two edge of water (RWE/LWE) or water surface elevation (WSE) shots on the transect; one for each side of the submerged area. Submerged ground surface shots should be between the edge of water shots.

As part of the QA/QC process we'll first look to see how a transect line was surveyed. To check this, you can either use a project template that already has the information included or you can draw a line using the CAD tab on the ribbon and the given transect end points. You should not need to do this by hand if using a project template. We will create a project template in TBC having transect lines drawn between the endpoints for each of the sentinel sites and then export this as an Access JOB file to the controllers. The line objects should be visible in the Map function on the controller and eliminate the need for hand drawing any of the transect lines. However, if you do need to create the transect lines by hand you can do so from the CAD menu and select Create Linestring (Figure 32). Name the line if you want to and draw the line between the endpoints.

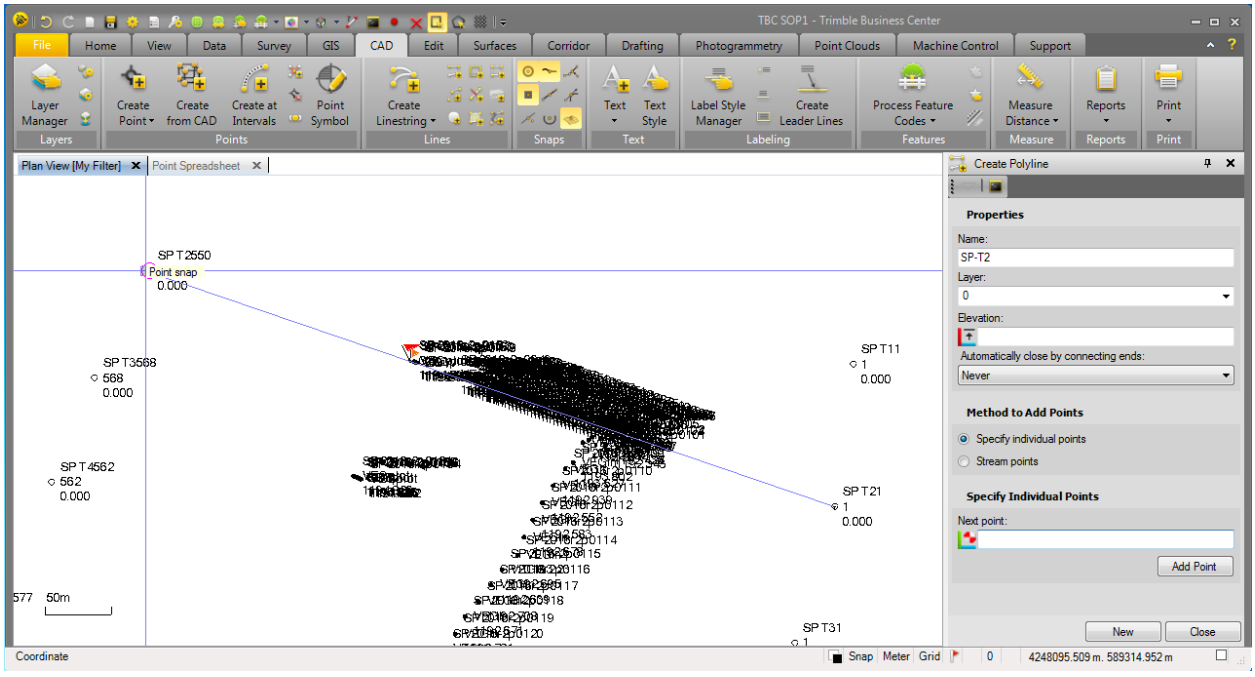


Figure 35 – Example of survey data associated with a transect type survey

Once the transect lines are created or imported using the template provided you can zoom in to see if the transect was surveyed correctly and if the shots were actually on or close to the line. The sample data set we brought into this job contains transect/profile topography, vegetation plot locations, part of a vegetation outline, and reference points defining the transect lines. Zooming in will give a closer inspection of any point. Points should be within a few centimeters of the transect line. There is a scale bar in the lower left side of the *Plan View* to help you estimate distances. To find an exact distance use either the *Inverse* or *Measure Distance* tool. There should not be any long gaps between shots. Figure 33 shows an example of surveyed vegetation plots where not all the points fall exactly on the line but are well within acceptable error (+/-0.05m) for the type of survey we are conducting.

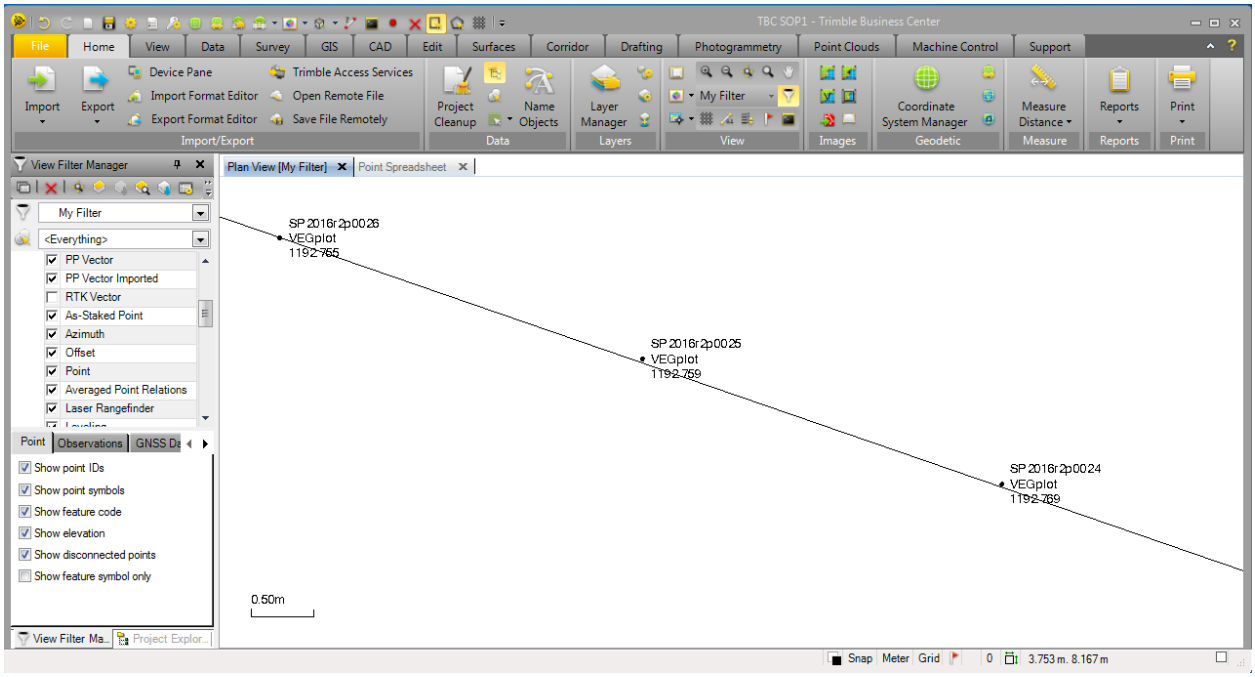


Figure 36 – Example of survey data points collected along a predefined transect line.

Next you want to check the survey data for errors related to rod heights that might have occurred but not recorded in the field notes. The elevations or elevation changes should make sense with the topography. You can create a *Points Spreadsheet* (Data tab > Spreadsheet group, upper left icon) and then order the points by elevation and check for obvious elevation problems such as a sudden high or low point among a group of similar elevation points.

4.5.3 Survey Data for 3D Topography (Yampa and Lodore):

For a 3D topo inspection, you should see a large distribution of points covering the entire survey site along with breaklines and outlines connecting certain features that are best represented by lines. The lines should make sense with the topography and vegetation at the site. Look for large gaps in lines that don't seem to make sense.

You are also looking to see if there are any large areas that are not covered. Large flat areas should have at least a ground shot every 15-20 meters or so.

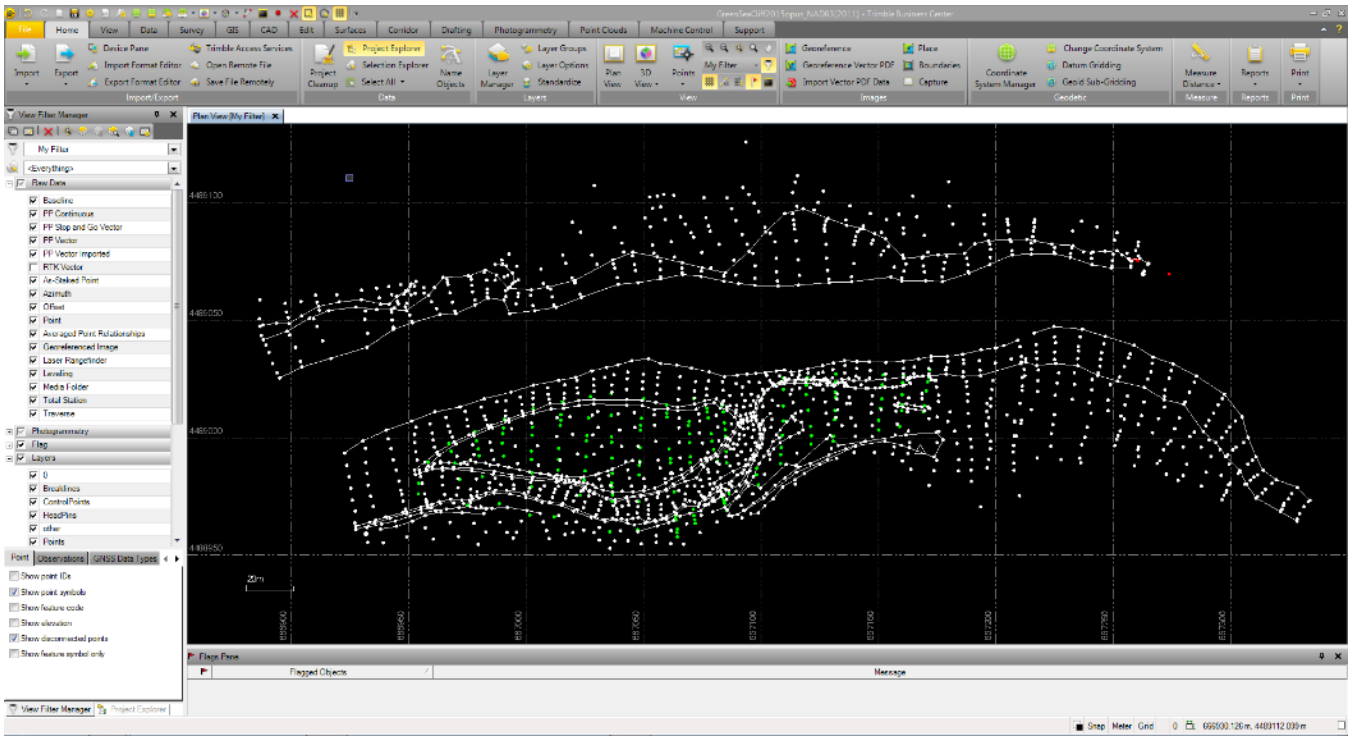


Figure 37 – Example of survey data associated with a 3D topographic type survey.

Next you want to check the survey data for errors related to rod heights that might have occurred but not recorded in the field notes. You can create a Points Spreadsheet (Data tab > Spreadsheet group, upper left icon) and then order the points by elevation and check for obvious elevation problems such as a sudden high or low point among a group of similar elevation points.

4.5.4 Compare with Historical Data (if possible)

After making all the required corrections to the data and saving your updated "processed" TBC project, it is a good idea to then compare the overall survey data to any historical data that you might have. This process provides additional data checking methods to confirm that the current survey is comparable to previous surveys. While individual topo survey points will be different you are looking to see that each of the surveys represent roughly the same overall extent of the study site. You also want to check the control points, transducers, and photo points to confirm that they are within acceptable errors since all of these survey points are considered "hard points" and should not change over time. This comparison can be done in either a "Master" TBC project for each study site which includes all the historical survey data or by exporting the current survey as an ArcGIS shape file and viewing the data in ArcGIS along with any historical data for the site.

TBC vs ArcGIS?? Which program you use really depends on what you are most familiar and comfortable with using. Below are the critical points that you want to compare to confirm that your control points have not been altered and that the appropriate vegetation plots were surveyed.

- Control points (i.e. Base station setup) are within acceptable errors (+-2cm max)
- Check shots (Rebar or "x" in rock) are within acceptable errors (+-2cm max, this should have been confirmed in the field but good to double check)
- Transducers (TopBolt, RefMark, WSE)
- Veg Plots

You also want to make sure that the overall extant of the study site was covered and that there is not any missing data. This should have been done as part of the field data QAQC check while in the field prior to leaving the site but a good idea to confirm that everything was collected and imported properly.

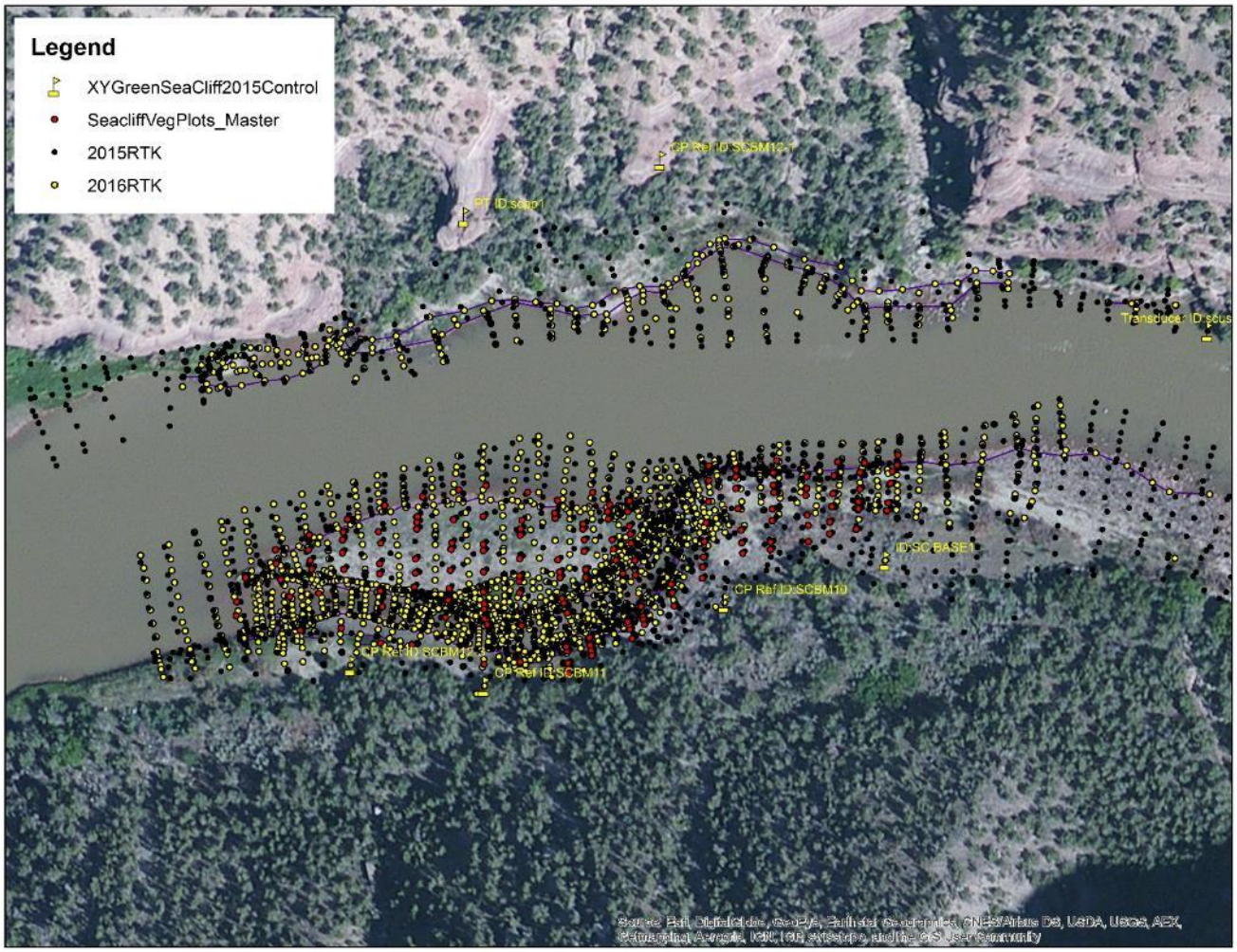


Figure 38 – Example of current survey data compared with historical surveys of the site.

5 Saving and Exporting Final Processed Survey Data

After completing the QAQC process you then need to save the final processed data using the following naming convention: RiverSitenameYYYY_FinalProcessed_CurrentDate (i.e. CanyMC2016_FinalProcessed_10232016) and export the data. To export the final survey data for analysis and data archiving use the export template provided (NCPN Master Survey Export2017_GlobalDD). This template provides a standard output format that is common among each of the surveys and historical data sets.

6 Field QA/QC process

6.1 Overview

We generally survey to produce five data set types:

- If the site is small enough, a **3D topographic survey** to digitally record the shape of the ground as it exists at that time. This includes ground surface above, at, and below the water line.
- If the site is too large to effectively produce a 3D topo then a **2D profile survey (Transect)** is done to digitally record the shape of the ground along several lines roughly perpendicular to the river channel producing cross-section profiles at the time of survey above, at, and below the water line. The profile/transect lines are held spatially fixed so they are repeatable in the same location.
- **Vegetation outlines** to aid in the evaluation of the migration of vegetation above the water line.
- **Vegetation plots**. These are meter square tracts held in a spatially fixed horizontal position and are repeatable. Detailed vegetation and limited geomorphic analysis is performed in the plots.
- **Spatial positioning of water depth recording instrumentation** (transducers) to provide continuous water level/stage records with which to evaluate the other data. Water surface elevation is also recorded at the transducer for calibration purposes along with RWE/LWE at various locations throughout the study site.

Field checking the survey work is important to ensure that all required information is gathered before packing up and leaving the site as the sites are visited only annually and access is remote and difficult. Often, the survey work is divided up amongst several rover operators and while this practice speeds up the fieldwork and/or allows for more data acquisition, it is also prone to missing data. Additionally, field checking the "critical" measurements such as control points and transducer elevations ensures that there will be no disappointing surprises in the office later. Following is general protocol for field checking the survey data by importing into *Trimble Business Center* survey data handling application running on a portable computer.

6.2 Open TBC application and import data from controllers

Open TBC, go to the *File* tab and select *New* to open a new TBC project. Select the *Blank Template* option. Connect a controller to the computer using a mini USB cable. You should immediately see a connection message on the controller screen and see *Windows Mobile Device Center* start on the computer and the *Devices Pane* in the TBC project should open. You may also hear an audible sound.

If the controller won't connect, press the *Windows* button on the controller and go to: *Settings > Connections > USB to PC* and change the current setting (check or un-check) for the *Enable advanced network functionality* option and *OK* it. Then close out of the *Windows* applications screen and try connecting again.

When the controller is correctly connected the *Device* pane will appear. Open the *Trimble Access* sub-folder and the root folder by clicking on the plus signs so you can see the job files. Then drag the job file(s) into the *Plan View* to import it. This will also bring in any associated files such as a feature coding library and images. However, you may get warning messages about non-existent files if there is data associated with the job that is not in the same root folder. These files are often found in the *Other Files* sub-folder in the folder tree. Generally, you don't need these additional files right now. The primary purpose is to review the newly collected survey data. You should see the points appear on the screen, most of them will be connected to the base point with blue vector lines. You may also see straight lines representing transects if this data is from a transect site. Disconnect the controller after the job file(s) have imported.

Connect other controllers that have pertinent survey data. Make sure you get all the available recently collected point location data including the base file(s) so you have a complete picture of what was done at the site. The

images don't have to be imported, you're just evaluating the survey data. However, it is a good idea to make sure that the images were recorded and turned out.

You will probably get an *Import Feature Definitions* message when you try to import job files from other controllers. This just means you are attempting to overwrite the existing feature coding library (just imported) with another copy of the same thing as all the controllers should be running the exact same copy of the library. Just say no.

6.3 Flagged data evaluation

You should now be looking at a bunch of white colored points and blue lines (vectors) coming from the base point. You may also see some colored flags.

- The smaller vertical orange flags indicate the point has an "as-staked" classification. What this means is that this measured point (rover shot) is being compared to a pre-determined coordinate position (commonly called the "design" point or reference object). If you use the *stakeout point* function while surveying and measure a point, it will have an orange flag associated with it when you import it into TBC. As-staked points often also come with red flags because if the as-staked position is beyond tolerance (a few cm) it generates an error message.
- Red flags mean there is a problem with this point. If there are any problem points, you will see a flag button in the bottom status bar, which opens the *Flags Pane*. Opening the *Flags Pane* will explain what the problem is.
- A yellow flag means a warning or a condition that needs to be pointed out. Not necessarily a problem.

The first order of business is to convert the "as-staked" points (orange flagged points).

6.4 Converting "As-Staked" points

Converting "as-staked" points is a two-step process that basically puts a copy of the point on the *Points* layer and then deletes the original "as-staked" value. The easiest way to do this is using the methods described below:

a) ***Turn on all the layers*** *by check-marking the Layers category.*
b) ***Turn off (uncheck) all Raw Data*** *and in the View tab on the ribbon, Zoom Extents. You should see nothing in the Plan View. If you see anything such as lines, turn off that layer.*
c) ***Turn on only the As-Staked Point*** *raw data type by check-marking it. Now you see only points with orange flags in the plan view. Select all the as-staked points by pressing Ctrl+A or select all, right-click and pick Convert As-Staked Point. Then right-click again and pick Delete to get rid of the as-staked copies. Now click on the red Compute Project button. Now all the as-staked points have been copied to the Points layer and the as-staked originals deleted.*
d) *Turn on all the raw data again by check-marking the Raw Data category header and any layers you turned off.*

You may notice several of the red error flags have disappeared as well. If you have any remaining errors there will be a flag button in the status bar at the bottom. This will open the *Flags Pane* and you can review the remaining errors and determine if they affect the survey data.

6.5 Process Feature Codes

Toggle or open the *View Filter Manager* and click on the *Survey* tab on the ribbon. Select *Process Feature Codes* to open the *Process Feature Codes* pane. Check mark the file you want to process and click on the *Process Source(s)* button. You should now see most or all of the points change color as they are layered. If this is a 3D topo site you should also see line-work showing the feature outlines and break-lines.

6.6 Review the collected survey data

The following are the minimum required survey data points that should be collected for all surveys being conducted regardless of if they based on transects or full 3D topographic mapping. Each of the following data points should be confirmed as surveyed in the TBC project.

- Control points (i.e. Base station setup) and check shots (Rebar or "x" in rock)
- Photo pts (overview and feature)
- Transducers (TopBolt, RefMark, WSE)
- Veg Plots
- Topo Points (with appropriate coverage)
- WSE and/or LWE&RWE
- Vegetation (extent) line mapping

For a transect inspection, you are looking to see if current data has been collected at all the plots on the transect and at changes in slope along the transect. You should also see at least two edge of water (RWE/LWE) or water surface elevation (WSE) shots on the transect; one for each side of the submerged area. Submerged ground surface shots should be between the edge of water shots.

Zooming in will give a closer inspection of any point. Points should be within a few centimeters of the transect line. There is a scale bar in the lower left side of the *Plan View* to help you estimate distances. To find an exact distance use either the *Inverse* or *Measure Distance* tool. There should not be any long gaps between shots. The elevations or elevation changes should make sense with the topography.

Make sure there are current shots on the transducer, reference marks, and water surface at or near the transducer.

For a 3D topo inspection, you should see breaklines and outlines connecting certain features that are best represented by lines. The lines should make sense with the topography and vegetation at the site. Look for large gaps in lines that don't seem to make sense. You are also looking to see if there are any large areas that are not covered. Large flat areas should have at least a ground shot every 15-20 meters or so. You can create a *Points Spreadsheet* (Data tab > Spreadsheet group, upper left icon) and then order the points by elevation and check for obvious elevation problems.

Make sure there are current shots on the transducer, reference marks, and water surface at or near the transducer.

Save the project with the date in the file name, the following is the suggested file naming convention: RiverSitenameYYYY_download_CurrentDate (i.e. CanyMC2016_download_09302016). If you need to conduct more survey work at this site then do the field work in the same controller job and when you go to review the additional work in the TBC project just re-open the previous project file and drag in the job files that contain the new work. You will probably be asked if you want to over-write, say yes. You may also get a *merge points* message. Then save the project using the naming convention above with a new date to distinguish it from the former project.

6.7 Save and Export the entire survey project as needed

If additional surveying at a site is required then is can be helpful to load all of the current survey data that has been collected back into the controllers as a reference file for everyone to be able to see what has been surveyed. This can be done by exporting the entire project to a reference .csv file and loading the file into each of the controllers as a linked file.

SOP #17 Trimble Business Center Office and Field QA/QC Operating Instructions

Appendix A

Big Rivers 3D sentinel site survey data QC processing

This has been used for 2019 and later data processing. TBC projects created by the breakup/disintegration of the large master project (ie- everything prior to 2019) will not have followed this processing structure, although similar.

Trimble Business Center processing:

Creating the TBC project

1. Open a new TBC project using the ***NCPN_BigRivers*** template.
2. **Import survey data:** Import the job files by dragging them into the *Plan View*. Bring in just the job files first and work with the collected survey data before bringing in the linked files/stakeout data. You may get pop-up messages about coordinate system differences, errors, warnings, etc. Investigate these as they occur to see if they affect your data in an adverse way.
    - For the 'difference in coordinate systems' message, the default button is *Convert to the imported file's definition*. For RTK data, you generally will want to *Keep the existing project definition* (which comes from the template). Use the *Details…* button to see what the differences are.
    - For total station data you will most likely want to *Convert to the imported file's definition* because total station data needs a project height to scale ground distances to grid distances and compute grid coordinates. The template was not set up with local site settings because all the sites are different.
    - When prompted about the Feature definitions, just say no as the feature definition file is included in the template.
3. **Project title format:** Save the project as *ssyy*QCprocessed_*yyyy-mm-dd*, where *ss* is the site ID and *yy* is the data collection year, *yyyy-mm-dd* is the processing date. Save in the *Processed* folder for the site and year. If you make changes later that affect any exported data then save again with a new processing date. This way the exported data, QCcheck, and related files (also saved with this date marker) can be tracked and related correctly. Move any superseded files to the archive folder.
4. **Incorrect site data:** Sometimes the field crew forgets to change the job when they start surveying at a site. When this happens, you will see survey data appear far away at another site (usually from the previous site) in the *Plan View* of the TBC project you are currently in. Make a note of which job file(s) contains data from a different site so that you will remember to import this file(s) into that project even though it is identified (named) for this site. Then, in the *Plan View*, select and delete the information not relevant to this site. Recompute if necessary (red dot in the project's status bar at the bottom of the window).
5. **Check in the *Project Settings*:**
    - that you are in the correct coordinate system.
    - that you have the correct As-Staked point tolerance setting.

- These things can change if you make a mistake in setting the job properties in the controller and then switch to the imported file's settings when importing the jobs. Or, if you make the wrong choice to a question when importing files.

6. **Control check:** Open a copy of the stakeout control file and compare the base point (or total station setup CP) coordinates with those in the project. These should be identical. Merge any duplicate points having to do with the base or total station setup. Import the control file, isolate it and re-layer onto the *stakeout control* layer. Check that the vectors emanate from the correct base point or control point coordinates. Compare the measured check points against the stakeout check point coordinate, looking for consistency in elevation and close proximity to the stakeout point. Check/compare any other stakeout CP's that were measured.
7. **Create & export CSV's with notes:** These are helpful to evaluate linework and other field conditions. There are two ways a field operator can attach notes to a point. One way is to simply type in a note in one of the description fields during the survey. The caveat is that the note must be cleared from the description field after the point is stored else the note persists for every point following. The other way is to add a note to the point using the Notes function during the survey. If this latter method was used then the note will only be visible if a special report/file is run. This is a *CSV with Notes* file. Open the *Reports > Job Report Generator* menu. You should see a job listed in the Job file field. Navigate to and load the *Comma Delimited with notes* stylesheet. Uncheck the 'View output file' unless you want to see them now. Hit the Apply button and then load the next job file and repeat. These get stored in the folder of the same name as the project. Move them to the CSV's with Notes folder.
    - **Additional Reports:** Create and save *Survey reports* from the jobs, an *Import report*, and an *As-Staked report*. Move them into the reports subfolder.
    - **Open Spreadsheets:** Open a *Point Spreadsheet*, *Vector Spreadsheet*, *Feature Spreadsheet*, and an *Optical Spreadsheet* if you have total station data.

Data vetting

- **Process feature codes:** Process the feature codes of the job files and save a copy of the report in the reports subfolder.
- **Error Flags:** If there are errors, you will see red flags in the plan view and a flag icon in the status bar at the bottom of the window. Open the *Flags Pane* to see the errors. There are many sources for errors so there are different ways to fix these. Leave the ones related to 'As-Staked' data. These will show up colored red in an As-Staked report. Fix the others that you can. Don't worry about yellow flags.
- **Investigate uncoordinated points:** In the *Point Spreadsheet*, sort by either Northing or Easting. Make sure you are at the top of the list by running the scroll bar at the right side of the list all the way up to the top. You may see points with "?" for coordinates. These are uncoordinated points. These will not be visible in the *Plan View*. Highlight these and in the *Project Explorer* open both the *Points* and *As-Staked Points* nodes to investigate the highlighted items. Mostly, these have probably been deleted in the field by the field surveyor if they made a mistake and caught it. In this case the vector will have an attached note stating 'Deleted' with a time stamp corresponding to the time and date of survey. If this is the case, the vector will also not be

visible in the *Plan View* and will have a *Disabled* status in the *Vector Spreadsheet*. For these uncoordinated points, make a note in one of the description columns as to why this point has no coordinates. Usually, I make a note stating "deleted by field surveyor" Basically, you are checking that uncoordinated points are uncoordinated for a good reason and recording a note as to why. Once these have been checked and an explanation entered, they can be re-layered from the *points* layer onto the *unused* layer. The *CSV with Notes* files you created previously are helpful if notes were attached to the point using the Notes function.

- **Unprocessed points:** Open only the *Points* layer and review any unprocessed points. Some of these may be junk shots (used to set the point naming convention at the start of a site survey). Enter a note in one of the description columns such as "junk shot" and re-layer these onto the *unused* layer. After the mistake shots, junk shots, and other unwanted points are noted and re-layered onto the unused layer, open the unused layer only with RTK vectors showing. Then, zoom in close and highlight the vectors associated with the unused points. Then disable these vectors in the *Properties* pane to remove them from the *Plan View* and assign null coordinates (?) to the point. Investigate and fix the coding on any other unprocessed points. Recompute the project. There should be nothing left on the *Points* layer or the *unused* layer.
- **Check for improper point naming:** In the *Point Spreadsheet*, sort the points by the point ID and look through the list for mistakes. If there are only a couple of these then they can be renamed correctly right there. I usually copy the incorrect name into one of the description fields and make a note that this was the original ID for tracking purposes. If there is a long list of misnames then these can be renamed using the *Rename Points* function. Look through the report to see if they are renamed correctly and be sure to save a copy of the report in the TBC reports folder for tracking purposes. Duplicate points will have a "-1" or "-2" appended to the point ID. These are often associated with deleted points. Rename/fix these accordingly. Follow the conventional point naming format ***SS*** + ***yy*** + r + ***n*** + p + ***nnnn*** where: ***SS*** is the two letter site ID, ***yy*** is the last two digits of the survey year, r is for rover, ***n*** is the rover unit ID, p is for point, and ***nnnn*** is the consecutive point number. For total station collected data, use ts in place of r***n***.
- **Check Linework:** Turn off all layers except the *Breakline*, *Outline*, and *Veg outline* layers (one at a time) and look for problems with the linework. Fix as necessary. Use the CSV's with Notes exports and scan down the *Point Spreadsheet Descriptions* columns for linework notes entered by the field surveyors to help with this.
- **Import stakeout CSV files:** Import the stakeout files (linked csv files), isolate and relayer onto their respective layers. Check that the transducer shots are reasonably close to the stakeout locations and that the elevations make sense. Note any new changes/major differences in the processing notes. Do the same for any collected photo points. Be aware of float solutions or fixed solutions with large error estimates.
- **Update stakeout files:** Add new PP, CP, VEGplot, Transducer, or other stakeout data that was collected to the stakeout files for future use. These go into the next year's field upload file.
- **Review and correct data using field notes:** Using the *CSV with Notes* files and the *Description* fields in the *Point Spreadsheet*, look for and modify lines and shots as needed. Document these changes in a "processing notes" document and save.
- **Check for duplicate points:** Once you have checked through the *Points Spreadsheet* and merged any duplicate points you know about, you should check for any other duplicate points by running the *Select Duplicate Points* function. Run the utility/function at the default settings first.

Select the 'OK' button. This will highlight duplicates in the *Plan View* and provide a count in the status bar (at the bottom of the window) of any points within 1 millimeter of each other in the project. Investigate any of these as they may need to be merged. To check for identically named points, uncheck 'Within the following distance' and check the 'Identical' button and select 'OK'. This will highlight and provide a count in the status bar of any duplicate points ID's in the project. Investigate any of these. Although TBC will support duplicate point names, you do not want this. Rename as necessary.

- **Check for Veg plot mistakes:** Open the *Feature Spreadsheet* and sort through the veg plots for transect ID mistakes, plot ID mistakes, and duplicates with different ID's, etc.
- **Do a final data processing check** by going to the *Plan View*. Turn on the "Zoom extents when filter changes" button in the *View Filter Manager*. Make sure all the data sources are available to be seen (*<Everything>* in the selection set and all but the RTK vectors and Total Station in *Raw Data*). Turn off all the layers and vectors and then turn the layers on and off one-by-one. You are looking for things that may be on the wrong layer or are unprocessed/processed incorrectly. Keep an eye on the scale bar at the bottom. It should go to .20 m (default setting) if there is nothing on the layer and you should see nothing on the screen if the layer is empty. The *Points* and *unused* layers should be empty.
- **Compare the number of measured points against the number of vectors:** In the *Plan View*, and using the *View Filter Manager*, turn off the *Points* layer and turn on the *RTK Vectors* (and TS vectors if you have any) and select all the vectors to get a count. Compare the vector count against the measured point count from the previous step. Take note of any difference. This can help in resolving some errors.
- **Export CSV and SHP files:** When you are satisfied you have a good data set, turn on only the layers that have data you want to export. Normally, these would exclude the stakeout data layers, unused, and points layers. Select all the data in the *Plan View* and export two types; one as a SHP shape file (which will be a folder with lots of stuff in it) and the other as a CSV file using the latest *USGS FORT Survey Export* format. Move these into their respective folders. These should also be copied into the same named folders within the ArcGIS folder for use in ArcGIS processing.
- **Create the next set of survey prep files:** These are the stakeout CSV's and map files (DXF) used in the controller. Any modifications or additions should be reflected in the newest set of field uploads. Add any prep notes here as well.

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Appendix B

Applying an OPUS correction to a TBC project

Problem: OPUS positioning solutions are computed in the most current LOCAL datum transformation. That means if you are trying to incorporate newly acquired RTK survey data (via autonomous base location i.e. - "Here" key) into a project having a different datum transformation than the most current one, which OPUS uses, then you have a positioning mis-match problem that needs to be addressed.

Unfortunately, the OPUS report does not generate WGS84 (ie- "Global" in Trimble terms) coordinates. It gives you ECEF, Local, and Grid coordinates, leaving out the critical WGS84 Global coordinate which is generated from ECEF and is used to generate the Local and Grid values. If it did, you could just add those to the base point in the project and it would then generate Local and Grid coordinates using the current datum transformation definition. So, you have to set up the TBC project in such a way that it will correctly generate the missing WGS84/Global coordinates.

The process: Get the TBC project into the same local coordinate system that OPUS has generated it's coordinate solution in, then reposition the base point (and all vectored points by the process) to the new corrected OPUS position.

The steps:

1. First, use the RINEX utility to obtain the ARP height of the receiver antenna above the control point and write this number down. Then process the RINEX file to generate o, n, g files (observation, navigation, glonass). Submit the observation file to OPUS, filling in the "measure to ARP" value from the RINEX file and selecting the correct antenna model (usually near the end of the long list). You will get an email back from them containing the OPUS Report. The report will be in Local and Grid coordinates only.
2. Open or create the TBC project with the autonomous RTK job files included. These are RTK jobs where the base point coordinates were determined by using the "Here" function.
3. Change the project's coordinate system to the same system used in the OPUS solution report under REF FRAME:. The Global coordinates of any point in the project should not change but the Local and Grid coordinates should. Select any point in the project and open its *Properties* to see that this is in fact working properly. Use the Undo/Redo buttons or (Ctrl+Z, Ctrl+Y) to check.
4. Create a new point in the project exactly on top of the autonomous base point using *CAD* > *Create Point*. This is your marker point to check that the base is actually moving correctly.
5. Highlight the autonomous base point and open *Project Explorer*. Use the expansion arrows under *Points* to expand the points. Look for the highlighted base point. You should see at least

one red/white targeted coordinate entry for the base point; this/these come from the controller JOB files. Right-click on the base point and select *Properties*. Click on the *+red/white target icon* in the *Properties* window or just right-click on the point to add a coordinate value to the point.

6. Select "Local" under Coordinate Type in the *Add Coordinate* function then copy/paste the local geodetic coordinates from the OPUS report into the Latitude, Longitude, and Height boxes. Use the LAT:, W LON:, and EL HGT: from the OPUS report. Double check that the project's coordinate system shows the datum transformation to be the same as what is shown on the OPUS report under REF FRAME:
7. Set the point quality (square buttons next to the Latitude/Longitude and Height boxes) to Survey Quality or at least a higher quality than the other coordinate for that point and keep the point status Enabled. Zoom in on the base point in the *Plan View* and turn on the layer that has the copy of the autonomous base point you created. Click *OK* to add this coordinate to the base point. You may see the base point and all its vectors shift to the new position, verified by watching it move away from the unvectored point you created as a copy of the autonomous "Here" position.
8. For some reason, the points list will "un-expand" and you will have to re-expand the points list to get back to the base point coordinates. The newly added coordinate will appear as **Office Entered** in the list of coordinates for the base point in *Project* Explorer. Disable all other coordinates for the base point in *Project Explorer*. These might also have to have a lower point quality than the Office Entered (OPUS) coordinate. You may see the base point and all the vectors move to the new OPUS coordinate position when you do this. Click the round red Recompute button at the bottom of the screen and you should see all the points attached to the blue vectors move. Again, Use the Undo/Redo buttons or (Ctrl+Z, Ctrl+Y) to check.
9. Pay attention to any red flagged points as they may not move with the re-positioning of the base point to the OPUS coordinates. You can zoom in on these and use the undo/redo buttons to see if they do. If not, you have to fix the error first. This is a block shift/translation of all points tied to the base point from the autonomous "Here" key positioning to a more accurate position provided by the OPUS positioning solution. The horizontal shift is generally small, around a meter or less. The vertical shift is generally larger, sometimes a couple of meters.
10. Beware that non/vectored points will not shift. This is why you normally do this transformation/translation repositioning of RTK data before you bring in grid coordinates from other sources.
11. Total station data should shift as well if vectored RTK points were used for the total station orientation. Again, verify by zooming in on this data in the *Plan View* and using the undo/redo buttons to see that all of it shifts correctly.
12. Check the point properties of the base point and you should now see the Local coordinates exactly as you copied from the OPUS report, the Grid coordinates should have generated exactly (or very nearly so within a millimeter or two) of what is reported in the OPUS report if your projection is either UTM or SPCS.
13. TBC will also have generated Global (i.e.- WGS84) coordinates for the OPUS positioned base point. These will be different than the Local coordinates (if you used a transformation other

than *Molodensky NAD83(Conus)* which is a null transformation) and is a key piece of information.

14. You can now change the project's coordinate system to whatever you want. The Global coordinates should not change.

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Appendix C

Trimble Business Center custom file formats

These are user defined (ie- 'custom' formatted) files that instruct TBC how to:

- Set up projects using a ***Project Template*** other than the standard templates that come with TBC.
- Set up an ***Export File Format*** other than the standard export file formats that come with TBC.

These have been created to standardize and expedite the data handling processes in TBC. They generally are named with respect to the data sets being processed. They are generally located in the last folder of the application

To find out where these files get stored in your TBC installation, open a copy of TBC and open the first tab (far left in the ribbon tabs) that is labeled **File**. From there, open the **Options** and then **File Locations**. In the File Locations you will see paths to where the *Templates* and *Custom Export format definitions* are found.

Copy these custom formatted files and paste them into these folders.

For TBC version 4.x
C:\Users\h-johnsonc\AppData\Roaming\Trimble**Trimble Business Center Survey\29.0**
And then paste in the following file: USGS FORT Master Survey Export2019_GlobalDD.ocexp

For TBC version 5.32 (latest version which I just installed and will use moving forward)
C:\Users\h-johnsonc\AppData\Roaming\Trimble**Trimble Business Center\33.0**
And then paste in the following file: USGS FORT Master Survey Export2019_GlobalDD.ocexp

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Appendix D

Converting Total Station to RTK Coordinate System

1. Open a TBC project and import the GNSS data files (Trimble Access job files). This should set up the TBC project coordinate system parameters. Check them in the project settings.
2. Import the total station Access job file. Because the TS file was done in scale=1, no datum, no projection, the data will come in just north of the equator and just east of the UTM zone central meridian according to the incoming grid coordinates because that is where they are located according the project's coordinate system definition from your GNSS import. So it will assign Local and then Global Lat, Long, Ellipsoid height to those grid coordinates according to where they are defined in the project's coordinate system. You should see a message that the imported TS job has a different coordinate system.
3. Check mark *Keep project settings* and open the *Details* to see the differences which are highlighted in yellow. Close that and import the TS file.
4. In the *View Filter* > *Raw Data* be sure the RTK and Total Station boxes are checked. You should see blue vectors for all the GNSS data and green vectors for all the TS data.
5. Open a second *Plan View* and drag the title tab down to the right side of the current plan view to make two plan views side-by-side. Bring each data set into a plan view so you can work on them both at the same time.
6. Go to the *Survey* > *Transform Survey Points* function.
    a. Pick 5 at the top for a 5 parameter transformation.
    b. Uncheck the Horizontal scale function so it stays at one.
    c. Pick the *From First point* option. In the point pairs definition below select the initial instrument point from the TS plan view and the corresponding GNSS point from the GNSS plan view. For the second pair pick the initial backsight point from the TS data and the corresponding point from the GNSS data.
    d. Put the cursor in the *Selected:* box at the top and select all the TS data in that plan view.
    e. Make the transformation. All the TS data should now be in the proper orientation compared to the GNSS data set.

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

Standard Operating Procedure (SOP) #18

Vegetated vs. Non-vegetated Mapping in the Northern Colorado Plateau Network

Version 1.01 (February 2018)

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.00	2/2018	D. Perkins	Editorial, clarifications	Peer Review comments	1.01

This SOP describes the methods for mapping of vegetated vs unvegetated areas (polygons) along the big rivers in the NCPN to determine if the river channel is narrowing (becoming more vegetated) over time. This mapping takes place along the entire river corridor within the park unit, at least as much of the corridors as are available in the imagery datasets available. These methods are generally most effective in broad alluvial stretches of rivers and are less effective in entrenched meander sections due to the steep walled canyons.

1.0 Imagery Acquisition

In order to create vegetated polygons, aerial imagery must first be obtained. One reliable source of high quality imagery is NAIP (National Agriculture Imagery Program, https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/index). Since the mid 2000s, NAIP imagery has been completed state-wide during growing seasons every three years, and is available free of charge from USDA Geospatial Data Gateway (https://gdg.sc.egov.usda.gov/). Imagery is stored on a NCPN server.

Any imagery datasets (potentially from other projects) such as Lidar, or satellite acquisitions can also be used for this mapping effort.

Older imagery datasets occasionally are found, and they too are acquired and stored on an NCPN server. Some older datasets are only in 9x9 hardcopy format, and in order to be used for this project, they are scanned and orthorectified. If orthorectification is too cost prohibitive, the

photos are scanned and rubbersheeted, and the output linework should contain metadata noting the base imagery was only rubbersheeted, not rectified.

All aerial imagery is stored on NCPN server "inpcanyimms3 (esatabox)" in the appropriate folder under the Imagery folder hierarchy.

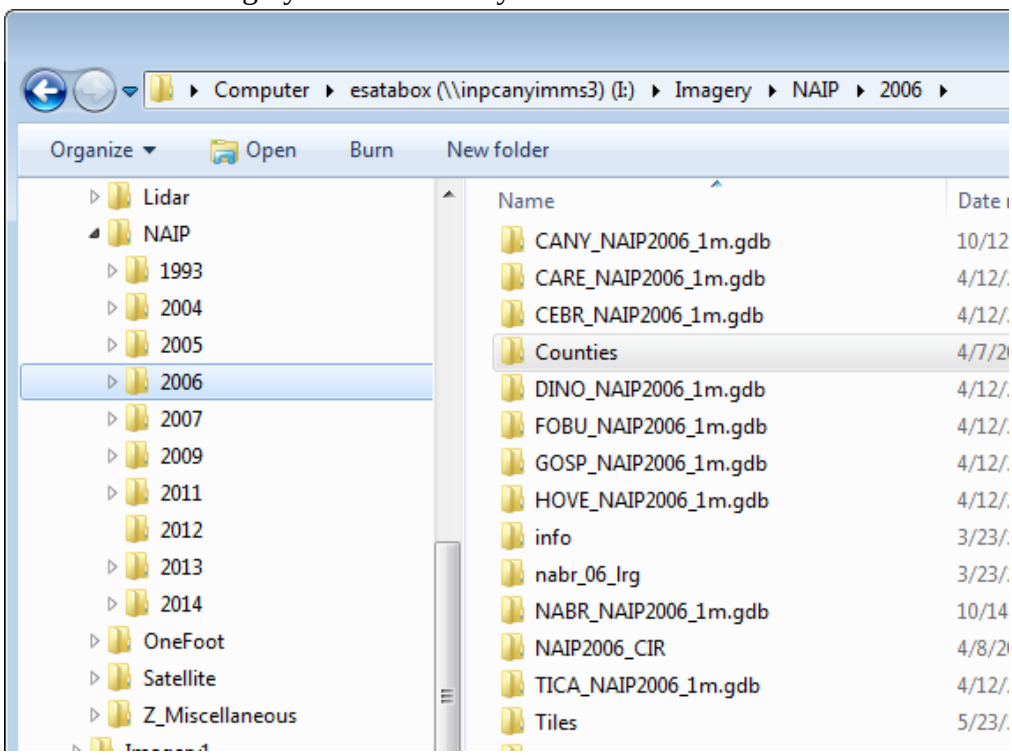


Figure 1. NCPN imagery hierarchy example

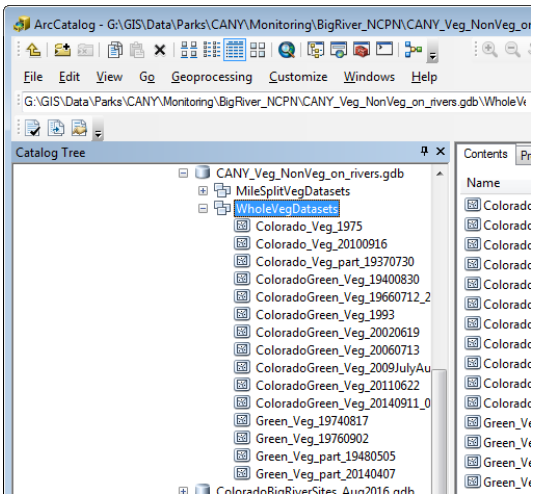
2.0 Mapping

The mapping of vegetated vs non-vegetated is fairly straight forward. Mapping has been completed in ArcMap, using a geodatabase to store the various years of mapping. The data mapped are only the vegetated polygons visible from the imagery.

NCPN has chosen to use the park vegetation map (Coles et al. 2008, 2010, Tendick et al. 2010, 2012) polygons as the baseline for the mapping of the river corridors as this data has been thoroughly vetted and described in the vegetation map reports. This also allows for a common upland boundary for all years of unvegetated vs vegetated data, which is helpful in area comparisons. Also, it's much simpler to edit existing linework than create new linework. An area was considered vegetated if there was more than 50% cover. Areas were mapped as vegetated if they were greater than 0.01 hectares (0.03 acres).

1. Open and create a project in ArcMap. Add the imagery to be mapped, and the base year feature class (vegetated feature class originally created from the vegetation map data). This can be found on NCPN server "inpcanyimms3," G:\GIS\Data\Parks\CANY\Monitoring\BigRiver_NCPN.

2. Create a new feature class in the geodatabase by exporting the feature class based on the vegetation map. Name the exported feature class with the river(s) and imagery date (example: ColoradoGreen_Veg_20110622 = Colorado and Green rivers vegetated areas from 6/22/2011 imagery). The new feature class will be then be edited to reflect the imagery (year) being mapped.



3. In ArcMap, begin an edit session, and using tools such as the "Reshape" tool, begin refining the linework to fit the imagery. Generally, the mapping should take place between 1:2,000 - 3,500 scale so that actual changes can be observed and effects that can look like changes from shadows or if the imagery is oblique are minimized. Only edit the river side of the vegetated polygon, leaving the upland side as is. Continue editing until river corridors are complete. Generally most imagery we use follows USGS methodology and error rates that dictate that "requirements for meeting horizontal accuracy as 90 per cent of all measurable points must be within 1/30th of an inch for maps at a scale of 1:20,000 or larger, and 1/50th of an inch for maps at scales smaller than 1:20,000." For our scales this translates to an error rate between 1.01 and 4.06 m.

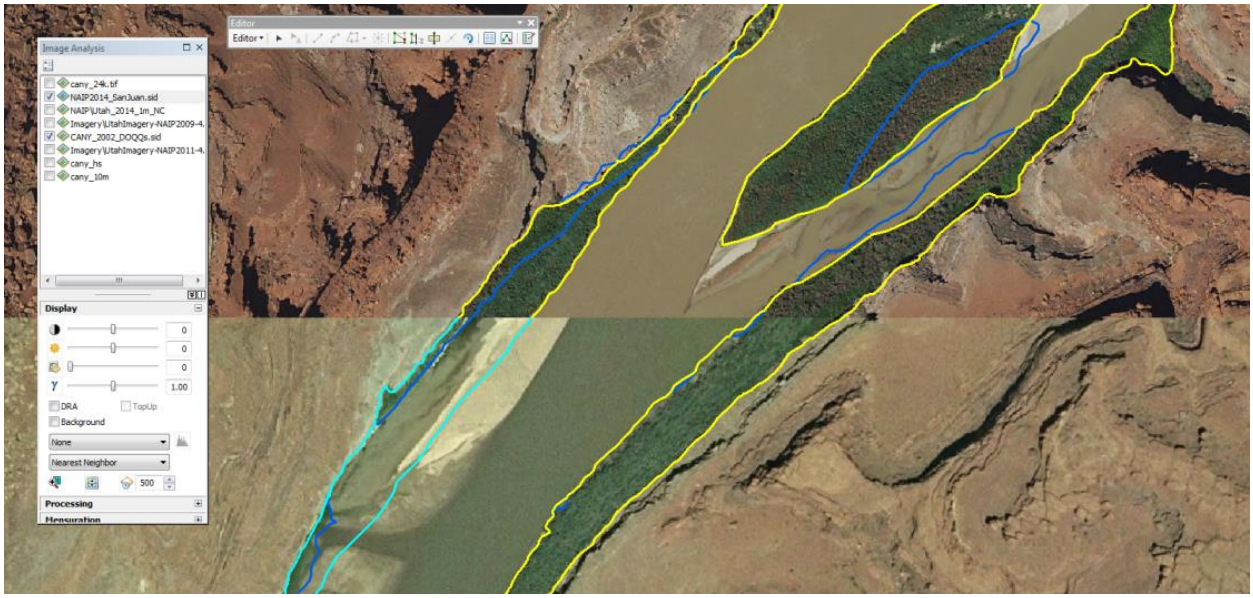


Figure 2. Base linework (2002, blue) and 2014 (yellow) linework and corresponding imagery (2014 imagery top, 2002 imagery bottom)

4. Once all the line editing is completed, calculate Acres and Hectares in the attribute table.
5. Create metadata stating which year the feature class represents, when it was completed and other relevant metadata details.

These data will give us a variety of channel metrics for the entire river corridor within a park, something that would not be possible with ground based metrics. In addition to the work we have done, a recent thesis from Utah State University analyzed aerial imagery on the Green River in CANY and validated and improved upon our methods (Walker 2017). These data are free and are becoming more frequent. However we are limited to when others acquire these data. Time of year, frequency of collection, level of detail may change over time and sometimes may be inadequate. For example in 2011, the flight occurred in June when river stage was still high due to the extremely high runoff that year, it would have been better for our purposes if the imagery was acquired in September or October when the flows had resided. The parks and NCPN have committed to acquiring imagery if we have not found free imagery for a period of more than 5 years.

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