Standard Operating Procedures: Topographic Survey of Stream Channels

Colorado Water Conservation Board
Watershed Protection Program

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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1.0 INTRODUCTION

This Standard Operation Procedure (SOP) describes methods for surveying a stream channel and for the establishment of cross sections for the purpose of long-term monitoring of channel dimensions and location.

The Colorado Water Conservation Board (CWCB) administers the Colorado Watershed Protection Program. In 2010 CWCB co-initiated the Measurable Results Program (MRP) to assist in monitoring and evaluation of stream restoration projects. The MRP has developed this SOP to provide guidance on minimum elements included in all CWCB funded stream channel reconfiguration that requires survey monitoring.

A survey of the stream channel is a critical component of monitoring activities for monitoring of stream restoration projects. Repeat channel surveys with a common datum and coordinate system will enable detection of geomorphic change that might occur as a result of flood scour, bed-material aggradation, or lateral channel migration.[1] Many restoration projects funded by the Colorado Watershed Protection Program, require the grant recipient to collect reproducible cross-section monitoring data using established data collection methods. It is the intent of this SOP to formalize a repeatable methodology for the collection and electronic storage of cross section information in order to assist analysis and reporting efforts.

The goal and purpose of this SOP is to collect high quality reproducible survey data that can be: 1) Used to track and assess stream condition changes at a particular location within a project site over time; 2) To assess trends and to assist in determination if restoration goals are being met. The objective is to establish repeatable surveys. It is therefore, important that collection methods are consistent to maximize data usefulness and to ensure that data collected by different surveyors at different sites over the course of numerous years are comparable.

2.0 EQUIPMENT

1. Survey-grade GPS equipment or total station (preferred), or laser level or tape and rod
2. Field notebook or data recorder
3. Pins (rebar with caps), concrete, markers (stakes, t-posts, or similar)
4. Pens, pencils, flagging
5. Handheld mapping-grade GPS unit

1 RCMAP Website. http://co.water.usgs.gov/projects/rcmap/monitormethods.html. Accessed 2/2/12.

3.0 GENERAL SAMPLING PROCEDURES

EQUIPMENT

For accurate survey and long-term monitoring of stream channels a survey-grade GPS or total-station unit is recommended. By using this equipment a channel survey will capture not only elevation data but also record point coordinates (northing and easting). Location and elevation data captured in the field can be used to generate topographic maps of the channel, the streambed, gravel bars, banks, terraces, structures and be used to relocate and track changes in these features over time. While more expensive to own and rent, the use of this equipment ultimately will lead to a more accurate set of survey data.

In some instances traditional tape and rod may be used to complete cross section surveys as described in USDA Technical Report RM-245[2]. This type of survey equipment is typically not as accurate but can still be effective for coarse monitoring of cross-sectional change and may be more feasible for some applications (e.g., remote hike-to field locations, limited budget, etc.). Use of GPS and setting of "control" to ensure future surveys are at the same location is still critical for change-detection monitoring.

ESTABLISHING SURVEY CONTROL

Key to ensuring that repeat surveys are conducted at the same location is setting of "control" – permanent markers that have a known coordinate and elevation data. Control points have an unchanging location and elevation and therefore allow for survey work to be relocated by future parties despite what changes may have occurred to the channel, banks, or floodplain of a river that is the subject of the survey monitoring.

Survey control consisting of 2-3' pieces of ½" rebar set in concrete (Figure 1), brass caps set in concrete, chiseled marks in bedrock or concrete structures, or other identifiable items not susceptible to frost heave, vandalism, and flood or animal damage. Concrete monuments should be 4" x 4" minimum up to 6" x 6" maximum and 24" to 30" deep for stability. Rivers subject to flooding should attempt to locate control on surrounding hillsides or at least on old abandoned terraces when possible. Having several control points located out of the floodplain is a good idea to ensure that at least a few will persist should a flood occur. A minimum of 2 reference points within a clear "view" of each other are required for adequate control.[3] Vertical accuracy of 0.05' is the target for all monuments and reference points; horizontal accuracy of +/- 0.10' is acceptable for ground points.

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2 USDA General Technical Report RM-245. 1994. Stream Channel Reference Sites: An illustrated guide to field technique. Harrelson et. al.

3 While GPS equipment may be able to "see" through vegetation or over hills, setting control in line of sight will typically allow for more equipment options for future re-surveys.

Control points and the subsequent stream channel surveys that are obtained from them must be referenced to a datum and coordinate system that can be re-occupied by subsequent surveys. The location of control points should be identified with Latitude and Longitude coordinates (decimal degrees) determined from global-position satellite (GPS). Mapping-grade hand-held or survey-grade GPS is preferable for this type of data collection due to the increased accuracy over standard hand-held GPS technology. The GPS datum used should be identified. Labeling of control points is also encouraged (Figure 1).

Figure 1: Control point set in concrete and labeled

In some instances it may be impossible to obtain "real-world" coordinates of a control point. In these cases it will be necessary to assign a local coordinate system (e.g. assign x=3000, y=2000, z=1000) to your first control point. Be certain to record these local coordinates and mark, map, photograph and/or note with hand-held GPS coordinates the location of this and other control points for future use.

CROSS-SECTIONS

Cross-sections are an excellent way to track channel stability following realignment, placement of structures, bank stabilization or other restoration work. Monitoring cross-sections should be physically surveyed on site and not "cut" or extracted from a topographic survey (streambed detail for change-detection monitoring purposes is not adequately represented in a "cut" or otherwise extracted cross-section).

Establish new cross-sections perpendicular to the bankfull flow. Cross-section spacing is determined by site and project-specific considerations. Cross-sections can be spaced wider apart where the channel is uniform (has little curvature, similar cross-section shape, same grade, same roughness) and should be spaced more closely where the channel is irregular (width or slope vary abruptly, islands or bends are present, roughness varies), near bridge abutments and piers, and near flow-directing structures commonly used in channel reconfiguration.[4] If streamflow modeling is proposed, the cross-sections should be spaced more closely to capture downstream variations in streambed topography. Data points throughout the river channel also help with creating 2D and 3D models and should be captured where this is an objective.[4]

4 RCMAP Website. http://co.water.usgs.gov/projects/rcmap/monitormethods.html. Accessed 2/2/12.

The right and left endpoints of a cross-section ideally will consist of 2-3' rebar (pin) hammered into the ground. It is helpful to have stamped plastic cap on the rebar as the color helps with future relocation. In order to make relocating the pin easier it is advised that a persistent marker (e.g., T-post, heavy wooden grade stake, plastic reflective driveway marker) be placed in the nearby vicinity as it will be visible in tall vegetation and make the pin easier to find (Figure 2). Mapping-grade GPS coordinates of the pins, hand drawn maps and narrative directions should also be obtained at the time of this marking for future reference. The cross-section endpoints will serve as additional control points for northing, easting and elevation and their permanence is therefore helpful for repeat surveys. Cross-section endpoint pins should be located high enough above bankfull (when vegetation allows) to be safe from flood scour or debris and may even want to be located far back into the floodplain to capture floodplain changes over time.

Figure 2: Mark rebar pins with lathe or t-posts, flagging, and record their coordinates with a GPS. Building a small rock cairn around the pin can also be useful for relocating them in the future.

Survey points along the cross-section should be in as straight of a line as possible. It is advised to stretch a tape line along the cross-section in order to keep survey points in a straight line - a navigated course (e.g., run "stakeout to line" on a total station) between two endpoints would also achieve this standard. There is no set rule for the number of data points to take through a cross-section. Closer spacing is beneficial when there is great streambed irregularity; wider spacing is acceptable when the streambed is more uniform (Figure 3). Elevations are especially important to capture where major slope changes occur as one surveys across the channel (e.g., top of bank, toe of bank, mid-channel bar, etc.). In larger non-wadeable rivers, at a minimum edge of water, top of bank, and bankfull (if known) should be surveyed.

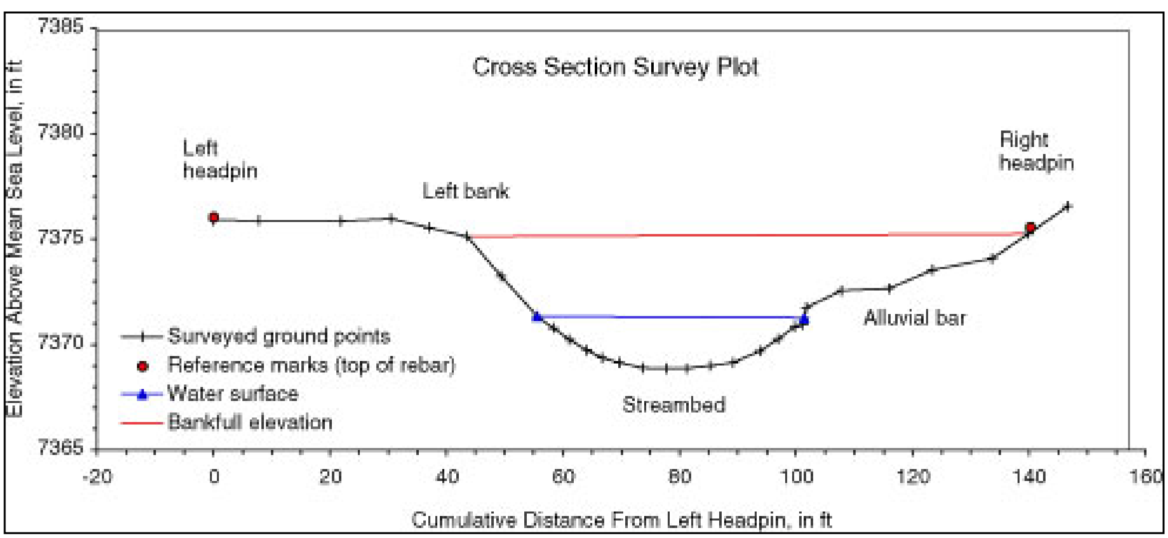


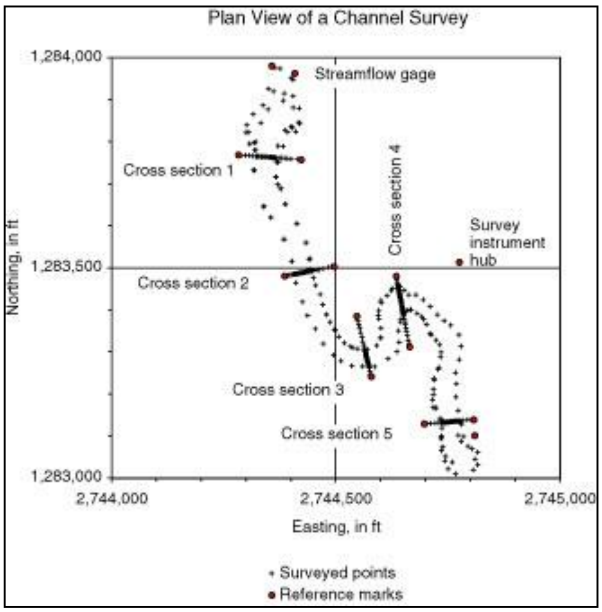
Figure 3: Example of plotted cross section survey (credit: RCMAP website)

Further documentation of the cross-section consists of taking four photographs that depict the cross-section (this is extremely helpful when perhaps months or years later the data is looked at in the office). For each cross-section assessed, the photographer should circle around the cross-section in order to capture images of the section itself. Take at least 4 photos; **upstream view**, **downstream view**, **right bank** and **left bank**, in order to fully represent the conditions of the cross-section. Walk upstream of the section to take a "downstream" image that captures the entirety of the cross-section looking downstream (Note: on larger rivers it may not be practical or possible to capture a bank to bank photograph nor will it be possible to stand in the middle of the stream to do so – standing upstream on one bank and looking downstream through an unobstructed view is acceptable. Panorama setting on a camera may also be useful). It is helpful for organizational purposes to choose a standard routine and stick with it. For instance when documenting cross-sections start downstream and continue in a clockwise circle capturing the four photographs (i.e., looking upstream, looking to the left bank, looking downstream, looking to the right bank). Repeating this order for any other cross sections documented that day will reduce any confusion back at the office (although a photo log should be recorded in the field to aid in organization). Include some measurement of scale in your photos if possible; for example, have a person stand next to the pins when taking the left and right bank photos (these images may also help in relocating pins in the future – see Figure 4). A measuring tape or depth rod can also be used to achieve scale in photographs.

Figure 4. Cross-section photo reference example. From left bank looking towards right bank across the section. Note person standing over right pin to provide scale and to aid in relocation of pin in future years.

LONGITUDINAL PROFILE SURVEYS

Longitudinal channel transects may be useful depending on the objectives of the project. Longitudinal surveys define the downstream slope or grade, and identify, for mapping purposes, the edge of water, bars, banks, and other topographic features. These transects could include the left and right edge of water, thalweg, the left and right banks, the tops of gravel bars, levees, and terrace scarps. Features surveyed will vary from project to project. Ideally longitudinal transects have endpoints like a cross-section but if not the data points do need to be referenced to northing and easting coordinates established through the use of control points.



Depending on the project goals a river channel survey may also include the bed, bars, islands, side channels, eroding or constructed banks, berms, in-channel structures, terraces and other important features to the project. As with cross sections it is important to collect data at places where significant slope changes occur (e.g. riffle crest, riffle tail, pool, tail of pool, etc.). Vertically, the survey should include the deepest portion of the channel (thalweg) to the floodplain including any flood-confining terrace, bank, or berms. Spacing between longitudinal transect data points can be wider than for the cross sections. The purpose of the survey is to capture the topographic variability of the streambed and floodplain and significant channel-formed features (Figure 5).[5]

Figure 5. Example of data points collected during a channel survey (credit: RCMAP website)

SURVEY POINT NUMBERS AND DESCRIPTIVE CODES

Each survey point collected should have a unique number. Descriptive codes are recommended for all key data points such as bench marks, reference points, cross section end points, or other permanent monuments. Other recommended descriptive codes include: a cross-section identifier, the edge of water, bankfull, top of bank, beginning and tops of bars, toe of bank or slope, change in vegetation, flow-directing structures (vortex weir, cross vane), levee, riprap, gabions, and bridge abutments or piers, etc. Point numbers and use descriptive codes will help subsequent investigators reproduce and interpret the surveys.

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5 RCMAP Website. http://co.water.usgs.gov/projects/rcmap/monitormethods.html. Accessed 2/2/12.

4.0 QA/QC

See "Standard Operating Procedures for the Planning of and Field Procedures for the Conducting of Monitoring Activity". Colorado Department of Public Health and Environment Water Quality Control Division, May 2005.

5.0 DOCUMENTATION

1. Raw survey data
   All raw data should be stored in a space delineated file (.csv) labeled with point#, northing, easting, elevation, and description so that multiple programs (e.g. Hec-Ras, CAD, Excel, etc.) may be used for final analysis.

2. Cross section plotting
   It is recommended that using a standardized scaling of 10:1 for the horizontal and vertical scales (e.g., if the horizontal scale is 1"=50' then the vertical scale is 1"=5' and so on) in the cross sections is beneficial for depicting vertical changes when comparing cross sections over time.

6.0 REFERENCES AND RESOURCES

Columbia Habitat Monitoring Program (CHaMP) Protocols:
https://cnr.usu.edu/streamrestoration/files/uploads/2011%20Resources/CHaMP_HabitatProtocol_v1.1_TopoExcerpt.pdf

RCMAP Website. http://co.water.usgs.gov/projects/rcmap/monitormethods.html. Accessed 2/2/12.

Reconfigured-Channel Monitoring and Assessment Program
USGS Water-Resources Investigations Report 99-4111, 6 p., 4 figs. *by* J.G. Elliott *and* R.S. Parker

Standard Operating Procedures for the Planning of and Field Procedures for the Conducting of Monitoring Activity. Colorado Department of Public Health and Environment Water Quality Control Division, May 2005.

USDA General Technical Report RM-245. 1994. Stream Channel Reference Sites: An illustrated guide to field technique. Harrelson et. al.