STANDARD OPERATING PROCEDURES
FOR FIELD SAMPLERS

VOLUME II
Revision 3.2

BIOLOGICAL AND HABITAT RELATED TECHNIQUES

Rapid Creek below Pactola Reservoir

STATE OF SOUTH DAKOTA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
WATERSHED PROTECTION PROGRAM

STEVEN M. PIRNER, SECRETARY

MAY, 2018

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VOLUME II

BIOLOGICAL AND HABITAT SAMPLING

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1.0 PRE-SAMPLING PROCEDURES

Each field investigation must be evaluated and designed on an individual basis. Common procedures addressed in developing an assessment work plan include the following:

1. Determine the objectives for sampling.
2. Review existing information and data on the waterbody to be studied.
3. Obtain adequate maps and diagrams to define the study area.
4. Conduct field reconnaissance of the proposed study area.
5. Develop a list of proposed sampling sites, sampling frequency, and sample analysis.
6. Arrange schedules, responsibilities, funding and contracts with all agencies, sponsors, and laboratories involved with the study.
7. If sampling near or on private land, secure permission prior to deployment.
8. Coordinate all activities.
9. Develop a list of necessary equipment and supplies.
10. Check the operation of all equipment prior to field use.

2.0 LAKE MACROPHYTE SURVEY

A. Purpose

An aquatic plant survey of a lake or any other waterbody will provide data in three categories:

1. Density of plant species
2. Species present
3. Distribution of plant species within a waterbody (areal coverage)

The quantitative method described here is a combination of the Minnesota Department of Natural Resources Division of Fish and Wildlife Manual of Instructions for Lake Survey Special Publication No. 147, 1993; and Game Investigational Report #6: An Evaluation of a Survey Technique for Submerged Aquatic Plants by Robert Jessen and Richard Lound, January 1962. Report #6 is also a publication of the Minnesota Department of Conservation, Division of Game and Fish, Section of Research and Planning, Fish and Wildlife Surveys Unit.

Aquatic plants can be used as indicators of the state of water quality within a watershed and lake. Documentation of species, distribution, and relative abundance will allow a descriptive mechanism through which the progressive or regressive state of the watershed can be monitored over an extended period of time. These methods should also provide data for tracking the distribution and spread of exotic plant species.

B. Materials

Boat and related equipment	plant grapple/garden rake
plastic bags	labels
data sheets	tape measure
taxonomic keys	bathymetric map of the lake
previously collected data	metal or wooden stakes

GPS Unit
100 meters of floating rope marked off in meters with a buoy and anchor

C. Procedures

1. Surveys for aquatic plants should be conducted during the period of time when plant growth has reached its peak which is sometime during the summer months preferably around early August. However, plant species vary as far as periods when peak growth occurs. It may be prudent to identify the dominant species in the waterbody in question and determine its period of highest growth. Aquatic macrophyte data should also be put into a database delineating species composition and abundance for each lake that is surveyed.
2. Aquatic plants should be identified to at least the genus level if not to species. If the plant specimen cannot be identified in the field it should be placed in a plastic bag labeled as to date, time, transect #, etc., and brought back to the lab for further identification.

3. Mapping the location of plants and aquatic weed beds should be conducted in association with each transect and is described below. Bathymetric maps or a copy of the lake on a topography map will be useful in the survey.
4. Transects will be determined by first choosing a starting point which would probably be the access point or boat ramp. Determine the number of transects by using the following method employed by the Minnesota Department of Fish and Game:

   The number of transects needed, based on lake size, can be determined below:

Lake Size (Acres)	Number of Transects
< 150	10
150 - 500	20
501 – 1,000	30
1,001 – 5,000	40
> 5,000	50

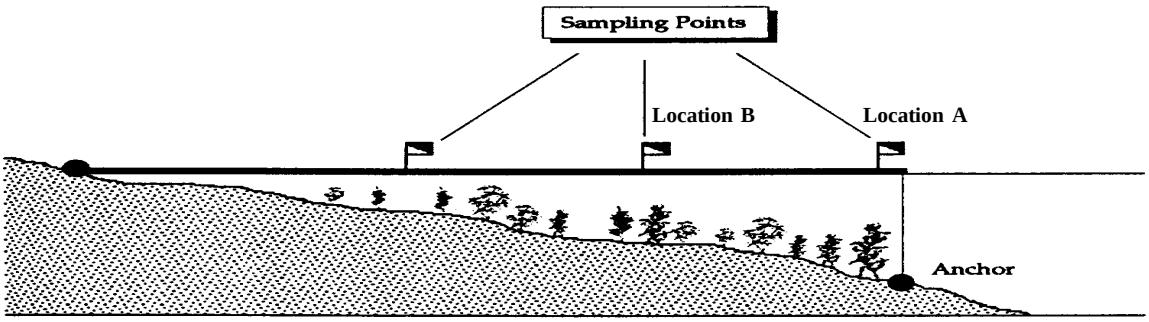
   Divide the shoreline length by the number of transects plus 1 (n+1) to determine the distance between transects. For example, Lake Brant in Lake County is a 1,000 acre lake with 6.2 miles of shoreline would require 30 transects. Dividing the 6.2 miles of shoreline by 31 (n+1) would result in 0.2 miles between each transect. Space transects evenly around the shoreline (0.2 miles apart) in a clockwise direction from the starting point (access area). Do not use the starting point as your first transect. Number each transect consecutively on the Macrophyte Survey Lake Map (Figure 2.0. 2) sampling station map. Additional transects can be established around islands, or in mid-lake areas (especially for larger lakes) if desired. Be sure to include these transects on the macrophyte survey lake map.

   A transect does not have to be at the exact location on the map, but determine whether transects can be located again if a survey is repeated. This can be accomplished by GPSing the shore point where the transect begins (the latitude and longitude at the point where the transect intersects the shoreline). Use other landmarks such as access areas and docks to help locate the transect.

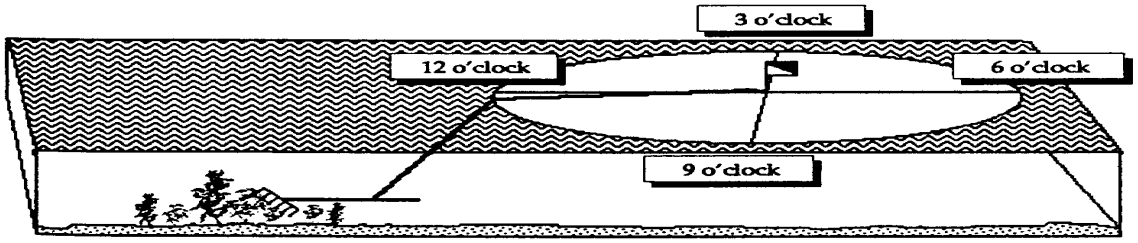
5. Transects will run perpendicular from shore to the maximum depth of vegetation growth or the entire width of the lake depending on size of waterbody (Figure 2.0. 1).

   a. If vegetation extends across the entire lake, end the transect at the halfway point across the lake.

Copied from: US EPA. 1991. Volunteer Lake Monitoring: A Methods Manual. EPA 440/4-91-002. Off. Water, Washington, DC.



A transect line is stretched from the shoreline to the end of the littoral zone. Sample sites are marked on the line for the raking survey.



A rake is pitched at each o'clock position and then dragged along the lake bottom. The rake is then hauled back into the boat, and the collected vegetation is sorted into plant types.

Figure 2.0. 1 Aquatic Plant Survey Diagram.

6. For each transect, begin at the shore-point and identify all emergent and submergent species either side of the boat along the length of the transect.

   a. Take the 100-meter floating rope and stake the one end at the shore point where you want the transect to begin. Pay the rope out with the boat out into the littoral zone of the lake until you reach the following:

      i. The end of the littoral zone.
      ii. The end of the rope.
      iii. In narrow lakes (small reservoirs) the transect goes across the entire width of the lake.

   b. Place the float line out in the lake by tying it to a stake or tree on the shoreline. Pay out the float line until you reach the desired length or the end.

SD DENR WPP Macrophyte Survey Lake Map

Macrophyte Survey Lake Map			
Lake ID:	**Lake Name:**		**Acres/Hectares:**
Date:	**Time:**	**Sampler(s)**	

Draw a sketch of the lake with transect numbers and locations. Include the location of the deepest part of the lake, macrophyte beds not on survey transects, locations of photographic points, direction of photograph, and frame number. Also identify, mark locations, and list other plant species not on transects on Lake Map.

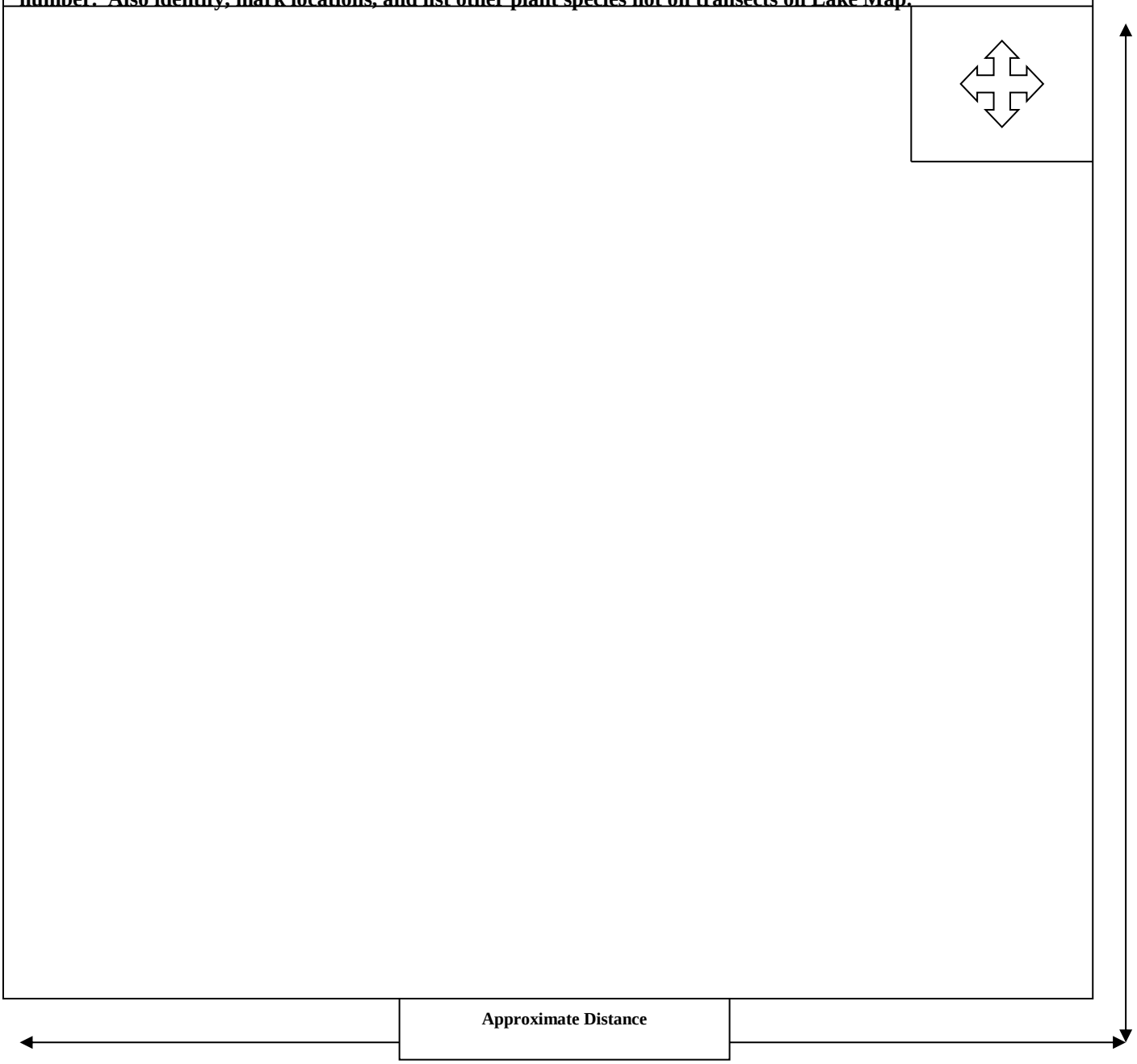


Figure 2.0. 2 SD DENR WPP Macrophyte Survey Habitat Assessment Field Data Sheet

c. Make sure the anchor and buoy are tied at the appropriate depths and in such a way that the line remains floating (Figure 2.0.1) measure the depth at the end of the transect and record it on the data sheet (Table 2.0. 1).

d. The end of the rope or the location of the buoy will be the first sampling location position.

e. Position the boat so the bow is perpendicular with the shoreline. The bow will be the 12 o'clock position. Cast the rake/plant grapple approximately 2-3 meters from the boat and let it sink to the bottom. When it hits bottom slowly drag it to the boat. Once the grapple is inside the boat, identify and separate plant species into piles and estimate the percentage of each species. Fill in species and species percentages beginning at the end of the transect rope (Location A) and working toward shore on the lake assessment data sheet. The total should equal 100 percent for each position (Table 2.0. 1).

f. Repeat this procedure until all 4 positions around the boat have been sampled (3, 6, 9 o'clock).

g. Each species sampled from each position should be given a density rating as described in Table 2.0. 1. If the plant species is present in all 4 casts and very dense, it should be given a density rating of 5. If a plant was found in all four casts but in a limited amount, give it a density rating of 4. If the plant was found in only 3 casts, give it a rating of 3, etc.

h. Measure the total water depth and total Secchi depth at each sampling point. Especially note the depth at which aquatic plants are no longer present. Fill in maximum depth of colonization in meters on the SD DENR WPP Lake Habitat Assessment Data Sheet – Macrophyte Survey (Table 2.0. 1).

i. If the plant species cannot be identified in the field put a specimen in a plastic bag, label and transport it back to the lab for further identification. Be sure to document the density of the unknown plant species at the appropriate location (i.e. Location A, etc.) in the Density Rating Chart (Table 2.0. 1).

j. Continue moving the boat approximately 10 meters and repeating steps "a." – "i." until the shore point has been reached.

k. Include those transects that are absent of vegetation. If these transects can be visually inspected with reasonable certainty that vegetation is not present, a plant grapple/rake does not have to be used. However, document the depth at the end of the transect as you would do with any other transect. Document these transects as absent of vegetation.

l. The objective is to provide a list of all species (if any) present at each transect and their density (abundance).

Table 2.0. 1 SD DENR WPP Lake Habitat Assessment Field Data Sheet—Macrophyte Survey.

Lake Name:	**Lake ID:**	**Date:**	**Time:**
Acres/Hectares:	**Station #**	**Transect _____ of _____**	
Sampling Personnel:			

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Bank Stability	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ____	10 9	8 7 6	5 4 3	2 1 0
2. Vegetative Protection	More than 90% of the bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the bank surfaces covered by vegetation; disruption of bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ____	10 9	8 7 6	5 4 3	2 1 0
3. Riparian Vegetative Zone Width	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ____	10 9	8 7 6	5 4 3	2 1 0

Total Score _____ Maximum Depth of Plant Colonization_____ (m)

Density Rating Chart					
Rake Recovery of Aquatic Plant Type	Density	Descriptive Term	Rake Recovery of Aquatic Plant Type	Density	Descriptive Term
Taken in all 4 casts (teeth of rake full)	5	Dense	Taken in 2 casts	2	Scattered
Taken in 4 casts	4	Heavy	Taken in 1 cast	1	Sparse
Taken in 3 casts	3	Moderate	None	0	None

Location A		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

Location B		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

Location C		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

Location D		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

m. At the end of the transect, complete the shoreline habitat portion of the data sheet (upper portion) to evaluate bank stability, vegetative protection and riparian vegetative width. Circle and fill in the appropriate score for each habitat parameter. When all three parameters are complete, sum the values and write in the total score below the habitat score box (left side, Table 2.0. 1).

n. After completing the Lake Habitat Assessment Data Sheet for each location on the transect, collect the rope and move down the shore to the next shore point (transect). Between transects note any aquatic plant beds present or if aquatic plant growth is no longer present. Note the location, stop and take a depth measurement.

o. If there is a significant aquatic plant bed located between transects you should stop and set up a transect for this area. This may be the only aquatic plant bed in the lake, which makes it necessary to collect the information.

p. Aquatic plant beds should be estimated in size on the Macrophyte Survey map and should correspond to transect or transects and general locations of the beds on the Lake Map.

7. List any other species which were sighted in the lake but were not observed within any transect and estimate their abundance. Place their approximate location(s) on a map or use a GPS unit to pinpoint their location within the confines of the lake. If the lake is large and shallow it may be necessary to do some mid-lake transects, repeating the procedure above, to document the presence or absence of aquatic plants in this region of the lake.

8. Disturbed areas or areas of special interest should also be located within the lake and transects should be estimated to determine the extent of the disturbance and density of predominant species present in these areas.

When Finished Sampling the Lake/Reach/Site, Clean all boats, equipment; and sampling gear including waders, nets and buckets. Be sure to remove all debris, dirt and grime with lake or stream water and follow all cleaning procedures outlined in Section 9.0 in SD DENR WPP SOP Volume I (Decontamination Protocols for Equipment and Field Workers)!!!

3.0 PHYTOPLANKTON (ALGAE) SAMPLING

A. Purpose

Phytoplankton/Algae can be used as indicators of water quality within a watershed/stream or lake. Documentation of species and relative abundance will allow a descriptive mechanism through which the progressive or regressive state of the watershed or lake can be monitored over an extended period of time.

B. Materials

1. Boat and related equipment (in-lake or large tributary).
2. 500 mL, 1-liter, or 2-liter brown polypropylene plastic bottles with screw top lids.
3. Integrated Depth Sampler or Van Dorn sampler with messenger.
4. Sample labels.
5. Secchi disk with metered rope.
6. In-Lake field datasheets (Appendix B, Tale B-1) and logbook.
7. Bathymetric maps for lakes and topographic maps for tributaries.
8. Plastic graduated cylinder (250 or 500 mL).
9. Lugol's solution (dark bottle, kept on ice).
10. Disposable pipettes.

Sample bottles consist of one or more 500 mL, 1-liter, or 2-liter brown polypropylene bottles, depending on project specific goals outlined in the PIP or under the direction of the Project Officer. When collecting phytoplankton/algae composite samples, be sure to collect enough sample water from each location to fill all required containers.

Bottle Labeling consists of securing SD DENR WPP Biological bottle labels and checking the appropriate boxes on the sample bottle labels. Based on the type of sample to be collected, complete all applicable fields including project, source water location, station ID, program initials (WPP, SWQ, SDSM&T, etc.), date, time, sampler initials, composite volume, filtered volume, or surface area (Figure 3.0. 1).

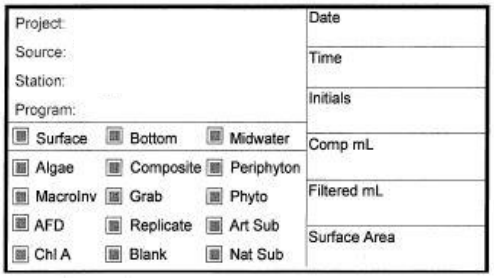


Figure 3.0. 1 Biological bottle label used by the SD DENR WPP.

Generally, in-lake phytoplankton/algal samples consist of collecting surface water samples from three locations (sites) on the selected lake and compositing them into one algae sample for the lake. The Project Implementation Plan (PIP) and/or the Project Officer will indicate the number of sampling sites to be composited or whether to keep algal samples separate.

C. In-lake Sample Collection

There are basically two sample collection methods for in-lake sampling:

- Composite sampling (in-lake sampling with an Integrated Depth Sampler (D-1), a Van Dorn-type sampler (D-2), or plankton nets (D-3)).

- Grab sampling can be done using sample bottles (E-1), the use of a Van Dorn-type sampler (E-2), or using Student, Wisconsin or plankton nets (E-3).

D. In-lake Composite Sampling

Most in-lake water samples collected for the SD DENR WPP will entail the use of an Integrated Depth Sampler which composites multiple samples from multiple sites within in a lake (Figure 3.0. 2). However, some lake projects require collection of separate surface, mid-level, and bottom samples from the same in-lake sampling location. These samples will be collected using a Van Dorn type sampler (Figure 3.0. 4 and Figure 3.0. 5).

1. Integrated Depth Sampler

Figure 3.0. 2 Modified integrated depth sampler based on MPCA Sampler.

Integrated Depth Sampler Setup Procedure and Summary of Methods

Collect water samples using an "integrated sampler"- SD DENR modified design (ball valve on both ends) which was based on the Minnesota Pollution Control Agency (MPCA), see Figure 3.0. 3. The device is a PVC tube 6.6 feet (2.01 meters) long with an inside diameter of 1.25 inches (3.18 centimeters) fitted with a stopper plug on one end and a ball valve on the other, old design (Figure 3.0. 3). The device allows collection of

water from the upper two meters of the water column (within the euphotic zone). If the euphotic zone is < 2.0 m deep (as calculated from the Secchi Disk Transparency section of the SD DENR WPP In-lake Sampling Field Data Collection Sheet (Appendix B, Table B-1)), lower the integrated sampler only to the depth of the previously calculated euphotic zone, and take additional grab samples as necessary to collect the total volume needed for filling all the sample bottles (4 m).

Remove the rubber stopper (old design) or open both the upper ball valves (newer design) and rinse the sampler by submerging it in the lake three (3) times. With the lower valve open and/or the stopper off, slowly lower the sampler into the water as vertically as possible until the upper end is just below the surface (or you have reached the depth of the euphotic zone if it is < 2.0 m). Cap or close the top ball valve and slowly raise the sampler as vertically as possible. Close the lower ball valve when the bottom of the sampler is near but still below the surface of the water. Dispense the contents of the sampler into an appropriate sample botte or composite storage container.

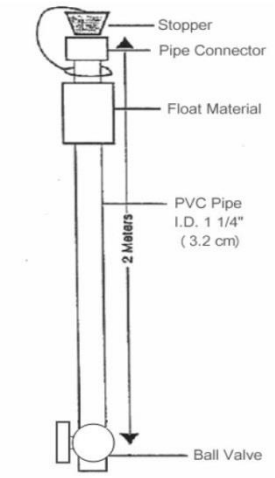


Figure 3.0. 3 Integrated depth water sampling device (MPCA), SD DENR modified version has a ball valve at both ends which seems to work better.

2. In-lake Integrated Depth Sample Collection.

a. Rinse each water sample collection container and/or composite sample collection container with surface water 3-times.

b. Collect a Secchi depth reading at each in-lake sampling site to calculate the depth of the euphotic zone. Method follows:

i. Confirm that the lowering line is <u>firmly</u> attached to the Secchi disk.

ii. Remove sunglasses and hat. Also, do not use view scopes or other visual aids. If wearing prescription sunglasses,

temporarily replace them with regular clear prescription glasses.

iii. Lower the Secchi disk over the shaded side of the boat until it disappears.

iv. Read the depth indicated on the lowering line. If the disappearance depth is <1.0 meter, determine the depth to the nearest 0.05 meter by marking the line at the nearest depth marker and measuring the remaining length with a tape measure. Otherwise, estimate the disappearance depth to the nearest 0.1 meter. Record the disappearance depth (DAD) on the appropriate datasheet (Appendix B, Table B-1).

v. Lower the disk a bit farther and then slowly raise the disk until it reappears and record the Re-Appearance Depth (RAD) using the same level of precision as before (Appendix B, Table B-1).

vi. Calculate the euphotic zone depth by multiplying the depth where the disk reappears (RAD) by 2. Use this calculation to determine the depth at which water samples will be taken with a depth integrated sampler and record it on the datasheet (Appendix B, Table B-1).

(1) If euphotic zone is less than 2 meters, water samples will be collected only within the euphotic zone.

(2) If euphotic zone is greater than or equal to 2 meters, water samples will be taken from the top 2 meters of the water column.

vii. Record the depth of integrated water samples at each site (Sites A, B, and C) for all measurements on the In-lake Field Datasheet (Appendix B, Table B-1).

viii. Note any conditions that might affect the accuracy of the measurement (waves, sun, excessive algal bloom, etc.) in the notes field at the bottom of the datasheet.

c. Remove the rubber stopper cap (older version) or open the ball valve at the top of the sampler (newer version) and open the ball valve on the bottom end of the sampler. Rinse the sampler by submerging the sampler in the lake three times and draining. Do this on the opposite side of the boat you plan to sample from. DO NOT TAKE ANY SAMPLES NEAR THE MOTOR!

d. Slowly lower the sampler into the lake as vertically as possible. Stop when the upper end is just below the surface if the euphotic zone is $\geq$ 2 m deep. SD DENR WPP protocols are to collect two full (2 m) integrated samplers of surface water at each in-lake sampling site (a total of 4 vertical meters of euphotic surface water per sampling site). If the euphotic zone is < 2.0 m deep, the

integrated sampler will be vertically lowered into the lake to a depth of the previously calculated euphotic zone for that site and sample; additional samples will be taken to collect the total volume needed to equal a total of 4 m of eutrophic only surface water.

e. Cap the upper end with the rubber stopper firmly (older version) or close the ball valve on top of the sampler (newer version) and slowly raise the sampler as vertical as possible.

f. When the bottom of the sampler is near the surface, reach underneath the surface of the water and close the ball valve on the bottom end of the sampler.

g. Lift the sampler into the boat, keeping it as vertical as possible.

h. Dispense the contents of the sampler into the previously rinsed sample collection container 500 mL, 1-liter, or 2-liter brown polypropylene bottle with screw on lid or composite sample container by removing the rubber stopper (older version) or opening the upper ball valve (newer version) and then the lower ball value and drain contents of the sampler into an appropriate pre-rinsed composite storage container. When the last sample is transferred to the composite container at each site, seal (cap) the sample container, and move it to a shaded area of the boat or cover it to avoid exposing the sample to direct sunlight and/or higher temperatures.

i. When all samples have been collected at the lake and dispensed into sample bottles and preserved, rinse the sampler with tap or distilled water prior to using it at the next lake.

3. In-Lake Composite Sample Collection using Van Dorn-type samplers.

Sampler Setup Procedures

Rinse the sampling apparatus thoroughly with water from the sampling site prior to collection of samples. *Surface samples* should be collected approximately 1 meter (3.28 feet) below the surface of the water.

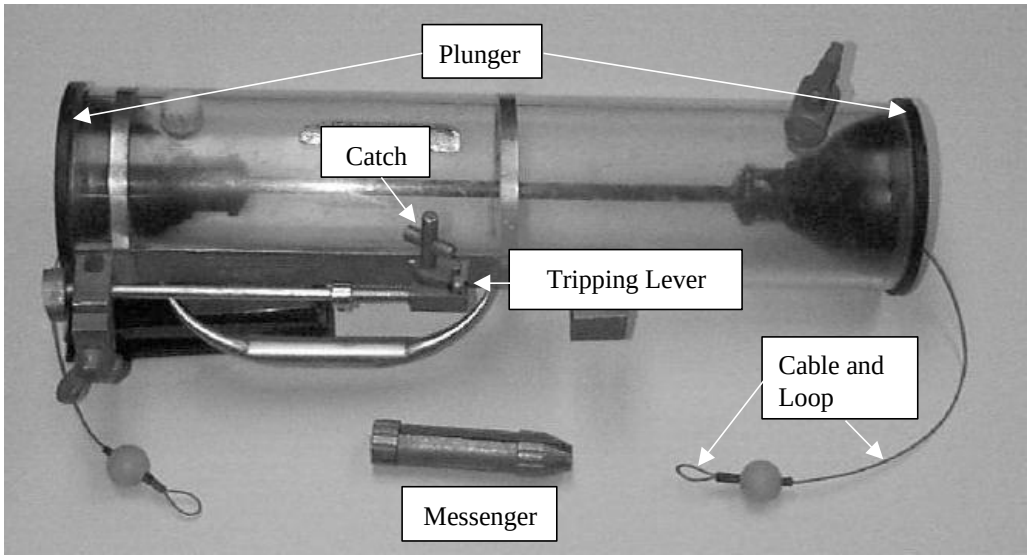


Figure 3.0. 4 Trip lever style "Van Dorn" sampler (older style).

Collecting a Sample using a Van Dorn Sampler (Trip Lever Style (older style, Figure 3.0. 4).

a. Place the sampler catch behind the tripping lever.
b. Pull one of the plungers from one end of the sampler and clip the cable loop of the plunger to the appropriate sampler catch. If placed properly, the plunger and cable will put pressure (torque) on the sampler catch and tripping lever.
c. Pull the plunger and cable from the opposite end and hook the loop appropriately to the opposite sampler catch. The Van Dorn sampler is now ready to be used to collect a water sample.
d. Lower the sampler into the water and stop the sampler at the appropriate depth. Send the messenger down the line to trip the sampler (Figure 3.0. 4.).
e. Pull the filled sampler up from the lake and dispense the sample water using petcocks into sample bottles, a composite sample container, or graduated cylinder depending upon PIP sampling protocols. If flow from the petcock is slow, open the upper petcock or vent to release pressure, or if there is no upper vent or petcock on the sampler, grasp one side of the upper plunger and gently pull upwards to break the seal to release vacuum and increase flow.

f. When bottom samples are collected, check for an excessive amount of bottom sediment or turbidity in the Van Dorn sampler. If the sample appears turbid, discard the sample and repeat steps "a" through "f".

g. Before lengthy storage, rinse the Van Dorn sampler with distilled water and dry.

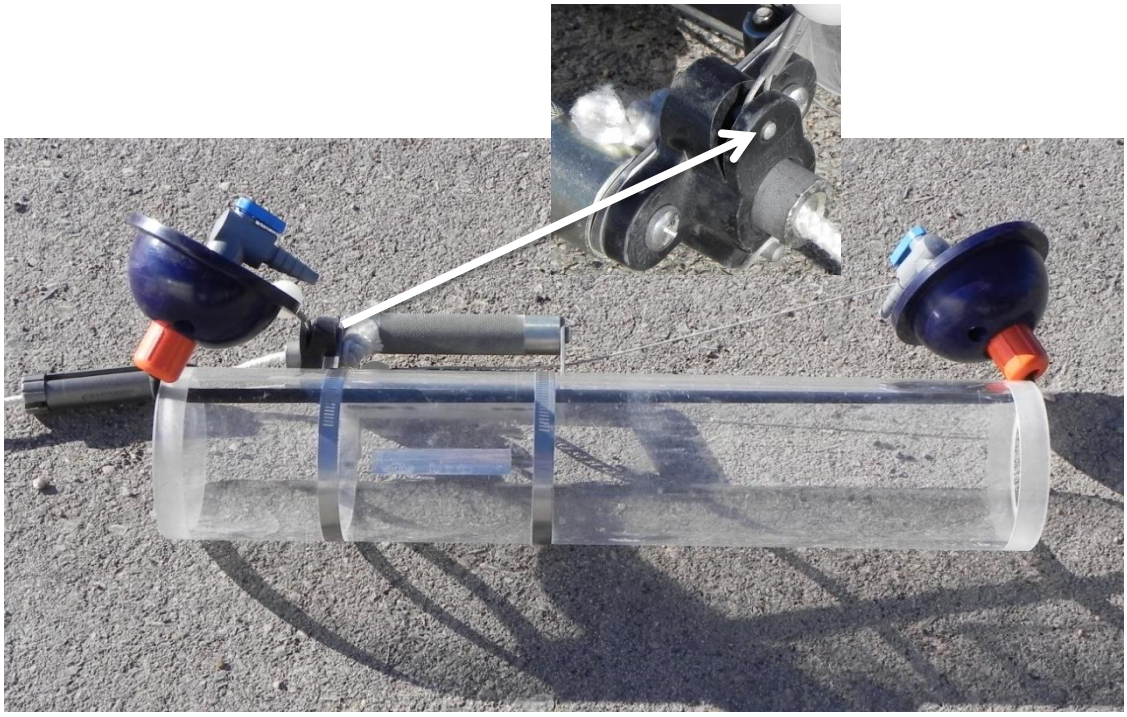


Figure 3.0. 5 Pin release style "Van Dorn" sampler.

Collecting a Sample using a Van Dorn Sampler Pin Release Style (newer style, Figure 3.0. 5).

a. Make sure the pin mechanism is in good working order.

b. Press down the pin release and pull plunger from the end nearest the trip release and hook the cable loop of the plunger into the appropriate slot in the pin release mechanism (Figure 3.0. 5.).

c. Release the pin release and ensure the cable loop is completely around the pin (not pinched by the pin).

d. Pull the plunger and cable from the opposite end and hook the cable loop to the opposite pin on the pin release. The Van Dorn sampler is now ready to be used to collect a water samples.

e. Lower the sampler into the water and stop the sampler at the appropriate depth (Surface = 1-meter (3.28 feet) from the surface of the water or Bottom 0.5 meters (1.64 feet) from the bottom of the lake). Send the messenger down the line to trip the sampler.

f. Pull the filled sampler up from the lake and dispense the sample water using petcocks into sample bottles, a composite sample container, or graduated cylinder depending upon PIP sampling protocols. If flow from the petcock is slow, open the upper petcock or vent to release pressure, or if there is no upper vent or petcock on

the sampler, grasp one side of the upper plunger and gently pull upwards to break the seal to release vacuum and increase flow.

g. Before lengthy storage, rinse the Van Dorn sampler with distilled water and dry.

4. In-lake Composite Sample Collection using Wisconsin, Student, or other appropriate plankton nets

a. Phytoplankton/algae composite samples collected using a Wisconsin, Student or other appropriate plankton nets are completed following collection procedures below.

b. Measure the total depth of the water column at the sampling site location.

c. Gently lower a metered rope (measured from the bottom of the collection cup with a Wisconsin, Student, or other appropriate plankton net to a depth of 0.3 meter (1-foot) from the bottom of the lake and record this depth as tow length at each site on the in-lake sampling data sheet (Appendix B, Table B-2).

d. To sample, slowly retrieve the sampler at a constant speed until the aperture reaches the surface.

e. Grasp the top of the sampler and raise the net until the cup is just above the water and rinse the outside of the net with a squirt bottle or splash lake water onto the outside of the net to dislodge algae and organisms trapped on the inside of the net.

f. Continue to rinse the net until all the organisms are rinsed into the sampling cup.

g. Detach the cup from the sampling net and set net aside.

h. Using a squirt bottle, rinse net panels of the cup, concentrate the sample at the bottom of the cup.

i. Open and rinse a 500 mL, 1-liter, or 2-liter (brown polypropylene) sampling bottle and place the drain of the sampling cup over the sample container.

j. Lift the plug from the center of the cup to discharge phytoplankton/algal sample into the sample container.

k. With a squirt bottle, carefully rinse off the plug inside the sample cup to ensure no organisms are attached to the plug.

l. Continue to rinse the collected sample from the cup into the sample container.

m. Visually inspect the inside of the cup to ensure all algae, phytoplankton, and organisms were rinsed into the sample container.

n. Set aside sampling cup and fill the sampling container with distilled water to approximately 490, 990, 1,990 mL, depending upon sample bottle size.

o. Preserve the sample by dispensing approximately 2 - 5 ml of Lugol's solution into the sample bottle, depending on bottle size until it appears the color of weak tea.

p. Close and gently invert the container two or three times to evenly mix the preservative.

q. Completely fill out a SD DENR WPP biological label using a permanent marker that includes: project, source "lake name" if a composite sample, station if not compositing lake samples, program, select and check sample depth, composite, and algae box. Fill out date, time, and sample composite volume (Figure 3.0. 1).

r. Complete the SD DENR water quality data sheet (Appendix C, Table C-1). Fill in all information through field observations (upper half of sheet), and under field comment write "Algal Analysis".

s. Ship the bottles following the procedures in "Section G".

E. In-Lake Grab Sample Collection

1. Grab Samples using Sample Bottles

a. Phytoplankton/algae grab samples using sample bottles are collected in 500 mL, 1-liter, or 2-liter brown polypropylene bottle(s) and filled following collection procedures below.

b. Phytoplankton/algae sample bottle(s) and cap(s) should be rinsed with sampling site water prior to collection of the sample to ensure no cross contamination occurs.

c. Position the open end of the pre-labeled bottle away from the boat, dock, or the hand of the collector.

d. Grasp the bottle securely at the base with one hand and plunge the bottle down into the water to avoid introducing surface scum. The sampling depth should be 0.5 foot (0.15 m) to 1 foot (0.30 m) below the surface of the water, if possible.

e. Tip the bottle slightly upward to allow air to escape and the bottle to fill.

f. The sample bottle should be filled completely. Immediately after obtaining the sample, pour off the excess sample water from the container until the sample volume is just below the base of the bottle neck.

g. Preserve the sample by dispensing approximately 2 to 5 ml of Lugol's solution into the sample bottle(s), depending on bottle size until it appears the color of weak tea and cap immediately.

h. Place the labeled phytoplankton/algae sample container(s) in a cooler on loose ice (6° C); no other preservative is required for phytoplankton/algae sample(s).

2. Grab Samples using Van Dorn type samplers

a. Phytoplankton/algae grab samples collected using a Van Dorn type sampler and filled following collection procedures below.

b. Make sure the pin mechanism is in good working order.

c. Press down the pin release and pull plunger from the end nearest the trip release and hook the cable loop of the plunger into the appropriate slot in the pin release mechanism (see Figure 3.0. 5.).

d. Release the pin release and ensure the cable loop is completely around the pin (not pinched by the pin).

e. Pull the plunger and cable from the opposite end and hook the cable loop to the opposite pin on the pin release. The Van Dorn sampler is now ready to be used to collect a water samples.

f. Lower the sampler into the water and stop the sampler at the appropriate depth (Surface = 1-meter (3.28 feet)).

g. Send the messenger down the line to trip the sampler.

h. Pull the filled sampler up from the lake and dispense the phytoplankton/algae sample water using petcocks into a pre-labeled 500 mL, 1-liter, or 2-liter brown polypropylene plastic sample bottle (Figure 3.0. 1). If flow from the petcock is slow, open the upper petcock or vent to release pressure, or if there is no upper vent or petcock on the sampler, grasp one side of the upper plunger and gently pull upwards to break the seal to release vacuum and increase flow.

i. The sample bottle should be filled to a volume that is just below the base of the bottle neck.

j. Preserve the sample by dispensing approximately 2 to 5 mL of Lugol's solution into the sample bottle(s), depending on bottle size until it appears the color of weak tea and cap immediately.

k. Place the labeled phytoplankton/algae sample container(s) in a cooler on loose ice (6° C); no other preservative is required for phytoplankton/algae sample(s).

l. Before lengthy storage, rinse the Van Dorn sampler with distilled water and dry.

3. Grab Samples using Wisconsin, Student, or other appropriate plankton net

a Collect algal samples at each in-lake sampling site following Section 3.0 (C) (1) or (2) steps "a" through "k".

b Sum all tow lengths together and indicate total tow length on in-lake field data sheet (Appendix B, Table B-2).

c For grab sampling, use a 500 mL, 1-liter, or 2-liter (brown polypropylene) container and rinse all tow samples from the lake into the same container.

d After all sampling sites in the lake have been sampled; fill or top off sample container with distilled water until approximately 490, 990, or 1,990 mL, depending upon sample container size is reached.

e For Algae/phytoplankton samples, add 2-5 mL of Lugol's solution 500 mL or 1-L, depending upon sample bottle size. Cap the bottle and gently invert until the sample is well mixed. The sample should resemble the color of weak tea. If needed (sample color is too week), add additional Lugol's 2-3 mL at a time.

f Close and gently invert the container two or three times to evenly mix the preservative.

g Complete the SD DENR WPP water quality data sheet (Appendix C, Table C-1). Fill in all information through field observations (upper half of sheet), and under field comment write "Algal Analysis".

h Ship the bottles following the procedures in "Section G" below.

F. Tributary Sampling

Wadeable streams and rivers

Tributary phytoplankton/algae samples consist of collecting water samples from three locations along one transect in the stream or river and compositing them into one phytoplankton/algae sample for that reach/stream site.

1. Collecting the Tributary Sample

a. Rinse sample containers (500 ml, 1-liter, or 2-liter brown polypropylene plastic) in the stream or river.
b. Collect three evenly spaced 500 ml, 1-liter, or 2-liter grab samples only from areas with noticeable flow in brown plastic polypropylene bottles; one along the transect near the stream bank (¼ of the stream width), one from mid-transect (½ of the stream width) and one along the transect near the far stream bank (¾ of the stream width).
c. Pre-rinse a graduated cylinder twice with sample water.
d. Calculate the amount of water needed from each sub-sample bottle to fill the composite sample bottle. Divide the size of your final sample container in milliliters, by the number of transect sub-sampling locations to be composited, normally three.

    i. Example: Sub-sampling three points along one transect and placing them in a brown plastic final sampling bottle (1,000 mL). The volume of water required from each sub-sample would be:

    1,000 mL/ 3 = 333mL

e. Gently invert each sub-sample bottle several times to ensure the sample is homogeneous (well mixed).
f. Pour the previously calculated amount of sampling water (333 ml) from one of the sub-sample bottles into a pre-rinsed graduated cylinder.
g. Pour the water from the graduate cylinder into the pre-rinsed and labeled 1,000 mL brown polypropylene plastic final sample bottle.
h. Repeat procedures “e.” and “g.” for each remaining sub-sample bottle.
i. Preserve the composite sample by dispensing approximately 2 - 5 ml of Lugol’s solution until it appears the color of weak tea.
j. Close and gently invert the container two or three times to evenly mix the preservative.
k. Completely fill out a biological label using a permanent marker that includes: project, source “tributary name”, tributary station, program, select and check sample depth, composite, and the algae box. Fill out date, time, and sample composite volume (Figure 3.0. 1).

l. Place the sample container and the Lugol's solution in a cooler with ice.

m. Complete the SD DENR water quality data sheet (Appendix C). Fill in all information through field observations (upper half of sheet), and under field comment write "Algae Analysis".

n. Ship the bottles following the procedures in "Section G".

G. Shipping Samples

1. Fill out a SD DENR WPP Water Quality Data Sheet(s) (Appendix C, Table C-1) for all samples in the cooler.
2. Place all sample containers (bottles) in a large plastic bag. Seal the plastic bag with the samples and place into a shipping cooler.
3. Ice will be placed in a separate heavy plastic bag, which is then placed in the cooler with the samples.
4. Ensure SD DENR WPP Water Quality Data Sheet(s) (Appendix C, Table C-1) are filled out completely (one sample sheet for each sampling site, location, or lake in the cooler) and place these documents in a Ziploc bag and tape the bag to the top of the cooler or place between the insulation and cardboard lid when using South Dakota Public Health Laboratory coolers.
5. Securely seal the cooler with clear packing tape.
6. The cooler(s) are shipped or taken by the sampler to the South Dakota Department of Environment and Natural Resources at the address below or other contractual consultant labs where analyses are performed.

   South Dakota Department of Environment and Natural Resources
   Division of Financial and Technical Assistance
   523 East Capitol Avenue
   Pierre, South Dakota 57501-3181

   ATTN: (Project Officer)

H. SD DENR WPP Algal Analysis Procedures

In-house sample analysis consists of the following procedure:

1. Prior to counting, sample volume is concentrated or diluted to obtain the most efficient workable density of organisms. Each sample is thoroughly mixed and a random 1 mL sub-sample is withdrawn and placed in a Sedgwick-Rafter counting chamber. The sub-sample is scanned under 200x magnification to approximate the abundance of organisms. If the sub-sample appears to be of workable size, the relatively large-sized algal taxa are selectively counted in several strips across the chamber or in their entirety depending on abundance. It is desirable to count at least 30 to 50 individuals of each common taxon to properly estimate population density. In general, a total of at least 400 algal units (including single colonies and filaments) need to be counted in a sub-sample to obtain a precision of plus or minus 10 percent (Lund et al.1958).

2. For the smaller-sized and usually more abundant algal taxa, two drops (0.1 ml) of sub-sample are placed on a slide and covered with a coverslip

bordered with Vaseline to retard evaporation. Counting is conducted under 400x magnification with a Ziess® research microscope equipped with phase contrast. Organisms are counted in random strips across the slide or the contents of the entire slide are counted. When required, further identification of smaller organisms is accomplished under 1000x magnification.

3. For identification of diatoms, a 15 ml sub-sample is concentrated by centrifuging and cleaned with concentrated sulfuric acid and potassium dichromate solution. The cleared diatom frustules in a 0.1 ml concentrate are then identified and counted under 400x or1000x magnification.
4. All undamaged algal cells are identified to the lowest positive category, usually to genus or species when possible, using appropriate keys. Algal abundance (density) is reported as cells/ml. The number of cells in a colony or filament is counted or estimated as feasible.
5. Biovolume is computed for each identified taxon using the formula for the geometric shape configuration that most resembles the shape of the organism. All biovolumes are expressed as cubic micrometers per milliliter (μm^3/ml) or microliters per liter ($\mu l/L = \mu m^3/ml \times 10^{-6}$).

When Finished Sampling the Lake/Reach/Site, Clean all boats, equipment; and sampling gear including waders, nets and buckets. Be sure to remove all debris, dirt and grime with lake or stream water and follow all cleaning procedures outlined in Section 9.0 in SD DENR SOP Volume I (Decontamination Protocols for Equipment and Field Workers)!!!

4.0 ZOOPLANKTON SAMPLING

A. Purpose

Zooplankton can be used as indicators of water quality within a lake and can be used in in-lake modeling. Documentation of species, relative abundance and trophic relationships will allow a descriptive mechanism through which the progressive or regressive state of the watershed or lake can be monitored over an extended period of time.

B. Material

1. Boat and related equipment (in-lake or large tributary).
2. 100 mL, 200 mL, or 250 mL plastic bottles with screw top lids.
3. Current copy of the Standard Operating Procedures SOP (Vol. II) manual.
4. Biological bottle sample labels.
5. YSI Multiparameter meters.
6. Secchi disk with metered rope.
7. Data sheets and logbook.
8. Bathymetric maps for lakes and topographic maps for tributaries.
9. Wisconsin or student standard plankton net with 80 µm mesh.
10. 95 % ethanol solution.
11. Squirt bottle.

C. Zooplankton Sampling

Generally, in-lake zooplankton samples consist of collecting vertical tow samples (bottom to the surface of the water column) from two or three locations (sites) in the lake or a number of sampling sites to composite. The Project Implementation Plan (PIP) or the Project Officer will indicate the number of sampling sites or the number of in-lake sampling sites to be composited.

1. Collecting the Sample using a Wisconsin or Student Net

a. Collect zooplankton samples using a Wisconsin or student plankton net.
b. Measure the total depth of the water column at the sampling site location using a depth finder, Secchi disk or a weighted metered rope.
c. Gently lower a metered rope with a Wisconsin or Student plankton net to a depth of 0.5 meters from the bottom of the lake and record this depth as tow length for this site on the in-lake Zooplankton sample data sheet (Appendix B, Table B-2).
d. To sample, slowly retrieve the sampler at a constant speed (0.3 m or 1 ft/s) without stopping until the aperture reaches the surface.

e. Grasp the top of the sampler and raise the net until the cup is just above the water and rinse the outside of the net with a squirt bottle or splash lake water onto the outside of the net to dislodge organisms and algae trapped on the inside of the net.

f. Continue to rinse the net until all the organisms are rinsed into the sampling cup.

g. Detach the cup from the sampling net and set net aside.

h. Set the collection cup upright in a pail or bucket and fill the pail with lake water to a point where the collection cup is half submerged in water. Ensure that the organisms in the collection cup are submerged in the water, but be careful not to submerge the top of the collection bucket, or sample loss will occur. Add two (2) CO2 (Alka-Seltzer) tablets to the water in the bucket (NOT THE CUP). The CO2 narcotizes the zooplankton to relax their external structure prior to preservation in 95% ethanol. This facilitates taxonomic identification. Wait until zooplankton movement has stopped (usually about 1 min).

i. When all movement has stopped remove collection cup from the pail, use a squirt bottle to rinse net panels of the cup to concentrate the sample at the bottom of the cup.

j. Tip the cup slightly to drain out the excess water through the screen in the sampling cup.

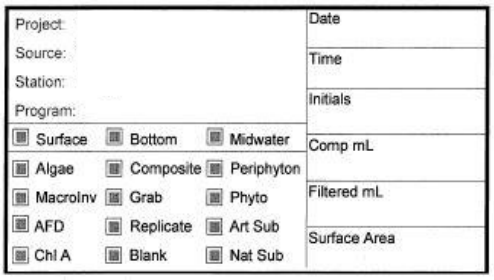


Figure 4.0. 1 SD DENR WPP Biological bottle label.

k. Estimate the amount (volume) of sample material in the cup and choose the appropriate bottle size (100 mL, 250 mL or 500 mL) based on that volume (do not fill the sample bottle more than half way to ensure proper preservation). Once a bottle has been selected, place an SD DENR WPP biological bottle label on the bottle and fill out appropriate fields (Figure 4.0. 1). Open a sample bottle based on sample volume and place the drain at the bottom of the sampling cup over the mouth of the sample bottle.

l. Lift the plug from the center of the cup to discharge zooplankton sample into the sample container.

m. With a squirt bottle, carefully rinse off the plug inside the sample cup to ensure no organisms are attached to the plug.

n. Using a minimal amount of water, continue to rinse the collected sample from the cup into the sample container.

o. Visually inspect the inside of the cup to ensure all material/organisms were rinsed into the sample container.

p. Set aside sampling cup and preserve the sample by filling the sample bottle with 95% ethanol to the bottom of the bottle neck.

q. Close the bottle and invert the container two or three times to evenly mix the preservative.

r. Complete the SD DENR WPP water quality data sheet (Appendix C). Fill in all information through field observations (upper half of sheet) and under field comments write "Zooplankton Analysis".

s. Ship the bottles following the procedures in "D" on the following page.

2. Composite Sampling

a Collect zooplankton samples at each in-lake sampling site following Section 4.0 (C) (1) steps "a" through "k", being sure to record the tow length, total depth, and Secchi depth at each in-lake monitoring site.

b For composite sampling, use a 500 mL or 1-liter sample bottle container and rinse all tow samples into the same container.

c In some cases, the volume of composite zooplankton collected in the collection bucket may exceed sample bottle size. Do not try to force the entire sample into a single bottle, or the preservative will not function properly and the sample may be lost. In such cases, fill the first bottle half full, and then use a second bottle to preserve the additional amount of sample. Use another sample bottle "extra jar" label (i.e., one with no sample number printed on it). Complete the label, and print in the sample number assigned to the first container on the label of the second container. On the form, record a "2" in the "No. Jars" field.

d After all samples in the lake have been collected, fill container with 95% ethanol until the solution is at the bottom of bottle neck.

e Close and invert the container two or three times to evenly mix the preservative.

f When all Zooplankton samples have been collected at the lake or waterbody complete the datasheet by summing all tow lengths together and indicate total tow length on in-lake field data sheet (Appendix B, Table B-2). Then sum all lake depths, average the sum of all lake depths and write in the average depth on the form; finally, sum all Secchi depth readings, average, and complete the in-lake Zooplankton field datasheet.

g Complete the SD DENR water quality data sheet (Appendix C). Fill in all information through field observations (upper half of sheet), under field comments and write "Zooplankton Analysis".

h Ship the bottles following the procedures in "4.0 (D)" below.

D. Shipping the Sample

1. Fill out a SD DENR WPP In-lake Zooplankton Sample Field Data Sheet(s) (Appendix B, Table B-2) for all samples in the cooler.

2. Place all sample containers (bottles) in a large plastic bag. Seal the plastic bag with the samples and place into a shipping cooler.
3. Ice will be placed in a separate heavy plastic bag, which is then placed in the cooler with the samples.
4. Ensure SD DENR WPP In-lake Zooplankton Sample Field Data Sheet(s) (Appendix B, Table B-2) are filled out completely (one sample sheet for each sampling site or location in the cooler) and place these documents inside the cooler between the insulation and cardboard lid or place paperwork in a Ziploc freezer bags and place it in the cooler..
5. Securely seal the cooler with clear packing tape.
6. The cooler(s) are shipped or taken by the sampler to the South Dakota Department of Environment and Natural Resources at the address below or other contractual consultant where analyses are performed.

   South Dakota Department of Environment and Natural Resources
   Division of Financial and Technical Assistance
   523 East Capitol Avenue
   Pierre, South Dakota 57501-3181

   ATTN: (Project Officer)

   When Finished Sampling the Lake/Reach/Site, clean all boats, equipment; and sampling gear including waders, nets and buckets. Be sure to remove all debris, dirt and grime with lake or stream water and follow all cleaning procedures outlined in Section 9.0 in SD DENR WPP SOP Volume I (Decontamination Protocols for Equipment and Field Workers)!!!

E. SD DENR WPP Zooplankton Analysis Procedure

In-house sample analysis consists of the following procedure:

1. Prior to counting, samples volume is concentrated or diluted to obtain the most efficient workable density of organisms. Each sample is thoroughly mixed to obtain a representative sub-sample. A random 1 to 5 mL sub-sample is withdrawn, depending upon the sample size, and placed in a Ward plankton wheel. Stratified counts of zooplankton in the sub-sample are done using a binocular dissection microscope at 20X to 40X magnification. Sub-sampling continues until a sufficient number of organisms are enumerated to estimate population densities (It is desirable to count at least 30 individuals of each common species to properly estimate population densities).
2. Microcrustacea are identified to species level with the exception of taxonomically indistinct immature copepods and cladocerans which are identified to lowest positive taxa. Rotifera are identified to lowest practical taxonomic level, usually to genus.

5.0 PERIPHYTON SAMPLING

A. Purpose

Collect periphyton from the 11 cross-section transects ("1" through "11") established within the sampling reach. Collect periphyton samples at the same time as benthic macroinvertebrate samples. Prepare one composite "index" sample of periphyton for each site. At the completion of the day's sampling activities, but before leaving the site, prepare three types of laboratory samples (an ID/enumeration sample to determine taxonomic composition and relative abundances, a chlorophyll-*a* sample, a biomass sample (for ash-free dry mass [AFDM] from the composite periphyton sample collected.

B. Equipment and Supplies

- Large Funnel (15-20 cm diameter)
- 12-cm^2 area delimiter (3.8 cm diameter pipe, 3 cm tall)
- Stiff-bristle toothbrush with handle bent at 90° angle
- 1-L wash bottle for stream water
- 500-mL plastic bottle for the composite sample
- 60-mL plastic syringe with 3/8" hole bored into the end
- SD DENR WPP SOP Volume II
- (#2) lead pencils for recording data on field datasheets
- Fine-tipped Sharpie® markers for filling out sample labels
- Sample labels (4 per set) with the same Sample ID Number
- Clear tape strips for covering labels

C. Procedures

1. Identifying the Sampling Reach

a. Use a surveyor's rod, tape measure, or laser range finder to determine the wetted width of the channel at 5 places of "typical" width within approximately 5 channel widths downstream of the monitoring site. Average the 5 readings together and round to the nearest 1 m. If the MRSW is <3 m, use 100 m as a minimum reach length. If the average width is >10 m and watershed area is > 500 km^2, use 2 times the MRSW calculate the reach length. Record this width on the Periphyton Site Map (Appendix D, Table D-1).
For channels with "interrupted flow", estimate the width based on the un-vegetated width of the channel (again, with a 100 m minimum).

b. Check the condition of the stream about the monitoring site by having one team member go downstream of the monitoring site. Proceed downstream to a distance of 30 times the average channel width determined in Step a.

c. Determine if the reach needs to be adjusted due to confluences with higher order streams (downstream), impoundments (lakes, reservoirs, ponds), physical barriers (e.g., falls, cliffs), or because of access restrictions to a portion of the initially-determined sampling reach.

d. Starting at the monitoring site (or adjusted monitoring site as described in Step 3), measure a distance of 30 channel widths down one side of the stream using a GPS unit, laser rangefinder, or tape measure. Be careful not to "cut corners". Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach, and is flagged as Transect "1".

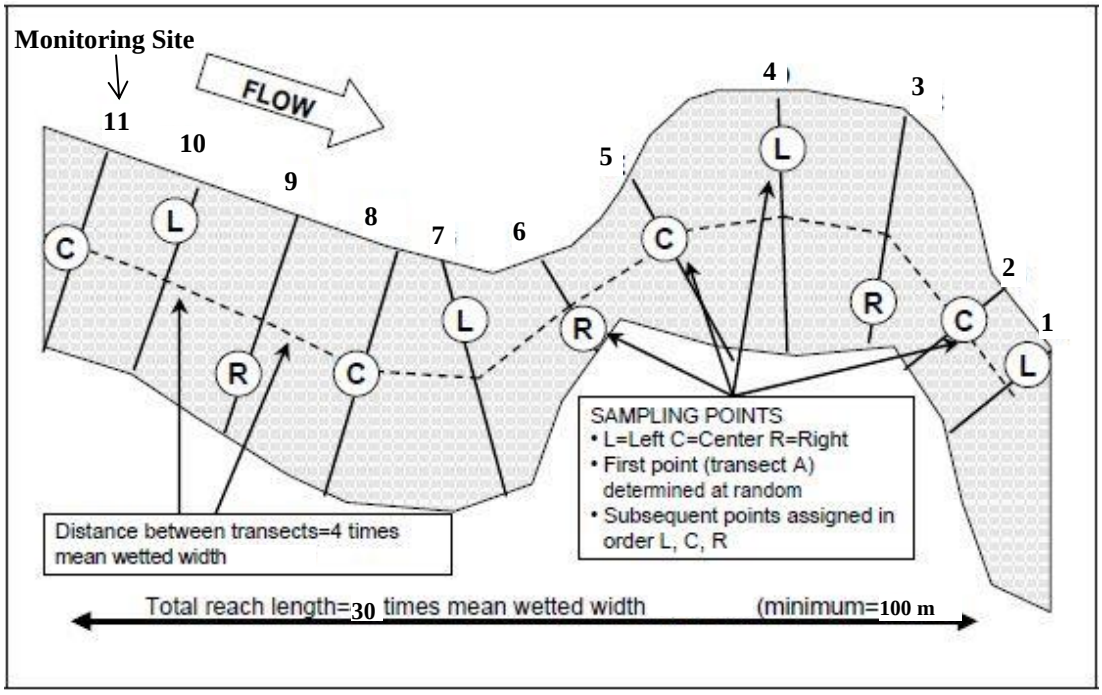


Figure 5.0. 1 Transect layout and sampling site location example for wadeable rivers and streams (from US EPA, 2007).

2. Sampling stations setup at wadeable sites:

a. At Transect "1", use the seconds display on a digital watch to select the initial sampling station for standard transect samples: 1-3="Left", 4-6="Center", 7-9=Right. Mark "L", "C", or "R" on the transect flagging; the three potential collection points are roughly equivalent to 25%, 50%, and 75% of the wetted width of the channel, respectively.

b. Measure 1/10 of the required reach length upstream from transect "1". Flag this spot as transect "2". Assign the sampling station systematically after the first random selection (Figure 5.0. 1).

c. Proceed upstream with the tape measure and flag the positions of 9 additional transects (labeled "3" through "11" with "11" being the original monitoring site) at intervals equal to 1/10 of the reach

length. Continue to assign the sampling stations systematically (Figure 5.0. 1).

d. Sketch a map of the sampling reach in the area provided on the SD DENR WPP Periphyton Map, Measurements and Documentations Datasheet (Appendix D, Table D-1). Draw the sampling reach, locating each of the measurements and transects described above. In addition, note any other pertinent features or observations on the map, including landmarks or directions that could be used to locate the site for future visits.

e. Sampling procedure can vary given the particular channel/habitat situation. More than one procedure may be required within a particular watershed or stream, so be sure to use a suitable procedure for each sampled reach.

3. Wadeable Sampling Procedures

At each of the 11 transects, collect samples from the sampling station assigned during the layout of the reach. Collect the substrate selected for sampling from a depth no deeper than 0.5 m. If a sample cannot be collected because the location is too deep, skip the transect. The procedure for collecting samples and preparing a composite sample is presented below. Collect one sample from each transect and composite in one 500-mL brown bottle to produce one composite sample for each site.

Starting with Transect "1" (the furthest downstream transect in wadeable streams), collect a single sample from the assigned sampling station using the procedure below.

a. Collect a sample of substrate (rock or wood) that is small enough (< 15 cm diameter) and can be easily removed from the river. Place the substrate in a plastic funnel which drains into a 500-mL plastic bottle with volume graduations marked on it.

b. Use the area delimiter to define a 12-cm^2 area on the upper surface of the substrate. Dislodge attached periphyton from the substrate within the delimiter into the funnel by brushing with a stiff-bristled toothbrush for 30 seconds. Take care to ensure that the upper surface of the substrate is the surface that is being scrubbed, and that the entire surface within the delimiter is scrubbed.

c. Fill a 500-mL wash bottle with river water. Using a <u>minimal</u> volume of water from this bottle, wash the dislodged periphyton from the funnel into the 500-mL bottle. If no coarse sediment (cobbles or larger) are present:

- Use the area delimiter to confine a 12-cm^2 area of soft sediments.
- Vacuum the top 1-cm of sediments from within the delimited area into a de-tipped 60-mL syringe.
- Empty the syringe into the same 500-mL plastic bottle as above.

d. Put the bottle in a cooler on ice while you travel between transects and collect the subsequent samples. (The samples need to be kept cool and dark because a chlorophyll-*a* sample will be filtered from the composite.)

e. Repeat Step "a" for transects "2" through "11". Place the sample collected at each sampling site into the same 500-mL bottle to produce the composite index sample.

f. If all 11 samples are not collected, record the number of transects collected and reason for any missed collection in the notes and calculations section of the Periphyton Map, Measurements and Documentation datasheet (Appendix D, Table D-1).

g. After samples have been collected from all 11 transects, gently and thoroughly mix the 500-mL bottle regardless of substrate type. Record the total estimated volume of the composite sample in the notes section of the Periphyton field datasheet.

4. Sample Processing

You will prepare three different types of laboratory samples from the composite index samples: an ID/enumeration sample (to determine taxonomic composition and relative abundances), a chlorophyll sample, and a biomass sample (for ash-free dry mass [AFDM]).

Identification/Enumeration Sample

Prepare the Identification/Enumeration sample as a 50-mL aliquot from the composite index sample. Preserve each sample with Lugol's. Record the sample ID number from the container label and the total volume of the sample in the appropriate fields on the SD DENR biological bottle label. Store the preserved samples upright in a container containing absorbent material.

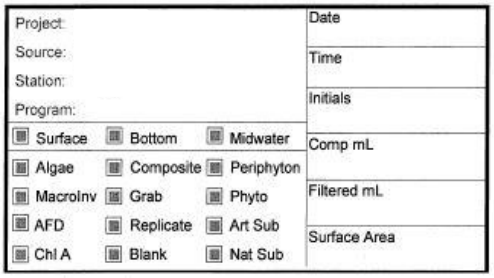


Figure 5.0. 2 Biological bottle label used by the SD DENR WPP.

a. Prepare a sample biological bottle label (with a sample ID number) for the Periphyton ID sample. Record the volume of the subsample (typically 50 mL) and the volume of the composite index sample on the label. Attach completed label to a sample bottle; avoid covering the volume graduations and markings. Cover the label completely with a clear tape strip.

b. Record the sample ID number of the label and the total volume of the composite index sample on the Periphyton Map, Measurements and Documentation datasheet (Appendix D, Table D-1).
c. Rinse a 60-mL syringe with deionized water.
d. Thoroughly mix the bottle containing the composite sample.
e. Withdraw 50 mL of the mixed sample into the syringe. Right after mixing, place the contents of syringe sample into the labeled 50-mL sample bottle.
f. Use a syringe or bulb pipette to add 1 mL Lugol's to the bottle and cap tightly and seal with plastic electrical tape. Shake gently to distribute preservative.
g. Record the volume of the sample in the bottle (excluding the volume of preservative) on the Periphyton Map, Measurements and Documentation datasheet (Appendix D, Table D-1).

Chlorophyll-*a* Sample

Prepare the chlorophyll sample by filtering a 25-mL aliquot of the composite index sample through a Pall 47 mm 1.0 micron GF/F glass fiber filter. Chlorophyll can degrade rapidly when exposed to bright light. If possible, prepare the samples in subdued light (or shade), filtering as quickly as possible after collection to minimize degradation. Keep the glass fiber filters in a dispenser inside a sealed plastic bag until use. It is important to measure the volume of the sample being filtered accurately (±1 mL) with a graduated cylinder. During filtration, do not exceed 7 inches of Hg to avoid rupturing cells. If the vacuum pressure exceeds 7 inches of Hg, prepare a new sample. If the filter clogs completely before all the sample in the chamber has been filtered, discard the sample and filter, and prepare a new sample using a smaller volume of sample. The procedure for preparing chlorophyll samples of periphyton is provided below.

a. Using clean forceps, place a Pall 47mm Type A/E 1.0 µm Glass Fiber Filter on the filter holder ruff side down. Use a small amount of deionized water from a wash bottle to help settle the filter properly. Attach the filter funnel to the filter holder and filter chamber, and then attach the hand vacuum pump to the chamber.
b. Rinse the sides of the filter funnel and the filter with a small volume of deionized water.
c. Rinse a 25-mL or 50-mL graduated cylinder three times with small volumes of deionized water.
d. Mix the composite sample bottle thoroughly.
e. Measure 25 mL (±1 mL) of sample into the graduated cylinder.
    - *NOTE: For a composite sample containing fine sediment, allow grit to settle for 10 - 20 seconds before pouring the sample into the graduated cylinder.*
f. Pour the 25-mL aliquot into the filter funnel, replace the cap, and pull the sample through the filter using the hand pump. Vacuum pressure from the pump should not exceed 7 inches of Hg to avoid rupture of fragile algal cells.

- *NOTE: If 25 mL of sample will not pass through the filter, discard the filter and rinse the chamber thoroughly with deionized water. Collect a new sample using a smaller volume of sample, measured to ±1 mL. Be sure to record the actual volume sampled on the sample label.*

g. Remove both plugs from the filtration chamber and pour out the filtered water in the chamber. Remove the filter funnel from the filter holder. Remove the filter from the holder with clean forceps. Avoid touching the colored portion of the filter. Fold the filter in half, with the colored sample (filtrate) side folded in on itself. Place the folded filter in a large piece of heavy weight aluminum foil completely enclosing the filter in the aluminum foil and fold all sides of the foil over to secure the sample ensuring no light gets to the filter. Be sure not to press or flatten the aluminum foil pouch it will press the sample out of the filter and onto the foil giving erroneous results! When complete discard the filtered water.

h. Complete a periphyton sample label for chlorophyll, including the composite volume, volume filtered, and area scraped (surface area). Attach it to the aluminum foil pouch with the filter inside. Cover the label and the aluminum foil with the sample inside completely with a strip of clear tape. Place the aluminum foil pouch into a self-sealing plastic bag and seal.

i. Record the sample ID number of the label and the total volume of the composite index sample, volume filtered, area scrapped, and number of transects in the "Chlorophyll" field on the Periphyton Map, Measurements and Documentation datasheet. Double check that the volume recorded on the collection form matches the total volume recorded on the sample label.

j. Place the plastic bag containing the aluminum foil and filter on dry ice. Immediately upon returning from the field, put all chlorophyll filter samples into the freezer to properly preserve them.

Biomass Sample

Prepare the ash-free dry mass (AFDM) sample by filtering a 25-mL aliquot of the composite index sample through a Pall 47 mm 1.0 micron Type A/E Glass Fiber Filter. The procedure for preparing AFDM samples is presented below. Keep the glass fiber filters in a dispenser inside a sealed plastic bag until use.

It is important to measure the volume of the sample being filtered accurately (±1 mL) with a graduated cylinder. During filtration, do not exceed 7 inches of Hg to avoid rupturing cells. If the vacuum pressure exceeds 7 inches of Hg prepare a new sample. If the filter clogs completely before all the sample in the chamber has been filtered, discard the sample and filter, and prepare a new sample using a smaller volume of sample. The procedure for preparing ash-free dry mass (AFDM) samples of periphyton is provided below.

a. Using clean forceps, place a PALL 47 mm 1.0 micron Type A/E Glass Fiber Filter on the filter holder gridded side down. Use a

small amount of deionized water from a wash bottle to help settle the filter properly. Attach the filter funnel to the filter holder and filter chamber, and attach the hand vacuum pump to the chamber.

b. Rinse the sides of the filter funnel and the filter with a small volume of deionized water.

c. Rinse a 25-mL or 50-mL graduated cylinder three times with small volumes of deionized water.

d. Mix the composite sample bottle thoroughly.

e. Measure 25 mL (±1 mL) of sample into the graduated cylinder.
   - *NOTE: For a composite sample containing fine sediment, allow grit to settle for 10 - 20 seconds before pouring the sample into the graduated cylinder.*

f. Pour the 25-mL aliquot into the filter funnel, replace the cap, and pull the sample through the filter using the hand pump. Vacuum pressure from the pump should not exceed 7 inches of Hg (Mercury) to avoid rupture of fragile algal cells.
   - *NOTE: If 25 mL of sample will not pass through the filter, discard the filter and rinse the chamber thoroughly with deionized water. Collect a new sample using a smaller volume of sample, measured to ±1 mL. Be sure to record the actual volume sampled on the sample label and the Sample Collection Form.*

g. Remove both plugs from the filtration chamber and pour out the filtered water in the chamber. Remove the filter funnel from the filter holder. Remove the filter from the holder with clean forceps. Avoid touching the colored portion of the filter. Fold the filter in half, with the colored sample (filtrate) side folded in on itself. Place the folded filter in a large piece of heavy weight aluminum foil completely enclosing the filter in the aluminum foil and fold all sides of the foil over to secure the sample inside. Be sure not to press or flatten the aluminum foil pouch it will press the sample out of the filter and onto the foil that could give erroneous results! When complete discard the filtered water.

h. Complete a biological bottle label for AFD biomass, including the composite volume, volume filtered, and area scraped (surface area) and attach it to the aluminum foil pouch with the filter inside. Cover the label and the aluminum foil with the sample inside completely with a strip of clear tape. Place the aluminum foil pouch into a self-sealing plastic bag and seal.

i. Record the sample ID number of the label and the total volume of the composite index sample on the form. Record the volume filtered in the "AFD" field on the Sample Datasheet. Double check that the volume recorded on the collection form matches the total volume recorded on the sample label.

j. Place the plastic bag containing the aluminum foil and filter on dry ice. Immediately upon returning from the field, put all chlorophyll filter samples into the freezer to properly preserve them.

5. SD DENR WPP In-House Ash Free Dry Mass [AFDM] Laboratory Analysis Methods

Controlled heating in a drying oven is used to evaporate all weight from water in the sample. The dry filter is weighed and the measurement recorded. The sample filters are then combusted (ashed) using a blast furnace to decompose the organic matter. The filters are saturated with water to rehydrate the clays, and placed back in the drying oven. Dry filters are weighed and that measurement is recorded. Ash free dry mass is then calculated using weight measurements and field data (area scraped, number of transects, volume of sample collected and volume of sample filtered).

Procedure

a. Remove sample from freezer and record sampling site ID, sample volumes, area scraped, and collection date on laboratory data sheets, Appendix D, Table D-2.
b. Remove filter from field packaging and place into an engraved aluminum weigh boat.
c. Dry sample in drying oven at 60 °C for 24 hours.
d. Place warm, dry samples in desiccator to cool. Weigh samples in aluminum weigh boats and record. Remove sample and ensure balance is zeroed. Reweigh sample and record second measurement (sample weight in grams to the nearest 0.1 mg).
e. Ash sample in a blast furnace at 550 °C for 30 minutes.
f. Remove samples from blast furnace and place in desiccator to cool. After ashing, the precipitate should appear gray and crumbly.
g. Saturate cooled samples with reverse osmosis water to rehydrate the clays.
h. Dry samples in drying oven at 60 °C for 24 hours.
i. Store dry samples in desiccator to cool. Weigh samples in aluminum weigh boats and record weight on datasheet. Remove sample and ensure balance is zeroed. Then reweigh sample and record second measurement. (Sample weight in grams to the nearest 0.1 mg).

Data Analysis and Calculations

a. If not provided on the field datasheet or the sample bottle label, obtain area scraped, number of transects, volume of sample collected and volume of sample filtered in the field to standardize Ash Free Dry Mass (AFDM) results to a unit area. Therefore, initial and final weights (second value) are reported by electronic spreadsheet and these raw data are used to calculate the AFDM using the following calculation:

$AFDM_{m\ (mass)}$ (g) = Initial wt (g) - Final wt (g)

$AFDM_{m/v\ (mass\ per\ unit\ volume)}$ (g/mL) = $AFDM_{m}$ (g) / Filtered volume $_{(mL)}$

$AFDM_{m/a\ (mass\ per\ unit\ area)}$ (g/cm^2) = $AFDM_{m/v}$ * [Total volume (mL) / area scraped (cm^2)]

Where:
Filtered volume = volume of sample filtered in the field (usually 25 mL)
Total volume = volume of sample collected (usually 500 mL)
Area scraped = (# of transects)*(area delimiter (cm^2)) (usually 12 cm^2 x 11 transects = 132 cm^2)

b. All results are recorded on a datasheet. Datasheets are filed in the AFDM binder created and maintained for each calendar year. Results are entered into electronic format and entries are verified by a second person.

When Finished Sampling the Lake/Reach/Site, Clean all boats, equipment; and sampling gear including waders, nets and buckets. Be sure to remove all debris, dirt and grime with lake or stream water and follow all cleaning procedures outlined in Section 9.0 in SD DENR WPP SOP Volume I (Decontamination Protocols for Equipment and Field Workers)!!!

6.0 CHLOROPHYLL ANALYSIS STANDARD OPERATION PROCEDURES FOR THE BECKMAN COULTER DU 720 SPECTROPHOTOMETER

In house Revision 2.0

South Dakota Department of Environment and Natural Resources (SDDENR)
Watershed Protection Program (WPP)

Last modified: Kris Dozark, Environmental Scientist III, November 2016

A. Equipment/Materials

1. Beckman Coulter DU 720 Spectrophotometer, narrow band width
2. Clinical centrifuge
3. 15 ml plastic centrifuge tubes with caps
4. Glass test tubes
5. Pipettes and pipette pumps/bulbs
6. Micropipetter
7. Glass fiber filters – Pall Corporation A/E, 47 mm
8. Flasks or beaker
9. Graduated cylinder
10. Glass pestel and grinding tube
11. Reagent grade acetone
12. Reagent grade methanol
13. 0.1N HCl
14. $MgCO_3$ (powder)
15. Timer with second hand
16. Bottle brush
17. Bench sheets
18. Distilled water
19. Test tube racks

B. Glassware Preparation

1) Clean glassware with detergent (dish soap).
2) Triple rinse glassware with distilled water.
3) Rinse glassware with reagent grade acetone.
4) Label and organize test tubes and centrifuge tubes in racks.

C. Spectrophotometer Purging/Flushing Procedure

1) Turn on spectrophotometer
2) Touch User Programs
3) Touch Purge/Prep Program, then Start
4) Touch Options, then More
5) Touch Instrument Setup, then Sipper Options
6) Touch Purge Time, then select 60 sec, also select the Purge Start: Manual
7) Return to the program screen. Put 60-70 ml of distilled water in a beaker. Blank the instrument

8) After blanking a sample, touch Purge, this will purge the distilled water for 60 seconds
9) Put 60-70 ml of methanol in a beaker
10) Following the blanking and purging, Read a sample of methanol
11) After reading a sample, touch Purge, this will purge the methanol for 60 seconds or about 50 ml
12) Put 60-70 ml of distilled water in a beaker and repeat steps 10-11
13) Now your spectrophotometer is flushed and ready to go
14) Always have the sipper tube in distilled water. Don't let the flow-through cell dry out!

D. Sample Preparation

1) Control laboratory light sources as to avoid exposing the samples to strong light (allow just enough light to visibly operate).

2) Remove one filter carefully from the aluminum foil wrapping. Fold and insert the filter into the glass grinding tube. Transfer 5 ml of buffered 90% acetone solution to the grinding tube using 5 ml pipette and green pipette pump (see below for acetone solution preparation).

3) Attach glass pestle to the handheld drill. Grind the filter with the pestle at a moderate speed until pulverized. Use caution when controlling drill speed, as high grinding speeds could cause contents of tube to spill and inaccurate readings.

4) Pour the pulverized filter and acetone slurry from the grinding tube into a plastic centrifuge tube. Rinse the remaining contents of the grinding tube twice with 5 ml of acetone each rinse to bring the contents of the centrifuge tube to a total volume of 15 ml.

5) Cap centrifuge tubes tightly to prevent evaporation. Avoid exposing samples to strong light during storage.

6) Repeat steps 2-4 for each sample. Be sure to thoroughly rinse pestle and grinding tube between samples.

7) Prepare blanks according to the bench sheet using new glass fiber filters and buffered 90% acetone solution (use the sample preparation method described above).

8) Record field data from sample label (waterbody, date, time, site, etc.) on bench sheet.

9) Place all samples in test tube rack, wrap in a black garbage bag and place in the refrigerator for a minimum of 2 hours and a maximum of 24 hours.

E. Sample Analysis

1) Turn on spectrophotometer. ON/OFF switch located on posterior left.

2) Check power up diagnostics view for any failures. Spectrophotometer automatically turns on the visible light source.

3) Allow spectrophotometer and visible light source to warm up for 30 minutes.

4) Control laboratory light sources as to avoid exposing the samples to strong light (allow just enough light to visibly operate).

5) Place samples in centrifuge. Be sure to arrange the samples evenly for balance. Set centrifuge speed dial to 0. Set timer for 15 minutes. Gradually increase speed to 63 (approximately 2000 - 2220 rpm). Let centrifuge spin down naturally (do not apply brake).

6) Decant 12 mL of the extract from the centrifuge tubes into glass test tubes without disturbing the filter at the base of the centrifuge tube. Use the marked 25 ml pipette with a pipette bulb to transfer extract.

7) Flush the spectrophotometer with the flushing/purging procedure

8) On spectrophotometer screen, touch “User Programs” prompt then touch "Before Acidification" program. This sets the machine to read at wavelengths of 664, 750, and 665nm. Select the “Options” button, and make sure the “Store:” is selected as “ON”

9) Return to the “Options” menu, touch “More”, touch “Instrument Setup”, touch “Sipper Options”, touch “Purge Time”, and enter “5 seconds”. This reduces the purging step that is implemented in the Purge/Prep program. Return back to the program screen.

10) Blank spectrophotometer using a beaker with distilled water. Insert sipper tube into beaker below surface a minimum of 5 ml and select “BLANK” (should be less than 0.002). “Purge” system with 5 seconds of distilled water

11) Read samples. Insert sipper tube into test tubes well below the sample and select “READ”. Each draw siphons approximately 3 mL. Always insure that sipper tube remains below sample surface and does not suck up any air.

12) Allow the machine to siphon sample until pump quits. Once the sample is drawn, a 3 second “settling” will occur followed by one beep will sound. The beep means the samples have been read. A message should appear “Data Stored”.

13) Following the “read” “settling” and “data stored”, a 5 second “purge” with distilled water will need to be selected.

14) Repeat with remaining samples.

15) Run blank and duplicate samples when required (see Laboratory QA/QC below).

16) When samples are finished being read, exit the program.

17) Select program on spectrophotometer “User Programs” screen labeled "After Acidification". This sets the machine to read at wavelengths of 665 and 750nm.

18) Repeat steps 8 - 14 with addition of the following:

    a) With remaining sample in tube
    b) Acidify the sample by adding 0.30 ml of 0.1N HCl.
    c) Gently agitate sample.
    d) Start timer (set for 90 seconds).
    e) Siphon sample to obtain readings at exactly 90 seconds (assuming extra time comes from agitation).
    f) Repeat for each sample.
    g) Discard sample.

19) Following procedure for three samples at a time:
    a) Work with sets of three samples
    b) Must use a stopwatch that counts down and then when it gets to zero starts to count up
    c) With remaining sample in tube
    d) Acidify samples following table times below by adding 0.30 ml of 0.1 N HCL
    e) Siphon samples following table times below

Table 6.0. 1 Stopwatch times for acidifying and reading/siphoning Chlorophyll samples.

Sample	Acidify Time (sec) Counting down on stopwatch	Read/Siphon Time (sec) Counting up on stopwatch
1	90	0
2	60	30
3	30	1:00

20) Exit program and capture data as follows. Insert flash drive/memory device into one of the USB ports in the back portion of the machine. Touch “Recall Data”, touch the “Options” button and touch “Send Data” (USB Port Icon). Select “All Data”, then touch “OK”. The instrument automatically sends the data as a single DATALOG file to the memory device using the CSV file format. The file name uses the following format: DL*Year_Month_Day_Hour_Minute_Second.*csv

21) Follow the procedure for purging/flushing the spectrophotometer.

22) Turn off spectrophotometer when finished. Make sure the sipper tube is submerged in distilled water.

F. Laboratory Quality Assurance/Quality Control (QA/QC)

1) Read a blank after every 10 samples to check for spectrophotometer drift. Record on bench sheet.

G. Data Handling

1) Enter bench sheet data in chlorophyll access database (N:\WATRSHED\CHLOROPH\chlorophyll).
2) Open CSV file on memory device in Excel.
3) After opening the CSV file in Excel, highlight the first column and under the Data tab, select Text to Columns, then select Delimited and Next, then select Comma and Finish
4) Copy and paste the selected wavelength values (Abs) into the proper columns in the Access database. Disregard the result (mg/L) column, only use the value (Abs) columns

H. Calculating Total Chlorophyll and Chlorophyll *a* Concentrations

$$\text{Total Chlorophyll} = \frac{11.0\,(664_b - 750_b) \times V_1}{V_2 \times L}$$

$$\text{Chlorophyll a } (mg/m^3) = \frac{26.7\,(664_b - 750_b - 665_a + 750_a) \times V_1}{V_2 \times L}$$

where:

V_1 = volume of extract (liters)
V_2 = volume of sample ($m^{3)}$
L = light path length or width of cuvette (1 cm)

664_b, 665_a, 750_b, 750_a = optical densities of 90% acetone extract before and after acidification, respectively.

Calculate the chlorophyll:pheophytin ratio for each sample by dividing the absorbance at 664 nm by absorbance at 665nm. Healthy samples will have a chlorophyll:pheophytin ratio ranging between 1.0 - 1.7. Samples with a chlorophyll/pheophytin ratio of 1.70 are considered to contain no pheophytin and to be in excellent physiological condition. Samples of pure pheophytin will show no reduction after acid yielding a ratio of 1.0. Samples with ratios above or below this range should be considered unusable do to sample age, improper handling, or field/laboratory error.

I. Buffered 90% Acetone Preparation

It is critical that the buffered acetone be prepared carefully and to exact proportions.

1000 ml recipe:

900 ml acetone
100 ml buffer solution (recipe below)

1) Add 900 ml acetone to capped flask
2) Add 100 ml buffer solution to flask, making sure to get a little precipitate from bottom of buffer solution beaker
3) Stir, cap, refrigerate, and rest overnight to allow settling and clarity
4) Should be a light film of precipitate (saturated) on bottom of flask following resting period

Buffer solution

1) Add 5 tablespoons powdered magnesium carbonate ($MgCO_3$) to 1000 ml distilled water. Dissolve.
2) Stir for 2 minutes to saturate solution. Cap tightly.
3) May be used multiple times. Do not need to make every time.

J. References

The methods and equations for chlorophyll analysis adopted by the SD DENR WPP are derived from the following:

Eaton, A.D., L.S. Clesceri, and A.E. Geenberg (editors). 1995. *Standard Methods for the Examination of Water and Wastewater*, 19th Edition. American Public Health Association, Washington, D.C.

Golterman, H.L. and R. S. Clymo. 1971. *Methods for Chemical Analysis of Fresh Waters*. IBP Handbook No. 8. Blackwell Scientific.

Lind, Owen T., 1985. *Handbook of Common Methods used in Limnology*, 2nd Edition. Kendall/Hunt Publishing Company, Dubuque, IA.

7.0 BENTHIC MACROINVERTEBRATE SAMPLING FOR WADEABLE STREAMS AND RIVERS

A. Purpose

The purpose of sampling benthic macroinvertebrates is to quantify the benthic community, evaluate community structure, stream condition, and correlate density with nutrient loading and delineate bio-and ecoregions in rivers and streams in South Dakota. This procedure is designed to give a general overview; sub-samples will be composited in an attempt to eliminate the patchiness of invertebrate populations typically found in streams.

B. Wadeable Site Setup Procedures

1. Identifying the Sampling Reach
   a. Use a surveyor's rod, tape measure, or laser range finder to determine the wetted width of the channel at 5 places of "typical" width within approximately 5 channel widths downstream of the monitoring site. Average the 5 readings together and round to the nearest 1 m. If the average width is <4 m, use 100 m as a minimum reach length. Record this width on the Macroinvertebrate Site Map (Appendix E Table E-1).
   For channels with "interrupted flow", estimate the width based on the un-vegetated width of the channel (again, with a 100 m minimum and 4 km maximum).
   b. Check the condition of the stream about the monitoring site by having one team member go downstream of the monitoring site. Proceed downstream to a distance of 30 times the average channel width determined in Step a.
   c. During the stream condition check, determine if the reach needs to be adjusted around the monitoring site (see Figure 7.0. 2) due to confluences with higher order streams (downstream), impoundments (lakes, reservoirs, ponds), physical barriers (e.g., falls, cliffs), or because of access restrictions to a portion of the initially-determined sampling reach (Step "b").
   d. Starting at the monitoring site, measure a distance of 30 channel widths down one side (left) of the stream using a GPS unit, laser rangefinder, or tape measure. Be careful not to "cut corners". Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach, and is flagged as Transect "1". For reaches that need to be adjusted around the monitoring site as described in Step "c", start at the monitoring site and measure upstream the total number of average wetted widths determined to avoid downstream conditions outlined in Step "c". Mark this as location as Transect "11". From this transect, measure previously determined average stream width downstream and

flagging each transect "10" – "1") from one side of the stream (see Figure 7.0. 2 for example, shifted 4 transects upstream).

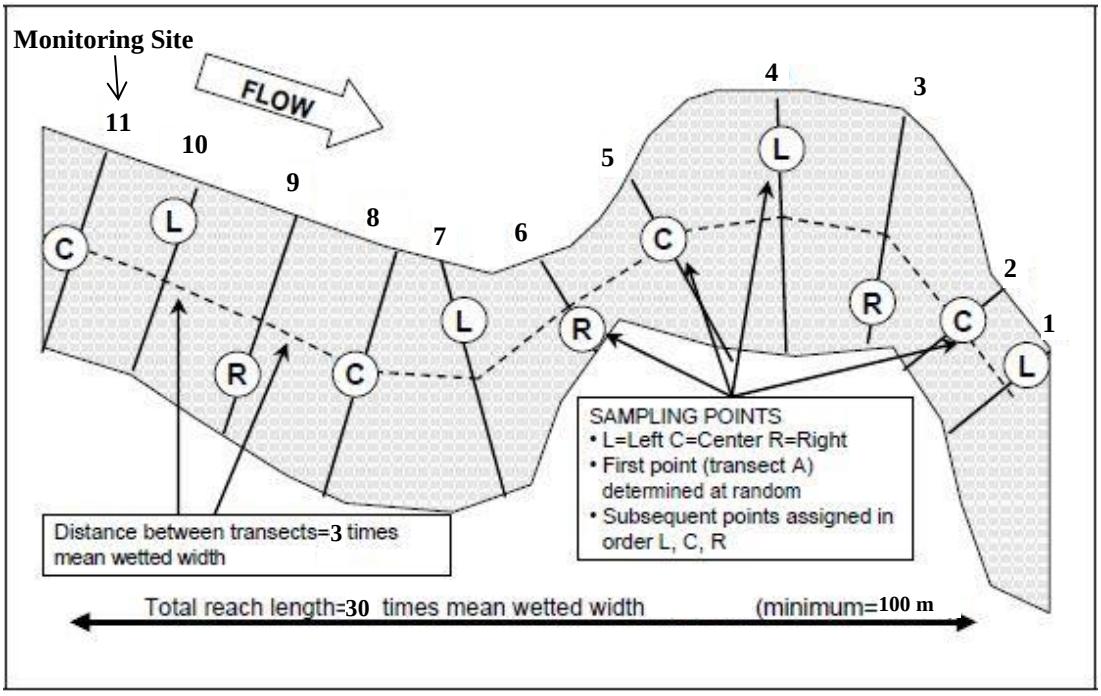


Figure 7.0. 1 Transect layout and sampling site location example for wadeable rivers and streams (Adapted/Modified from US EPA, 2007).

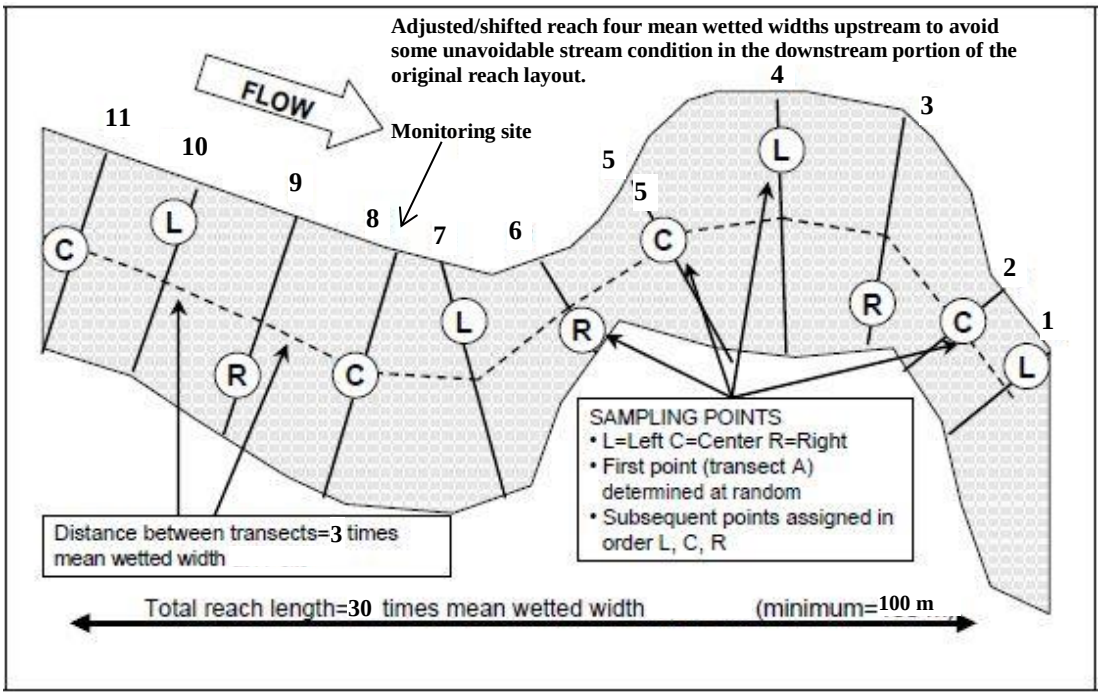


Figure 7.0. 2 Adjusted transect layout and sampling site location example for wadeable rivers and streams (Adapted/Modified from US EPA, 2007).

2. Sampling stations setup at wadeable sites:

a. At transect "1" (downstream transect), use the seconds display on a digital watch to select the initial sampling station for standard transect samples: 1-3="Left", 4-6="Center", 7-9="Right". Mark "L", "C", or "R" on the transect flagging; the 3 potential collection points are roughly equivalent to 25%, 50%, and 75% of the wetted width of the channel, respectively.

b. Measure $1/10^{th}$ of the required reach length upstream from transect "1". Flag this spot as transect "2". Assign the sampling station systematically after the first random selection (Figure 7.0. 1).

c. Proceed upstream with the tape measure and flag the positions of 9 additional transects (labeled "3" through "11" with "11" being the original monitoring site (the most upstream transect) at intervals equal to $1/10^{th}$ of the reach length. Continue to assign the sampling stations systematically (Figure 7.0. 1).

d. Sketch a map of the sampling reach in the area provided on the SD DENR WPP Macroinvertebrate Map, Measurements and Documentations Datasheet (Appendix E, Table E-1). Draw the sampling reach, locating each of the measurements and transects described above. In addition, note any other pertinent features or observations on the map, including landmarks or directions that could be used to locate the site for future visits.

C. Wadeable Sampling Procedures: Natural Substrates

1. At 1 m downstream of each transect, beginning with Transect "1", randomly locate the first sampling station that was marked on the transect flag during initial setup (Left, Center, or Right when facing downstream) as 25%, 50%, and 75% of the wetted width, respectively. If you cannot collect a sample at the designated point because of deep water or unsafe conditions, relocate to another random point on the same transect.
2. Determine if there is sufficient current in the area at the sampling station to fully extend the net. If so, classify the habitat as "riffle/run" and proceed to Step "3". If not, use the sampling procedure described for "pool/glide" habitats starting at Step "9". If the stream is extremely narrow use the sampling procedures described for "narrow channels" habitats starting at step "13"

   NOTE: If the net cannot be used, hand-pick a sample for 30 seconds from approximately $0.1m^2$ of substrate at the sampling point. For vegetation-choked sampling points, sweep the net through the vegetation within a 1 ft^2 quadrat for 30 seconds. Place this hand-picked sample directly into the sample container. Assign a "U" flag (non-standard sample) to the sample and indicate which transect(s) required the modified collection procedure in the comments section. Go to Step "18".

Riffle/Run Habitats:

3. With the net opening facing upstream, quickly position the net securely on the stream bottom to eliminate gaps under the frame. Avoid large rocks that prevent the net from seating properly on the stream bottom.

   NOTE: If there is too little water to collect the sample with the D-net, randomly pick up 10 rocks from the riffle and pick and wash the organisms off them into a bucket which is half full of water.

4. Holding the net in position on the substrate, visually define a quadrat that is one net width wide and long upstream of the net opening. The area within this quadrat is approximately 0.1 m^2.
5. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the net. Pick up loose rocks or other larger substrate particles in the quadrat. Use your hands or a scrub brush to dislodge organisms and wash them into the net. Scrub all rocks that are golf ball-sized or larger and which are halfway into the quadrat. After scrubbing, place the substrate particles outside of the quadrat.
6. Hold the D-net securely in position. Starting at the upstream end of the quadrat, vigorously kick the remaining finer substrate within the quadrat for 30 seconds (use a stopwatch).

   NOTE: For samples located within dense beds of long, filamentous aquatic vegetation (e.g., algae or moss), kicking within the quadrat may not be sufficient to dislodge organisms in the vegetation. Usually these types of vegetation are lying flat against the substrate due to current. Use a knife or scissors to remove only the vegetation that lies within the quadrat (i.e., not entire strands that are rooted within the quadrat) and place it into the net.

7. Pull the net up out of the water. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net. Avoid having any water or material enter the mouth of the net during this operation.
8. Go to Step 18.

Pool/Glide Habitats:

9. Visually define a quadrat that is one net width wide and long at the sampling point. The area within this quadrat is approximately 0.1 m^2.
10. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the net. Pick up loose rocks or other larger substrate particles in the quadrat. Use your hands or a scrub brush to dislodge organisms and wash them into the net. Scrub all rocks that are golf ball-sized or larger and which are halfway into the quadrat. After scrubbing, place the substrate particles outside of the quadrat.

11. Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds.

    NOTE: If there is too little water to use the kick net, stir up the substrate with your gloved hands and use a sieve with 500 μm mesh size to collect the organisms from the water in the same way the net is used in larger pools.

12. After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net, Go to Step 18.

Narrow Channel

13. If the stream is narrow (< 1m), collect one sample in the deepest point (thalweg) of each transect. If the channel is extremely narrow (as wide as the D-net or less) angle the D-net in the channel up to approximately 30° to fit into the channel, any more may crimp or bind the net reducing sampling efficiency. If the channel width is less than described above move the transect up or downstream until the stream widens out enough to sample. If the transect is moved because the stream is too shallow, indicate which transect(s) in the comments section of the datasheet. Samples will be collected at each of 11 transects and composited.
14. Visually define a rectangular quadrat that is one net width wide and one net width long at the sampling point (approximately 0.1 m^2).
15. Kick the substrate within the quadrat with the toe of your boot for 30 seconds (use a stopwatch).
16. After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.
17. Go to Step 18.

All samples:

18. Invert the net into a sieve bucket and transfer the sample. Remove as much gravel as possible so that the organisms do not get damaged. Inspect the net for any residual organisms clinging to the net and deposit them into the bucket. Use forceps if necessary to remove organisms from the net. Carefully inspect any large objects (such as rocks, sticks, and leaves) in the bucket and wash any organisms found off of the objects and into the bucket before discarding the object. Remove as much detritus as possible without losing organisms.
19. Determine the predominant substrate size/type within the sampling quadrat. Fill in the appropriate dominant substrate type for each transect on the Macroinvertebrate, Maps, Measurements, and Documentation Datasheet under the notes and calculations section (Appendix E, Table E-1).

NOTE: If there are co-dominant substrate types, you may fill in more than one identifier in substrate type box and note the co-dominants in the comments section of the form.

- Fine/Sand: not gritty (silt/clay/muck <0.06 mm diam.) to gritty, up to ladybug sized (2 mm).
- GRavel: fine to coarse gravel (ladybug to tennis ball sized; 2 mm to 64 mm).
- COarse: Cobble to boulder (tennis ball to car sized; 64 mm to 4000 mm).
- OTher: bedrock (larger than car sized; > 4000 mm); hardpan (firm, consolidated fine substrate); wood of any size, aquatic vegetation, etc. Note type of "other" substrate in comments section of the datasheet.

20. Identify the habitat type where the sampling quadrat was located. Fill in the channel habitat type for each transect on the on the Macroinvertebrate, Maps, Measurements, and Documentation Datasheet under the notes and calculations section (Appendix E, Table E-1).

- Pool; Still water; low velocity; smooth, glassy surface; usually deep compared to other parts of the channel
- GLide: Water moving slowly, with smooth, unbroken surface; low turbulence
- RIffle: Water moving, with small ripples, waves, and eddies; waves not breaking, and surface tension is not broken; "babbling" or "gurgling" sound.
- RApid: Water movement is rapid and turbulent; surface with intermittent "white water" with breaking waves; continuous rushing sound.

21. Thoroughly rinse the net before proceeding to the next sampling station. Proceed upstream to the next transect (through Transect "11", the upstream end of the reach) and repeat steps 1 - 16. Combine all kick net samples from riffle/run, pool/glide and narrow channel habitats into the bucket.

D. Procedure for preparing composite samples for benthic macroinvertebrates

1. Pour the entire contents of the bucket into a sieve bucket with 500 μm mesh size. Remove any large objects and wash off any clinging organisms back into the sieve before discarding. Remove any inorganic material, such as cobble or rocks.
2. Using a wash bottle filled with river water, rinse all the organisms from the bucket into the sieve. This is the composite sample for the reach.
3. Estimate the total volume of the sample in the sieve and determine how large a jar will be needed for the sample (500-mL or 1-L) and how many jars will be required. Try to use no more than 5 jars per site.

4. Fill out the appropriate number of biological bottle labels as determined in step 3 above. On each label be sure to include Project ID, Source, Station, Program, Date of collection, Time, Initials, and if not checked check Macroinvertebrate box on each (Figure 7.0. 3). When additional bottles are required fill in the bottom right corner of the label crossing out surface area and writing in sample jars (1 of 3, 2 of 3 of 3, etc.). Attach the completed label(s) to the jar(s) and cover it/them with a strip of clear tape. Record the number of composite sample jars on the lower left corner of the Macroinvertebrate Maps, Measurements, and Documentation Datasheet under the notes and calculations section, (Appendix E, Table E-1).
5. There should be only one Macroinvertebrate, Maps, Measurements, and Documentation Datasheet for each composite sampling site, make sure the number of sample jars on the bottles matches the number on the bottom left hand corner of the datasheet.

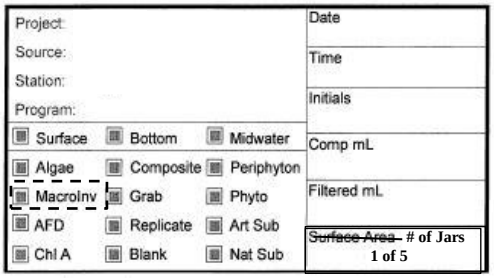


Figure 7.0. 3 Biological bottle label used by the SD DENR WPP.

4. Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large-bore funnel if necessary. If the jar is too full water pour off some water through the sieve until the jar is not more than 1/3 full, or use a second jar if a larger one is not available. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar.
5. Place a waterproof label inside each jar (Appendix E, Table E-2) with the following information written with a number 2 lead pencil:

   • Site ID
   • Collectors initials
   • Type of sampler and mesh size used
   • Number of transects sampled
   • Name of site
   • Date of collection
   • Jar "N" of "X"

7. Completely fill the jar with 95% ethanol (no headspace). It is very important that sufficient ethanol be used, or the organisms will not be properly preserved. Existing water in the jar should not dilute the concentration of ethanol below 70%.

NOTE: Composite samples can be transported back to the vehicle before adding ethanol if necessary. In this case, fill the jar with stream water, which is then drained using the net (or sieve) across the opening to prevent loss of organisms, and replace with ethanol.

8. Replace the cap on each jar. Slowly tip the jar to a horizontal position and gently role/rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape, optional.
9. Store labeled composite samples in a container with absorbent material that is suitable for use with 70% ethanol until transport or shipment to the laboratory.

When Finished Sampling the Lake/Reach/Site, Clean all boats, equipment; and sampling gear including waders, nets and buckets. Be sure to remove all debris, dirt and grime with lake or stream water and follow all cleaning procedures outlined in Section 9.0 in SD DENR WPP SOP Volume I (Decontamination Protocols for Equipment and Field Workers)!!!

E. SD DENR WPP Laboratory Procedures for Macroinvertebrate Identification

1. Samples will be shipped or delivered to a private consultant for identification and enumeration. Check with the project officer for details.
2. The methods for the most efficient laboratory protocols will be developed by analyzing a subset of 10 randomly selected samples from the original samples.
3. Sample processes will include washing and rinsing, sub-sampling, identification and enumeration.
4. Alternate laboratory procedures may be considered appropriate if approved by the SD DENR WPP and /or the project officer.

    a. Sub-sampling frequency

        i. One standardized sub-sample will be representative of the field sample.

    b. Sub-sampling procedure

        i. Laboratory sub-sampling and analysis of individual benthic macroinvertebrate field samples will involve thoroughly washing and rinsing the sample in a 500 µm screen to remove preservative and remaining sediment.
        ii. Each washed sample will be placed in a flat tray with a white bottom that is marked in 5 cm square quadrants. Water will be added to the tray to allow for complete dispersion of the sample and even distribution of the organisms within the tray.

iii. Initially, three additive sub-samples consisting of 100 organisms each will be obtained from each of the ten randomly selected field samples.

iv. Quadrants will be randomly selected for each sub-sample and all organisms removed within each quadrant until the total number of organisms obtained for that sub-sample is +/- 10% of the project specific number outlined in the PIP (100, 200, or 300 organisms).

v. Analysis of the data subsets (the three 100 counts) will be studied to determine if fewer organisms can be statistically counted with the results. Statistical analysis will compare the 100, 200, and 300 counts.

vi. Any changes from the 300 organism count will be discussed between SD DENR WPP and the contractor before fewer numbers are counted. The most statistically defendable and efficient methods of enumeration and identification will be used for the remaining samples.

vii. Any organism which is lying over a line separated by two quadrants is considered to be in the quadrant containing its head.

viii. After identification and enumeration, all organisms removed will be returned to a separate container, should additional analysis be required.

ix. Additional sub-sampling determinations may be made following organism identification and preliminary analysis of the data.

x. Situations which call for additional sub-sampling include those in which the results are ambiguous, suspected of being spurious, or do not yield a clear water quality assessment.

xi. If additional sub-samples are taken, the indices are averaged with that of the original sub-sample.

c. **Organism Identification**

i. Benthic macroinvertebrates will be identified to the lowest practical level, Genus and if possible species.

ii. The number of individuals in each group will be recorded on a laboratory data sheet.

iii. Representative specimens from a sample will be selected and stored separately in a voucher collection.

iv. The voucher collection of identified specimens will be maintained by SDSU for the department for comparative and quality control purposes.

v. All organisms which are not counted will be bottled and preserved for future use.

8.0 FISH COLLECTION METHODS FOR WADEABLE STREAMS IN SOUTH DAKOTA

A bag seine represents the primary fish capture technique used to sample the diverse array of wadeable stream habitats for the purpose of obtaining fish community level information. A backpack electro-shocker is considered a secondary fish collection method when it is not feasible to effectively sample the stream with a bag seine. A backpack shocker is used in streams with significant snags, often higher gradient cobble-boulder dominated streams found in the Black Hills and those along the Prairie Choteau escarpment. The decision to use either collection method is at the discretion of the field crew. Always make sure to obtain the appropriate collection permits (state and federal) prior to fish sampling.

The main objective of most fish sampling efforts is to gain a representative sample of the resident fish assemblage. The standard approach is to make a single pass with either sampling method through the established stream reach. A single pass provides a timely and standardized approach. A single pass is considered sufficient effort to determine precise patterns in fish assemblage, community structure, and function for bioassessment (Bateman et al. 2005, Bertrand et al. 2006). Multiple passes require significant time and would be warranted in situations when the objective is to determine absolute population densities.

Fish community structure and function in prairie stream environments can change spatially and temporally depending on seasonal hydrology. The SD DENR Watershed Protection Program recommends sampling fish in mid to late summer, generally July and August. This index period corresponds to a period when most stream flows are stable and at or near base-flow. The general rule is not to sample fish immediately after major storm events and to avoid sampling when the stream is at or above bank full depth. The following sampling protocols are consistent with techniques used by SD Game, Fish and Parks and the Co-op Research Unit at South Dakota State University.

A. Bag Seine Method

1. Use a standard bag seine with 3/16 inch (4.8 mm) to 1/4 (6.4 mm) inch mesh and 4 feet (1.2 m) to 6 feet (1.8 m) in height depending on depth of the stream. The seine should be wide enough to cover bank to bank in the widest location of the stream reach. If the stream reach has a section wider than the most appropriate seine width, sample the best available habitat in the widest section. Tighten the seine by rolling the net on the poles keeping the lead line on the bottom in narrower sections of the stream. Move the seine in a downstream orientation with stream flow.
2. Prior to starting the seine haul, place a straight seine or block net perpendicular from bank to bank across the stream at the furthest downstream end of the reach.
3. The length of an individual seine haul will depend on bank access, size of the stream reach and abundance of fish or debris (i.e. woody debris, aquatic plants-rocks). The recommendation is to scout out the stream reach prior to seining to determine the best exit points to drag the seine onto the bank. The best exit points are generally associated with the head of a riffle or sand bar on inside bends. Exit the stream as much as possible

in long stream reaches with significant fish and/or debris, (each transect) to minimize fish loss. A continuous seine haul is plausible in small stream reaches (i.e. < 100 meters) with low habitat diversity and fish abundance.

B. Runs/Glides and Pool Habitat

4. The seine haul will require 3 operators minimum to effectively sample the reach. One operator will be placed at each bank to hold a seine pole. Each operator will make sure the lead line is riding firmly on the bottom as the floats skim the surface. Start at the upstream end of the stream reach and move in a downstream orientation with the flow. Move downstream in a rapid fashion making sure the bag portion stays completely extended and does not become inverted. A third operator will move behind the seine to keep it free from snags and moving effectively downstream.

5. When exiting the stream channel one operator holds a seine pole firmly on the bank while the other operator swings the seine to the opposite bank. When both seine operators are on the same bank, each operator will drag the lead line in making sure it stays in constant contact with the bottom of the channel or bank. When the bag becomes visible, pick the bag up and place it in the fish holding basket. Invert the bag rolling fish and other contents into the basket. Process fish at the end of each seine haul if necessary to minimize stress and mortality.
6. When conducting the final seine haul at the end of the reach move the seine along the block net in route to the opposite bank. After the bag has been emptied into the fish basket two people will dislodge and roll the block net to form a small bag. Placing one end of the block net in the fish basket slowly work the remaining length of block net into the fish holding basket to capture fish entangled in the block net.

C. Riffle Habitat

1. The same seining process described for runs/glides and pools can be used for riffle habitat if riffle characteristics provide for fluent operation. When riffle characteristics are not conducive to seine operation due to factors such as shallow depth, high velocity-flow or large firm substrates, use the following seining technique to capture fish.
2. Stretch the seine from bank to bank at a location immediately downstream of the riffle. Have all available field crew members walk the riffle downstream towards the net, kicking and disturbing all interstitial spaces to actively push fish downstream into the net. When the process is complete, one seine operator will keep the seine anchored on the bank while the other seine operator arches the seine across the stream to the opposite bank. Each operator will drag the lead line in making sure it stays in contact with the bottom of the channel or bank. Place the bag into a fish holding basket and empty the contents.

D. Backpack Electro-Shocking Method

1. A back-pack electro-shocker should be used to capture fish when physical characteristics of the stream are not conducive to effective seining. The use of any backpack model developed by a major electro-shocking manufacturer (i.e. Smith-Root, Halltech, E-Fish) is considered acceptable. The SD DENR WPP uses an HT-2000 backpack electro-shocker manufactured by Halltech Aquatic Research Inc. It is important to understand the specifications and operating procedures of any unit prior to engaging in fish sampling. The Operations Manual for the HT-2000 is located at: http://www.halltechaquatic.com/pdfs/HT2000manual.pdf. (Halltech, 2013). Make sure to acquire all recommended safety equipment (non-conductive waders-rubber gloves etc.) prior to operation.
2. A measure of the streams conductivity (µS/cm) is required to calibrate voltage and frequency of the shocker unit, prior to fish sampling. Choose a location upstream or downstream of the established sampling reach to calibrate the unit. The operators will need to adjust the voltage and frequency for the streams conductivity in accordance with specifications described in the Operations Manual (Halltech, 2013) see below. Once the shocker unit is engaged, further adjustment to the voltage and/or frequency may need to be made until optimal fish shocking efficiency is achieved.

a. The output voltage switch is located in the middle of the unit on the far right side. The output voltage ranges from 50-950 V in 11 steps (50, 100, 150, 250, 350, 450, 550, 650, 750, 850, 950V).

- 50 to 350 volts is typically used in high conductivity waters, >300 µS/cm (microsiemens).
- 450 to 750 volts work best in moderately conductive waters, 100 to 300 µS/cm (microsiemens).
- 850 and 950 output voltage should typically only be used in low conductivity waters, < 100 µS/cm (microsiemens).

Increasing the output voltage just one step may increase the output peak wattage 100% plus or minus depending on the conductivity on the water and the voltage setting (adapted from the *HT-2000 User's Manual*).

b) The Frequency [Hz] switch is located in the middle of the unit on the far left side of the panel. The output frequency is in a range from 5-250 Hz in 11 steps (5, 10, 20, 40, 60, 80, 100, 130, 160, 200, 250Hz). The frequency is best described as the number of times the fish is shocked in a given time period, or the number of pulse waves produced each second. When first shocking a new site start with the lowest frequency setting. Gradually increase the frequency until the desired effect is achieved.

- For example when shocking a water body with a high conductivity, > 300 µS/cm (microsiemens) at an output voltage of 150 volts and a frequency of 60, if you are rolling some fish but feel you aren't getting all of them, try increasing the frequency to 80 or 100 Hz before increasing the voltage to 250 V.

3. During calibration, it is important to make subtle changes to either the voltage or frequency settings to minimize fish mortality. This is especially true in streams with potential to harbor endangered species such as the Topeka Shiner (*Notropis topeka*). In instances where Topeka Shiner presence is detected, immediately move to another location of the stream outside the reach to finish the calibration process. Follow all state and federal permitting guidelines and regulations.

4. Fish shocking should be conducted in an upstream orientation towards a block net positioned at the furthest upstream transect. The fish shocking process will require a minimum of 3 field personnel; one electro-shock operator, a fish netter and someone to trail behind with the fish collection basket. A second fish netter would be ideal if a fourth person is available in the field crew. Before starting the shocking process, document the shocker settings (volts, frequency, battery amps) and reset the timer.
5. A general rule for fish shocking is to cover all available habitats in the stream. In small streams (5-10 meters wide) with low habitat diversity it is possible to cover all available habitats with relative ease. In medium sized streams (10-25 meters), sampling effort should be directed towards those habitats most likely to hold fish such as snags, undercut banks, large cobble-boulders and scour holes along the banks and channel. Do not focus sampling efforts on one particular habitat. In larger streams >25 meters wide, sample right and left bank margins and major channel features, alternating between transects. Larger streams may be difficult to sample effectively with a back-pack shocker. Alternate methods such as a barge shocker or boat shocker may be warranted.
6. In very small streams less than 5 meters wide it is relatively easy to cover all habitats rather quickly and efficiently. A minimum of 30 minutes shock time should be spent in very small streams to avoid rushing through the process.
7. The level of shocking effort given to small and medium sized streams greater than 5 meters wide will depend on site-specific characteristics of the stream reach such as; size, navigability and habitat diversity. Field crews should devote sufficient shock time and overall fishing time necessary to thoroughly cover all available habitats required to gain a representative collection of the resident fish assemblage. As a benchmark,

field crews should spend a minimum of 2 hours shock time in streams with average widths of five to twenty-five meters.

8. When finished shocking at the furthest upstream transect make sure to record the shocking time, generally in seconds to quantify level of effort. Process the captured fish as often as possible to minimize stress and mortality.

E. Fish Processing

1. The level of fish processing will depend on individual project goals and objectives. The following stepwise procedures are conducted by the Watershed Protection Program to obtain information required to generate community level metrics, length frequency, and relative species abundance. A full set of datasheets are provided in Appendix F.

    - Start by sorting individual fish species into separate buckets for processing. A list of fish species found in South Dakota is provided in Appendix F, Table F-5 for reference.
    - Identify, measure and record the length (millimeters) of a random selection of at least 50 individual fish of the same species to cover representatives of the most abundant size classes (Appendix F, Table F-1). Measure any large fish not well represented in the collection, in addition to the subset of 50 individual fish.
    - If the number of a particular species is estimated to be less than 100 individuals, physically count the remaining individuals and record the total count on the datasheet (Appendix F, Table F-2).
    - If the total fish count is expected to exceed 100 individuals, bulk weigh the initial subset (n=50) of fish to the nearest gram. Take a

bulk weight of the remaining fish and record on the datasheet (Appendix F, Table F-3).

- For uncommon or unknown fish species, select one to two good fish specimens of each species in the collection to voucher.
- Place voucher specimens in an appropriate container and preserve with 10% formalin.
- Fill out the label information and place the label inside the voucher container. Make sure to use write in the rain paper to print fish voucher labels (Appendix F, Table F-6).
- For each common fish species photo vouchering procedures should be employed and are as follows.
- Chose one high quality representative fish and place it in or on a measuring board and place them on a large white board. On the top right corner of the white board write the project ID, date, stream name, location, species name, and collector initials.
- Using a digital or cell phone camera, take a picture of the fish on the whiteboard making sure to include documentation information in the photo frame. Fill out information and document species photos, common name, photo frame (ID), and comments in the Photo Vouchering Log Datasheet (Appendix F, Table F-4).

When Finished Sampling the Reach/Site, Clean all equipment, boats, shocker wands; and sampling gear including waders, nets, and buckets of debris, dirt and grime with stream or lake water and follow all cleaning procedures outlined in Section 9.0 of SD DENR WPP Standard Operating Protocols, Vol I, (Decontamination Protocols for Equipment and Field Personnel)!!!

SD DENR WPP Fish Data Sheet	**Page: 1 of _____**

Site ID:	**Stream Name:**	
Date:	**Habitat Sample ID #**	**Pass# _____ of _____**
Gear Type: (circle one) **Backpack**	**Seine (blocknet: Yes or No)**	**Boat Mounted Shocker**
Gear Style: (i.e. Halltech, model #, 3/16 inch, etc)		
Record Shocking Information below		
Water Conductivity (µS/cm):	**Water Temperature (°C):**	**Peak Voltage:**
Peak Amperes:	**Wave Form (ac, dc or pdc):**	**Duration (sec):**

Common Name	Length (mm)	Weight (g)	Disease	Common Name	Length (mm)	Weight (g)	Disease

***Parasites & Anomalies Code: D=deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=black spot, EM=emaciated, O=other**

SD DENR WPP Fish Data Sheet	**Page:_____ of _____**

Site ID:	**Stream Name:**	**Date:**

Common Name	Length (mm)	Weight (g)	Disease	Common Name	Length (mm)	Weight (g)	Disease

***Parasites & Anomalies Code: D=deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=black spot, EM=emaciated, O=other**

Site ID:	Stream Name:	Date:

Fish Counts (after first 50, for species with less than 100 total individuals)

Species Common Name	Count1	Count2	Count3	Count4	Count5	Count Total

Site ID:	Stream Name:	Date:

Fish Bulk Weights (weights after first 50, for species with more than 100 individuals)

Species Common Name	Weight1 (g)	Weight2 (g)	Weight3 (g)	Weight4 (g)	Weight5 (g)	Total Weight (g)

Fish Photo Vouchering Log			
Site ID:	**Stream Name:**		**Date:**

Count	Species Common Name	Photo frame number (ID)	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

South Dakota Fishes			
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
American eel	*Anguilla rostrata*	**mirrror carp**	*Cyprinus carpio*
banded killifish	*Fundulus diaphanus*	**mountain sucker**	*Catostomus platyrhynchus*
Black Buffalo	*Ictiobus niger*	**muskellunge**	*Esox masquinongy*
blue catfish	*Ictalurus furcatus*	**northern hogsucker**	*Hypentelium nigricans*
blackside darter	*Percina maculata*	**northern pike**	*Esox lucius*
blacknose shiner	*Notropis heterolepis*	**northern redbelly dace**	*Phoxinus eos*
bluegill x green sunfish	*L. macrochirus x L. cyanellus*	**orangespotted sunfish**	*Lepomis humilis*
Bigmouth Buffalo	*Ictiobus cyprinellus*	**other**	
bigmouth shiner	*Notropis dorsalis*	**paddlefish**	*Polyodon spathula*
brook trout	*Salvelinus fontinalis*	**pallid sturgeon**	*Scaphirhynchus albus*
black bullhead	*Ameiurus melas*	**pearl dace**	*Margariscus margarita*
black crappie	*Pomoxis nigromaculatus*	**plains killifish**	*Fundulus zebrinus*
blacknose dace	*Rhinichthys atratulus*	**plains minnow**	*Hybognathus placitus*
bluegill	*Lepomis macrochirus*	**plains topminnow**	*Fundulus sciadicus*
bluntnose minnow	*Pimephales notatus*	**pumpkinseed**	*Lepomis gibbosus*
blackchin shiner	*Notropis heterodon*	**quillback sucker**	*Carpiodes cyprinus*
brown bullhead	*Ameiurus nebulosus*	**rainbow smelt**	*Osmerus mordax*
brown trout	*Salmo trutta*	**rainbow trout**	*Oncorhynchus mykiss*
Bonneville Cisco	*Prosopium gemmifer*	**redhead**	*Cichlasoma synspilum*
bowfin	*Amia calva*	**red shiner**	*Cyprinella lutrensis*
brassy minnow	*Hybognathus hankinsoni*	**redfin shiner**	*Lythrurus umbratilis*
brook stickleback	*Culaea inconstans*	**river carpsucker**	*Carpiodes carpio*
Blue Sucker	*Cycleptus elongatus*	**rock bass**	*Ambloplites rupestris*
blue sucker	*Cycleptus elongatus*	**rosyface shiner**	*Notropis rubellus*
burbot	*Lota lota*	**smallmouth buffalo**	*Ictiobus bubalus*
channel catfish	*Ictalurus punctatus*	**smallmouth buffalo**	*Ictiobus bubalus*
central mudminnow	*Umbra limi*	**sauger**	*Sander canadensis*
common shiner	*Luxilus cornutus*	**sand shiner**	*Notropis stramineus*
common carp	*Cyprinus carpio*	**spotfin shiner**	*Cyprinella spiloptera*
coho salmon	*Oncorhynchus kisutch*	**shortnose gar**	*Lepisosteus platostomus*
creek chub	*Semotilus atromaculatus*	**shorthead redhorse**	*Moxostoma macrolepidotum*
cutthroat trout	*Oncorhynchus clarkii*	**shovelnose sturgeon**	*Scaphirhynchus platorynchus*
emerald shiner	*Notropis atherinoides*	**sicklefin chub**	*Macrhybopsis meeki*
european rudd	*Scardinius erythrophthalmus*	**silver lamprey**	*Ichthyomyzon unicuspis*
flathead catfish	*Pylodictis olivaris*	**mississippi silvery minnow**	*Hybognathus nuchalis*
chinook salmon	*Oncorhynchus tshawytscha*	**silverband shiner**	*Notropis shumardi*
fathead minnow	*Pimephales promelas*	**skipjack herring**	*Alosa chrysochloris*
finescale dace	*Phoxinus neogaeus*	**slenderhead darter**	*Percina phoxocephala*
flathead chub	*Platygobio gracilis*	**slender madtom**	*Noturus exilis*
freshwater drum	*Aplodinotus grunniens*	**smallmouth bass**	*Micropterus dolomieu*
goldeye	*Hiodon alosoides*	**sturgeon chub**	*Macrhybopsis gelida*
goldfish	*Carassius auratus*	**spottail shiner**	*Notropis hudsonius*
golden redhorse	*Moxostoma erythrurum*	**splake**	*S. fontinalis* x *S. namaycush*
golden shiner	*Notemigonus crysoleucas*	**silver chub**	*Macrhybopsis storeriana*
grass carp	*Ctenopharyngodon idella*	**southern redbelly dace**	*Phoxinus erythrogaster*
green sunfish	*Lepomis cyanellus*	**stonecat**	*Noturus flavus*
gizzard shad	*Dorosoma cepedianum*	**central stoneroller**	*Campostoma anomalum*
hatchery brown trout	*Htc Salmo trutta*	**steelhead trout**	*Oncorhynchus mykiss*
hornyhead chub	*Nocomis biguttatus*	**suckermouth minnow**	*Phenacobius mirabilis*
hatchery rainbow trout	*Htc Oncorhynchus mykiss*	**saugeye**	*S. canadensis* x *S. vitreus*
iowa darter	*Etheostoma exile*	**tadpole madtom**	*Noturus gyrinus*
jack dempsey	*Cichlasoma octofasciatum*	**tiger trout**	*S. trutta* x *S. fontinalis*
johnny darter	*Etheostoma nigrum*	**tiger muskellunge**	*E. lucius* x *E. masquinongy*
kokanee salmon	*Oncorhynchus nerka*	**topeka shiner**	*Notropis topeka*
lake chub	*Couesius plumbeus*	**trout-perch**	*Percopsis omiscomaycus*
lake herring	*Coregonus artedi*	**walleye**	*Sander vitreus*
lake trout	*Salvelinus namaycush*	**white bass**	*Morone chrysops*
lake whitefish	*Coregonus clupeaformis*	**white crappie**	*Pomoxis annularis*
largemouth bass	*Micropterus salmoides*	**white sucker**	*Catostomus commersonii*
longnose dace	*Rhinichthys cataractae*	**wiper**	*M. chrysops* x *M. saxatilis*
longnose gar	*Lepisosteus osseus*	**yellow bullhead**	*Ameiurus natalis*
logperch	*Percina caprodes*	**yellow perch**	*Perca flavescens*
longnose sucker	*Catostomus catostomus*	**zander**	*Sander lucioperca*

9.0 RAPID GEOMORPHIC ASSESSMENT (RGA)

To evaluate channel-stability conditions and stage of channel evolution of a particular reach, an RGA was carried out at each site using the Channel-Stability Ranking Scheme. RGAs utilize diagnostic criteria of channel form to infer dominant channel processes and the magnitude of channel instabilities through a series of nine unique criteria. Granted, evaluations of this sort do not include an evaluation of watershed or upland conditions; however, stream channels act as conduits for energy, flow and materials as they move through the watershed and will reflect a balance or imbalance in the delivery of sediment. Given the large number of USGS gages in EPA Region 8, it was not feasible to perform detailed, time consuming field surveys at every site, RGAs provided an efficient alternative, enabling the rapid characterization of stability conditions. Four steps are completed on site:

1. Determine "reach". The reach" is described as the length of channel covering 6-20 channel widths, thus is scale dependent and covers at least two pool-riffle sequences.
2. Photograph the reach, for quality assurance and quality control purposes. Photographs are used with RGA forms to review the field evaluation.
3. Carry out RGA. Make observations of channel conditions and diagnostic criteria listed on the channel-stability ranking scheme (Figure 9.0. 2).
4. Sample bed material.

A. Channel-Stability Index

A scheme that assesses nine unique criteria was used to record observations of field conditions during RGAs (Figure 9.0. 2). Each criterion was ranked from zero to four and all values summed to provide an index of relative channel stability. The higher the number the greater the instability: sites with values greater than 20 exhibit considerable instability; stable sites generally rank 10 or less. Intermediate values denote reaches of moderate instability. However, rankings are not weighted, thus a site ranked 20 is not twice as unstable as a site ranked 10. The process of filling out the form enables the final decision of "Stage of Channel Evolution".

Characterizing Channel Geomorphology

1. Primary bed material	
Bedrock	The parent material that underlies all other material. In some cases this becomes exposed at the surface. Bedrock can be recognized by appearing as large slabs of rock, parts of which may be covered by other surficial material (Larger than a Microwave Oven to Rough or smooth surface bigger than a car).
Boulder/Cobble	All rocks greater than 64 mm median diameter (sizes range from Tennis ball to Microwave Oven).

Gravel	All particles with a median diameter between 64.0 – 2.00 mm (sizes range from Tennis ball to Ladybug size).
Sand	All Particles with a median diameter between 2.00 – 0.63 mm (sizes range from Ladybug to gritty size).
Silt Clay	All fine particles with a median diameter of less than 0.63 mm (Not gritty).

2. Bed/bank protection

Yes	Mark if the channel bed is artificially protected, such as with rip rap or concrete.
No	Mark if the channel bed is not artificially protected and is composed of natural material.
1. bank protected	Mark if <u>one</u> bank is artificially protected, such as with rip rap or concrete.
2. banks	Mark if <u>two</u> banks are artificially protected.

3. Degree of incision (Relative elevation of "normal" low water)

Calculated by measuring water depth at deepest point across channel, divided by bank height from bank top to bank base (where slope breaks to become channel bed).

- This ratio is given as a percentage and the appropriate category marked.

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

- Often only found where obstructions or artificial protection are present within the channel. Taking the reach length into consideration, channel width at the upstream and downstream parts of the reach are measured and the relative difference calculated.

5. Stream bank erosion (Each bank)

The dominant form of bank erosion is marked separately for each bank, left and right, facing in a downstream direction.

- If the reach is a meandering reach, the banks are viewed in terms of "Inside, Outside" as opposed to "Left, Right" (appropriate for questions 5-8). Inside bank, being the inner bank of the meander, if the stream bends to the left as you face downstream, this would be the left bank. Outside bank, being the outer bank, on your right as you face downstream in a stream meandering left.

None	No erosion
Fluvial	Fluvial processes, such as undercutting of the bank toe, cause erosion.
Mass Wasting	Mass movement of large amounts of material from the bank is the method of bank erosion. Often characterized by high, steep banks with shear bank faces. Debris at the bank toe

	appears to have fallen from higher up in the bank face. Includes, rotational slip failures and block failures.
6. Stream bank instability (Percent of each bank failing) • If the bank exhibits mass wasting, mark percentage of bank with failures over the length of the reach. If more than 50% failures are marked, the dominant process is mass wasting (see question 5).	
7. Established riparian woody-vegetative cover (Each bank) • Riparian woody-vegetative cover is the more permanent vegetation that grows on the stream banks, distinguished by woody stems; this includes trees and bushes but does not include grasses. Grasses grow and die annually with the summer and thus do not provide any form of bank protection during winter months while permanent vegetation does.	
8. Occurrence of bank accretion (Percent of each bank with fluvial deposition) • The percentage of the reach length with fluvial deposition of material (often sand, also includes fines and gravels) is marked.	
9. Stage of channel evolution • Stage of channel evolution are given by Simon and Hupp, 1986 (see diagram below). All of the above questions help lead to an answer to this question. Refer to previously determined criterion for guidance. See Table 9.0. 1 for guidelines of features often found with each stage of channel evolution.	
Total Score	Total up the responses to the 9 questions.

B. Stages of Channel Evolution

The channel evolution framework set out by Simon and Hupp (1986) is used by TMDL practitioners to assess the stability of a channel reach (Figure 9.0. 1 and Table 9.0. 1). With stages of channel evolution tied to discrete channel processes and not strictly to specific channel shapes, they have been successfully used to describe systematic channel-adjustment processes over time and space in diverse environments, subject to various disturbances such as stream response to: channelization in the Southeast US Coastal Plain (Simon, 1994); volcanic eruptions in the Cascade Mountains (Simon, 1999); and dams in Tuscany, Italy (Rinaldi and Simon, 1998). Because the stages of channel evolution represent shifts in dominant channel processes, they are systematically related to suspended-sediment and bed-material discharge (Simon, 1989b; Kuhnle and Simon, 2000), fish-community structure, rates of channel widening (Simon and Hupp, 1992), and the density and distribution of woody-riparian vegetation (Hupp, 1992).

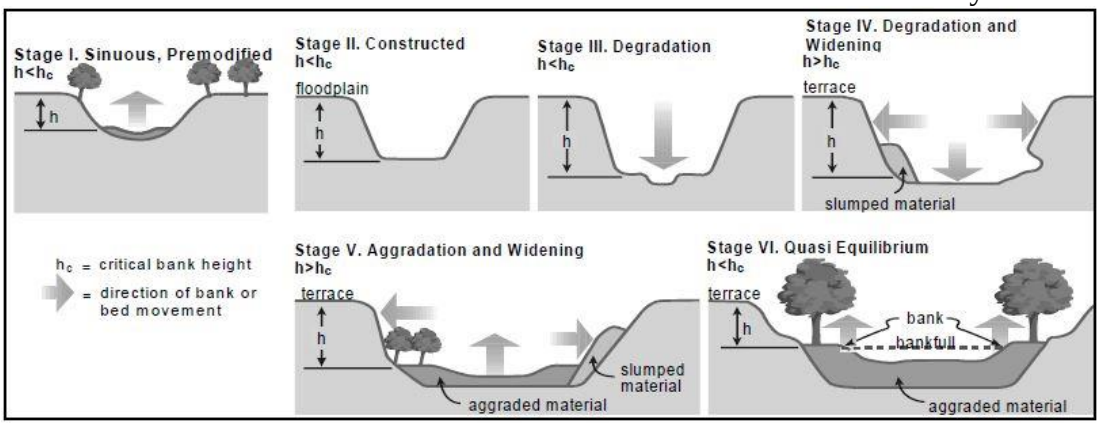


Figure 9.0. 1 Six stages of channel evolution from Simon and Hupp (1986) and Simon (1989) identifying Stages I and VI as 'reference' channel conditions.

An advantage of a process-based channel-evolution scheme for use in TMDL development is that Stages I and VI represent true "reference" conditions. In some cases, such as in the Midwestern United States where land clearing activities near the turn of the 20th Century caused massive changes in rainfall-runoff relations and land use, channels are unlikely to recover to Stage I, pre-modified conditions. Stage VI, a re-stabilized condition, is a much more likely target under present regional land use and altered hydrologic regimes (Simon and Rinaldi, 2000) and can be used as a "reference" condition. Stage VI streams can be characterized as a "channel-within-a-channel", where the previous floodplain surface is less frequently inundated and can be described as a terrace. This morphology is typical of recovering and re-stabilized stream systems following incision. In pristine areas, where disturbances have not occurred or where they are far less severe, Stage I conditions can be appropriate as a reference.

Table 9.0. 1 Summary of conditions to be expected at each stage of channel evolution.

Stage	Descriptive Summary
I	*Pre-modified* – Stable bank conditions, no mass wasting, small, low angle bank slopes. Established woody vegetation, convex upper bank, and concave lower bank.
II	*Constructed* – Artificial reshaping of existing banks. Vegetation often removed, banks steepened, heightened and made linear.
III	*Degradation* – Lowering of channel bed and consequent increase of bank heights. Incision without widening. Bank toe material removed causing an increase in bank angle.
IV	*Threshold* – Degradation and basal erosion. Incision and active channel widening. Mass wasting from banks and excessive undercutting. Leaning and fallen vegetation. Vertical face may be present.
V	*Aggradation* – Deposition of material on bed, often sand. Widening of channel through bank retreat; no incision. Concave bank profile. Filed material re-worked and deposited. May see floodplain terraces. Channel follows a meandering course.
VI	*Re-stabilization* – Reduction in bank heights, aggradation of the channel bed. Deposition on the upper bank therefore visibly buried vegetation. Convex shape. May see floodplain terraces.

Table 9.0. 2 SD DENR WPP Channel Stability ranking datasheet.

SD DENR CHANNEL-STABILITY RANKING SCHEME

Date:		**Crew:**		
Watershed:				
Station ID:		**Length Assessed:**	**Stream Width:**	
Structure type/ Dimensions:				
Reach Assessed from structu		(Above)	(Below)	(Both)
Pattern			**GPS Location (Lat/Long)**	
Meandering	Straight	Braided		

1. Primary Bed Material

Bedrock	Boulder/Cobble	Gravel	Sand	Silt/Clay	
0	1	2	3	4	

2. Bed/Bank Protection

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

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

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

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

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

5. Streambank erosion (Each Bank)

	None	Fluvial	Mass Wasting (failures)	
Left/ Inside	0	1	2	
Right/ Outside	0	1	2	

6. Streambank instability (Percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left/ Inside	0	0.5	1	1.5	2	
Right/ Outside	0	0.5	1	1.5	2	

7. Established riparian woody-vegetative cover (each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left/ Inside	2	1.5	1	0.5	0	
Right/ Outside	2	1.5	1	0.5	0	

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

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left/ Inside	2	1.5	1	0.5	0	
Right/ Outside	2	1.5	1	0.5	0	

9. Stage of channel evolution

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

TOTAL SCORE:

Station Notes:

10.0 PHYSICAL HABITAT CHARACTERIZATION

A. Introduction

Assessing the aquatic habitat provides information on the condition or availability of habitat within a reach of river/stream. In conjunction with water chemistry, stream flow gauging, fish and macroinvertebrate sampling, an overall picture of the condition or health of a river or stream can be discerned. The methods described in this protocol can provide comparable data regarding the physical, chemical, and biological health of a river/stream and help to understand the stream dynamics and relationship to the populations of fish and macroinvertebrates within a stream. The South Dakota Department of Environment and Natural Resources, Watershed Protection Program (SD DENR-WPP) uses a combination of habitat assessment protocol based on research conducted by US EPA and South Dakota State University (SDSU). The focus of that research was to determine if rivers within South Dakota exhibit longitudinal trends with regard to physical habitat and fish communities (Milewski 2001). A secondary goal was to determine which physical habitat variables have the most influence on the distribution fish and macroinvertebrate communities.

The physical habitat assessment methods used in the SDSU investigation were adapted from Simonson et al. (1994), Platts et al. (1983) and Frissell et al. (1986) (Milweski, 2001). The SDSU investigation using these methods focused on two major rivers within South Dakota. Data was collected from the Bad River in the Northwestern Great Plains ecoregion and the Big Sioux River in the Northern Glaciated Plains ecoregion. The habitat assessment protocols used by the SDSU study and described in this document were an effective assessment tool for quantifying the physical differences that exist along the longitudinal gradient of the rivers in South Dakota. River reaches were selected within one type of riparian land use in most cases, and where bridges and dams appeared to have minimal impact. This methodology is similar to other habitat assessment methods which uses transect data to assess a reach of stream or river, such as the Environmental Monitoring and Assessment Program (EMAP): Western Pilot Study, Rapid Bioassessment, National River and Streams Assessment Protocols, and the National Lakes Assessment.

Transect data collection is divided into three practical components based on tools used. The first suite of data is collected according to visual estimates and counts. On either end of a transect the riparian land use, dominant vegetation type, animal vegetation use, dominant bank substrate, and bank slumping (presence/absence) are recorded. Where a transect crossed the stream, dominant macrohabitat type is designated as pool, riffle, or run. Bed substrate data is collected using the modified Wolman “pebble count” by visually dividing the transect into eight “cells”. Within each cell, substrate size is measured and the class size recorded. This method, which objectively classifies substrates in clear streams, is a necessity in turbid streams where visual estimates are not possible.

A second suite of data focuses on stream bank and riparian features that are measured with a graduated pole (stadia rod) and angle finder (clinometer). After

identifying the break point between the channel bank and channel bottom, measurements related to stream bank length, bank angle, and bank height are taken (Figure 10.0.15). Along the stream bank length, the length of bank that was vegetated, eroded, and/or depositional was measured. The vegetated portion is the length of bank where root structure contributed to bank stability, eroded portions is that length with no root structure support, and a depositional portion is that length where recent deposition dominates the bank surface. Riparian-related cover types are measured at the end of each transect as the horizontal length of overhanging vegetation (OHV) and undercut bank (UCB) extending over the streambed.

A third suite of data focuses on horizontal and vertical point measurements which are used to calculate stream width, depth and velocity; channel bottom and top width; and bankfull width, depth, and width:depth ratio. At most sites, point data will be obtained by staking a tape measure left and right banks at the flood prone elevation. In some cases, the tape measure can be staked at left bankfull and right bankfull. Moving from left to right, key channel features (i.e., location codes) are identified and the distance from the left stake is recorded. Vertical measurements are bankfull depth, water depth, and water velocity. Bankfull depths are measured at water edge and at three points within the stream. Water depth and velocity are measured at the three points within the stream (1/4, 1/2, and 3/4 of the distance across the stream surface).

At each site, data are also collected on canopy cover, large woody debris (LWD), discharge, water surface slope, and water quality. The number of LWD is tallied for the entire reach according to methods designed by Robison and Beschta (1990). Length and diameter of all LWD are measured and can be used to calculate the volume of LWD within the reach. Discharge data is collected at a single transect or other stream cross-sections where flow is uniform. The velocity-area method described in the SD DENR WPP standard operation procedures manual (Volume I, SD DENR, 2016 and this manual) is used. Water surface slope (%) is calculated by dividing the drop in water surface from transect one (upstream transect) to transect 11 (downstream transect) by the longitudinal stream distance using a surveying level.

Physicochemical water quality data collected is water temperature, air temperature, turbidity, dissolved oxygen, and conductivity. These measurements are also made twice at each reach, once at the beginning of the assessment and a second time when all other physical habitat measurements have been collected, due to the length of time it takes to complete the assessment for one site. A standard chemical sample (nutrients, bacteria, and solids) can be collected during the habitat assessment. Standard operating protocols for this sampling are presented in the SD DENR-WPP SOP Volume I, Tributary Sampling Section 12.0 (SD DENR, 2016).

Most water quality sampling sites for the SD DENR WPP are usually at locations where permission is not needed to access the sites (within right-of-ways and easements). However, the reach selection for the habitat and physical assessment will be performed over a considerable distance (≈30 times the mean river/stream

width) so it may be necessary to gain permission from the land owners depending on the location of some sites within the sampling reach.

The flow chart on the following page shows the groups of parameters and how they should be collected in relation to one another, i.e. workflow (Figure 10.0. 1). The chemistry, hydrology, and biological data including chlorophyll *a* and periphyton communities will be integrated to determine, in relation to similar sites located in the same ecoregion, what cause and effect relationships may exist between the physical, chemical, and biological data.

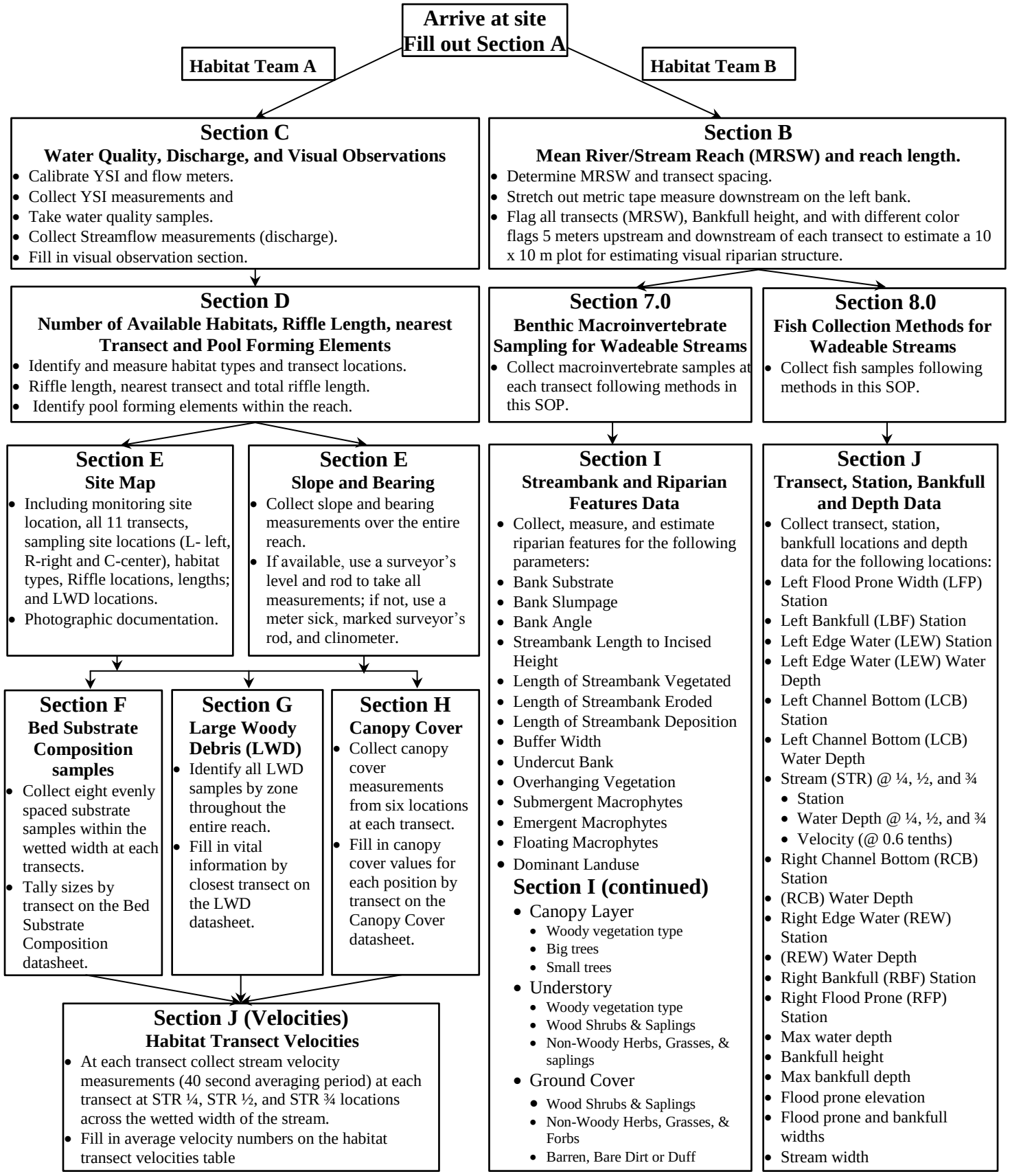


Figure 10.0. 1 Flowchart indicating the workflow for parameters collected using SD DENR WPP Habitat Assessment Protocols.

B. Data Collection Procedures

1. Reach Selection

Most water quality monitoring sites for the South Dakota Department of Environment and Natural Resources Watershed Protection Program (SD DENR WPP) are positioned at locations where permission is not needed to access the site (via right-of-way) and are outlined in the Project Implementation Plan (PIP). However, reaches should be selected either upstream or downstream of a bridge or culvert if one is present. The distance upstream or downstream of a channel modification should be long enough so that there is minimal influence on channel morphology and/or the riparian zone. Some general guidelines that should be considered when selecting the sampling reach are:

- Reaches should exhibit only one type of landuse outside of the riparian zone. A mix of CRP and heavily grazed land should be avoided.
- Minimal influence due to bridges, culverts or dams
- The entire reach should be inspected to determine any problems with site prior to sampling
- If at all possible, dams, bridge abutments, and other water control structures/obstructions should not be present within the stream length.
- Always Get Permission from the landowner(s) before accessing the reach.

2. On-Site Description Data Sheet - (Section A)

After selecting a suitable reach for the habitat assessment, On-Site Description Data Sheet (Section A) should be completed (Appendix G, Table G-1). This includes the following:

- Station ID
- Stream Name
- Project ID, i.e. nearest monitoring station for assessment
- Date
- Time
- GPS coordinates: UTM or DMS
- Sampler(s)

Section A

Station ID:			**Project ID:** _____		**Date:**
Stream Name:					**Time:**
GPS Coordinates					
UTM:	**Lat:**	**Long:**	**DMS**	**Lat:**	**Long:**
Samplers:					

3. SD DENR WPP Mean River/Stream Width (MRSW) - (Section B)

After a suitable sampling reach has been located, the MRSW (Mean River/Stream Width) needs to be calculated and used to determine transect spacing and reach length (Appendix G, Table G-2). Measure the wetted width of the stream in approximately five locations at various points along the tentative reach length. When low flows restrict stream width to a small portion of the streambed or the streambed is dry, the un-vegetated streambed width is used to calculate the MRSW. Fill in and complete the "Section B" datasheet to calculate MRSW, distance between transects and total reach length (see below).

Section B

SD DENR WPP Mean River/Stream Width (MRSW)							
	Width Number					**MRSW**	
	1	**2**	**3**	**4**	**5**	**Sum (1 through 5)**	**MRSW(Sum/5)***
Width (0.1m)							
Transect Spacing from Monitoring site (MRSW x 3)							
***If MRSW width is < 3.3 m, use 100 m as a minimum reach length. If MRSW is > 10m and watershed area is >500 km^2 then space transects 2 MRSW apart.**							
Total Reach Length: < 10m MRSW * 30 =			**> 10m and >500km^2 MRSW * 20 =**				

SD DENR WPP protocols for calculating MRSW, the distance between transects, and reach length are based on SDSU investigations (Milewski, 2001) and National Rivers and Stream Assessment protocols (US EPA, 2007) . Study reaches are based on 11 transects placed 3 MRSW's apart (Figure 10.0. 2). According to the SDSU investigation, in most cases, prairie streams within South Dakota >10 m (32.8 feet) wide can be homogenous (e.g., uniform in channel morphometry and depth), and transects spaced 2 MRSW's were judged to be adequate. However, data on the lower 4 reaches of the Big Sioux River indicated that transects spaced 2 MRSW were relatively homogenous in relation to channel morphometry and depth. Based on these results, watersheds greater than 500 km^2 (193.1 mi^2) and MRSW > 10 m (32.8 feet) will have transects spaced 2 MRSW's apart.

When calculating the MRSW the following should be taken into consideration:

- Mean river/stream widths should be determined at or near base flow conditions.
- When low flows restrict stream width to a small portion of the streambed, streambed width should be used to determine transect spacing.

- After progressing downstream for the associated reach and taking the necessary width measurements, calculate the average to determine the MRSW. Round the MRSW to the nearest 0.1m.

Transect Spacing

Transects are marked with flags, then data collection begins on the downstream stream end of the reach (transect "1") proceeding upstream. Left bank and right bank are determined as you look downstream.

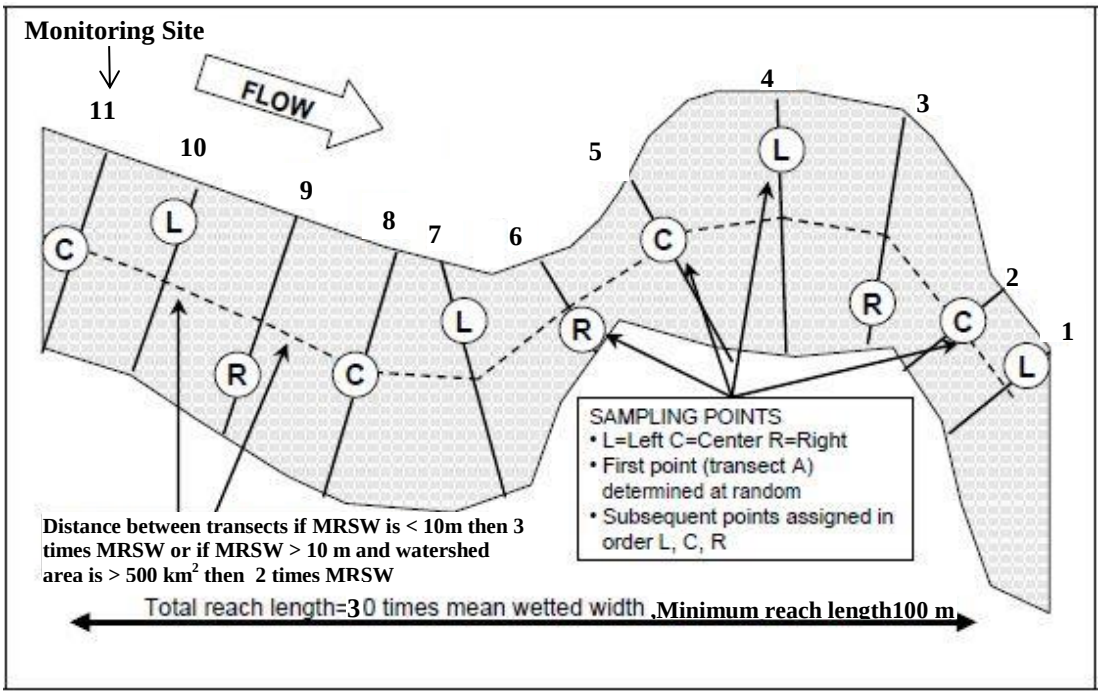


Figure 10.0. 2 Transect spacing and sampling site location example for wadeable rivers and streams (Adapted/Modified from US EPA, 2007).

a. If the MRSW is <10m, eleven transects will be spaced three (3) MRSW apart (Figure 10.0. 2).
b. According to Milewski (2001) most streams >10 m wide are homogenous in various habitat measurements, i.e. depth and channel morphometry.
c. On larger rivers and streams were MRSW is >10m, and since there is such a large distance between transects, the distance is dropped to 2 MRSW's between transects.
d. Eleven transects will be collected for each reach.
e. Transects are established every two to three times the MRSW depending on the MRSW and are perpendicular to stream flow, with the first transect (transect 1) located one-half MRSW upstream from the downstream end of the reach.
f. Distances between transects are measured from the bank and are perpendicular to the current/streambank.
g. Eleven transects are spaced evenly resulting in 30 mean river stream widths (MRSW's) for the entire reach length.

h. Flag transects on either side of the stream and locate the distance on the data sheet, On-Site Description Data Sheet (Section E map).

i. After flagging the locations and bankfull height of each transect, chemical sampling should be initiated at this time if required by the PIP (SD DENR WPP SOP Volume I Section.12.0 protocols). After chemical sampling is complete, macroinvertebrate and fish samples should be collected using methods outlined in SD DENR WPP SOP Volume II, Section 7.0 for macroinvertebrates and Section 8.0 for fish collection before anymore disturbance to the site (reach).

4. Water Chemistry - (Section C)

If chemical sampling is part of the overall sampling goal during the habitat assessment, this should occur during the preliminary stages of setup prior to any disturbance to the site. Samples should be collected below the most downstream transect of the sampling reach to minimize the impact from setting up the reach for transect data collection.

If a stream sample is to be collected, the method described in SD DENR WPP Volume I Section 12.0, Tributary Sampling Protocols, should be followed. The depth and velocity will dictate which sampling equipment will need to be used, i.e. integrated sediment sampler (isokinetic) vs. grab sampling method. The water quality sample should be collected at the same location as the discharge measurement. The water quality portion of Section C of the datasheet should be collected and filled out once daily, usually morning (Appendix G, Table G-3).

Section C

Water Quality								
Reading	**Time (2400)**	**Water Temperature (°C)**	**Air Temperature (°C)**	**pH (s.u.)**	**Dissolved Oxygen (mg/L)**	**Specific Conductance (µS/cm)**	**Discharge (from Section C discharge datasheet) Table 10.0. 1 (cfs)**	**Stage or Max Depth (ft)**
Morning								

Visual Observations			
Weather Conditions:	**Current**	**Past 24 hrs**	**Field Comments:**
Clear/sunny	☐	☐	
Partly cloudy	☐	☐	
Intermittent showers	☐	☐	
Steady rain	☐	☐	
Heavy rain	☐	☐	

Stream Discharge

Stream discharge should also be collected at this time one MRSW downstream of transect 1(the most downstream transect). It is important to choose a channel cross section that is as much like a canal as possible. A glide area with a "U" shaped channel cross section that is free of

obstructions provides the best conditions for measuring discharge by the velocity-area method (see Figure 10.0. 3 and Figure 10.0.4). In the method, the discharge is collected at 0.6 depth or 0.2/0.8 depth of the channel depending on the total depth of the channel at each measurement location (consistent with USGS and SD DENR WPP- Volume I SOP protocols).

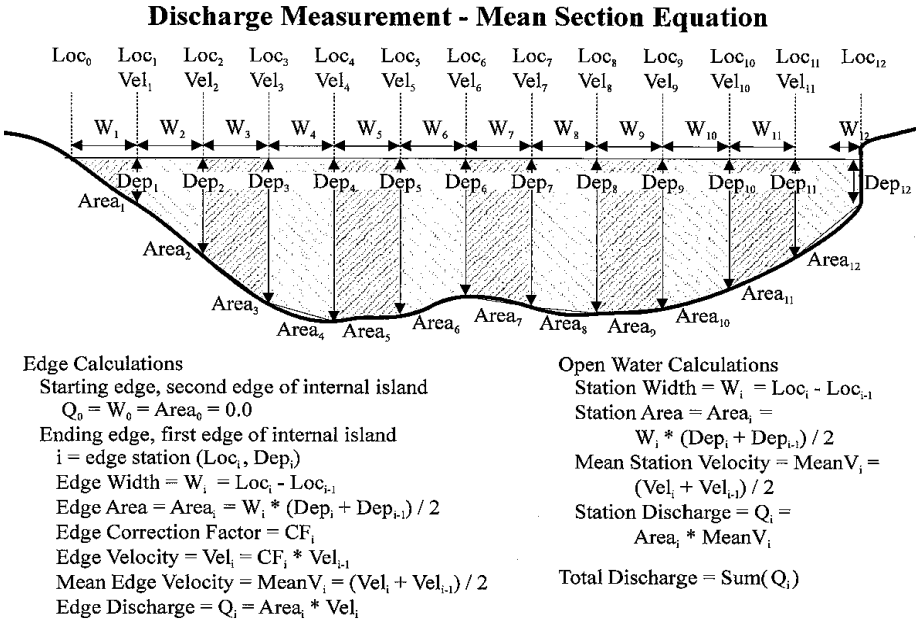


Figure 10.0. 3 Discharge Measurement "Mean Section" Method (2009).

a. Rocks and other obstructions should be removed from the cross-section prior to any measurement. The procedure for discharge measurements (depth and velocity measurements) is outlined in SD DENR WPP SOP Method in Volume I (SD DENR WPP-SOP). When discharge is calculated enter the stage or maximum transect depth if no staff gauge is available and calculated discharge values in Section C table (Appendix G, Table G-3).

b. SD DENR WPP Protocols state that in channels too small for the velocity-area method, discharge can sometimes be determined directly by measuring the time it takes to fill a container of known volume. 'Small' is defined as a channel so shallow that the current velocity probe (or pygmy meter) cannot be placed in the water, or where the channel is irregular due to rocks and debris, and suitable cross-section for using the velocity area procedure is not available. If obtaining data by this procedure will result in substantial channel disturbance, wait until all other activities (biological and chemical) have been completed (Peck et al., 2001).

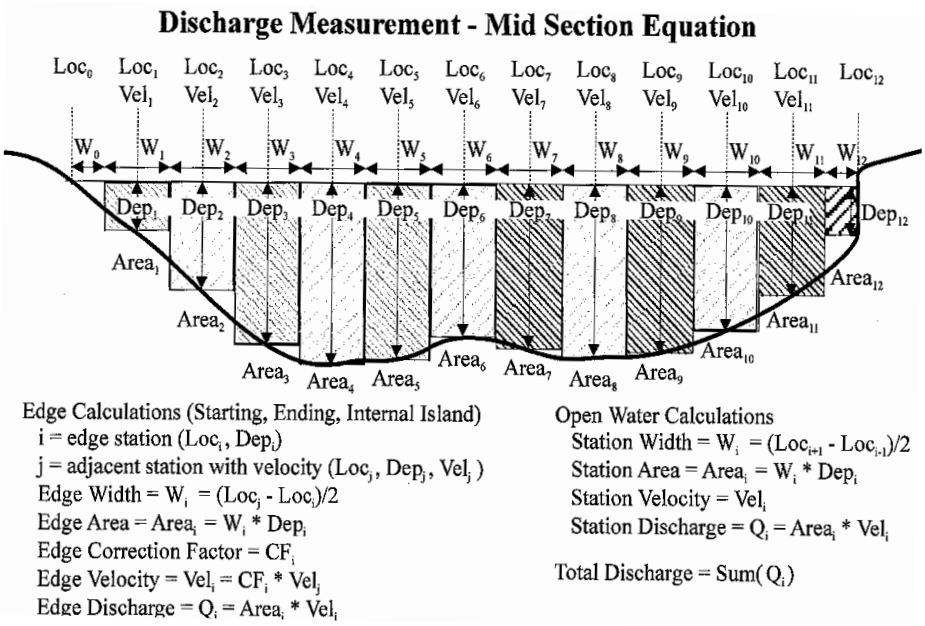


Figure 10.0. 4 Discharge Measurement "Mid-Section" Method (2009).

c. A datasheet for collection of the Section C discharge data is available below (Table 10.0. 1) and is part of the onsite data that needs to be collected only once. The full set of habitat datasheets is included in Appendix G (including an additional discharge datasheet Appendix G, Table G-12) of this document.

Table 10.0. 1 Section C: SD WPP Discharge Datasheet **(for Marsh-McBirney and/or Flowtracker flowmeters)**
(Record units under the heading for each column)

Site:_____ **Page ____ of ____**

Date:_____ Time:_____ Sampler(s):_____

Meter:_____, Stage Before:_____, Stage After:_____

If meter is Marsh-McBirney Flo-mate Model 2000 was Zero Adjust Test performed at lab or site: Y / N ?
If meter is FlowTracker was Automatic QC Test Run at site: Y / N ?
If Yes, did it pass Y / N, If No do not use meter. Comments _____

Row	Tape	Location	Width	Depth	Area (W*D)	Mean in Vertical	Discharge (W*D*MV)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
Total Discharge							

Number of Stations _____ **Measure discharge 1 MRSW downstream of transect 1**

Water **circle one**
Width _____(ft), Area _____ (ft^2), Temperature _____ (°F or °C), Method _____. Uncertainty _____ (%),

Mean Velocity _____ (ft/s), Max Velocity _____ (ft/s), Average Depth _____ (ft), Max Depth _____ (ft).

5. Habitat Classification - (Section D)

Once the MRSW has been determined and the transects have been located along the reach, one crew should be sampling macroinvertebrates (Section 7.0) and fish (Section 8.0) the second field crew should be determining the number of different habitat types found within the reach. As you start a new segment, estimate the number of habitats by documenting them in Section D of the on-site description datasheet (Appendix G, Table G-4) and locate them on the map in Section E (Site Map, Slope Measurement, and Photo Documentation Datasheet, Appendix G, Table G-5). Locate the riffles to the nearest transect and number. Also locate the riffles by transect and estimate their length within the entire stream reach.

Section D

Habitats Available number of each (also place on site map, Section E)	**Pool_____ Run/Glide_____ Riffle_____ Other (describe) _____.(Table 10.0. 2)** **Lengths of Riffle(s):_____, _____, _____, _____, _____, _____.(meters)** **Nearest Transect #:_____, _____, _____, _____, _____, _____, _____.** **Total Length (riffles) =_____(meters)** **Pool Forming Elements = _____, _____, _____. (Table 10.0. 2)**

a. After measuring the reach quickly estimate the number of general habitats found within the reach. This includes pools, run/glides, riffles, and others. For each riffle or other unique habitat types, estimate the length using the tape measure that was used to measure the reach length and layout transects (left bank) and locate it to the nearest transect number (Appendix G, Table G-4). Use definitions found in Table 10.0. 2.

- This is done for the entire reach. When you draw out your map of the reach area, you should describe the habitat between transects and document any riffles (thus, you should come up with a continuous map of the reach). Within the reach you measure every riffle and document where pools and runs are. Then count up the number of riffles and/or pools and/or run/glides. Record the total length of all riffles in the reach in Section D.

b. Identify the habitat type on the map to the nearest upstream or downstream transect (Table 10.0. 2). Before being considered large enough to be identified as a channel-unit scale habitat feature, the unit should be at least as long as the channel is wide. For instance, if there is a small, deep (pool-lie) area at the thalweg within a large riffle area, don't record it as a pool unless it occupies an area about as wide or long as the channel is wide. These channel unit habitat classifications and pool-forming elements are modified from those of Bisson et al. (1982) and Frissell et al. (1986). The channel habitat types in Table 10.0. 2 were developed specifically for salmonid streams.

Table 10.0. 2 Channel Unit Habitat Classes and Pool Forming element categories.

Channel Unit Habitat Classes [a]	
Class (Code)	**Description**
Pools:	Still water, low velocity, smooth, glassy surface, usually deep compared to other parts of the channel:
Plunge Pool (PP)	Pool at base of plunging cascade or falls.
Trench Pool (PT)	Pool-like trench in the center of the stream.
Lateral Scour Pool (PL)	Pool scoured along a bank.
Backwater Pool (PB)	Pool separated from main flow off the side of the channel.
Impoundment Pool (PD)	Pool formed by impoundment above dam or constriction.
Pool (P)	Pool (unspecified type).
Glide (GL)	Water moving slowly, with a smooth, unbroken surface. Low turbulence.
Riffle (RI)	Water moving, with small ripples, waves and eddies -- waves not breaking, surface tension not broken. Sound: "babbling", "gurgling".
Rapid (RA)	Water movement rapid and turbulent, surface with intermittent whitewater with breaking waves. Sound: continuous rushing, but not as loud as cascade.
Cascade (CA)	Water movement rapid and very turbulent over steep channel bottom. Most of the water surface is broken in short, irregular plunges, mostly whitewater. Sound: roaring.
Falls (FA)	Free falling water over a vertical or near vertical drop into plunge, water turbulent and white over high falls. Sound: from splash to roar.
Dry Channel (DR)	No water in the channel
[a]=Note that in order for a channel habitat unit to be distinguished, it must be at least as wide or long as the channel is wide.	
Categories of Pool-forming Elements (Taken from Peck, et.al, 2001)[b]	
Code	**Category**
N	Not Applicable, Habitat Unit is not a pool
W	Large Woody Debris
R	Rootwad
B	Boulder or Bedrock
F	Unknown cause (unseen fluvial processes)
WR, RW, RBW	Combinations
OT	Other (describe in the comments section of field form)
[b]=Remember that most pools are formed at high flows, so you may need to look at features, such as large woody debris, that are dry at baseflow, but still within the bankfull channel.	

Classify the appropriate habitat type and determine its length and position (nearest transect) within the entire sampling reach.

6. Site Map, Slope Measurements, and Photo Documentation Datasheet (Section E)

After each transect has been flagged, the water quality, discharge data, macroinvertebrate and fish samples have been collected, the water surface slope can be determined. This measurement can also wait until all other data has been collected. Water surface slope (%) is calculated by dividing the drop in water surface from transect eleven (11) to transect one (1) by the longitudinal stream distance using a surveying level. To determine slope on tributaries you can use the level instrument. For larger rivers, i.e. Belle Fourche, Cheyenne, Bad, James, and the Big Sioux, slope can easily be collected from the topography maps. Tributaries are defined as having a drainage area of less than 500 km^2. Anything greater than 500 km^2 is considered a large river (Milewski 2002). This is primarily done to save time as collecting water surface slope measurements for a reach on a large river can take a considerable amount of time.

Section E. SD DENR WPP Wadeable Physical Habitat Slope and Bearing Datasheet

Project Name:_____ **Stream Name:**_____ **Site ID:**_____ **Date:**_____ **Time:**_____

	Main				**First Supplemental**		**Second Supplemental**	
Transect	**Slope (%) or Elev. Difference. (cm)** (mark units for every transects)		**Bearing 0°- 359°**	**Proportion %**	**Bearing 0°- 359°**	**Proportion %**	**Bearing 0°- 359°**	**Proportion %**
1 < 2	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
2 < 3	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
3 < 4	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
4 < 5	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
5 < 6	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
6 < 7	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
7 < 8	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
8 < 9	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
9 < 10	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
10 < 11	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____
Total Slope	_____ ☐ %	_____ ☐ cm	_____	_____	_____	_____	_____	_____

Notes and Calculations:

Figure 10.0. 5 SD DENR WPP Slope and Bearing Datasheet (modified/adapted US EPA, 2012)

a. Site map, slope measurements, and photo documentation datasheets should be collected in the field for each site. The water surface slope should be collected in the field for tributaries that have a drainage area of less than 500 km^2 (123,553 acres) or 193.1 mi^2.

b. If the drainage area is greater than 500 km^2 then the slope should be taken from the topography maps and documented on the slope

and bearing datasheet. If the drainage area is less than 500 km^2 then the slope should be derived in the field using the following procedure and datasheet (Appendix G, Table G-5) in Section E of the datasheet section.

Surveyor's Level (Instrument Setup)

c. Extend the tripod legs to approximately eye level and set the legs firmly into the ground; adjust the legs so that they form a regular triangle and are firmly set with no wobble. Adjust the legs so that the base plate is approximately level.

d. Hold the instrument on the tripod and start the centering screw. Ensure the adjustable feet are roughly evenly adjusted. While the centering screw is still loose slide the instrument on the base plate until the bubble is approximately centered in the circular level. Tighten the centering screw.

e. Adjust the leveling foot screws until the bubble is exactly level in the center circle.

f. Self-Leveling instruments can now be swiveled gently on the base plate and maintain level as long as the tripod remains steady

g. Adjust focus, brightness and parallax according to manufactures specifications.

h. The instrument is ready to make measurements.

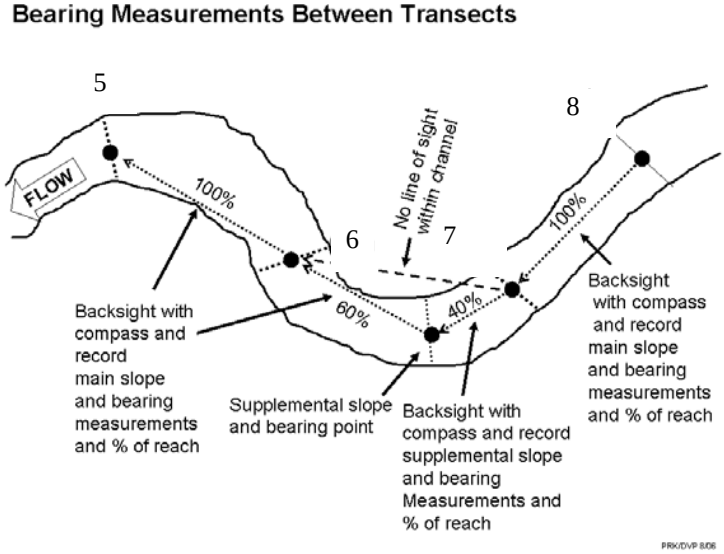


Figure 10.0. 6 Channel Slope and Bearing diagram (US EPA, 2009)

Procedure for obtaining slope and bearing data

a. Determine a location at transect 11 to hold a surveyor's rod that will be visible from a point between transect 10 and transect 11.

b. Set up the instrument at a point approximately halfway between points 10 and 11 and where a clear line of sight is possible.

c. Position the staff at point 11, holding the bottom of the staff at the water level and the staff as vertical as possible and the numbers facing the instrument.
d. Site the staff and record the reading to the nearest centimeter.
e. Move the staff to point 10 and gently swivel the instrument to face the next reading. Hold the staff as before, vertically, with the bottom at the water level and the numbers facing the instrument.
f. Site the staff and record the reading to the nearest centimeter.
g. Repeat measurements between each transect.
h. The difference in the readings is the height difference or gradient.
i. Note: In small streams with a clear line of site it may be possible to set the instrument up once and make readings to several transects from a single set up. Simply record the readings for each transect and do not skip transects.
   - If you are back-sighting from a supplemental point, record the bearing in the appropriate SUPPLEMENTAL section of the Slope and Bearing datasheet (Appendix G, Table G-5).
j. Proceed to the next cross-section transect (or supplementary point), and repeat Steps a - g above.

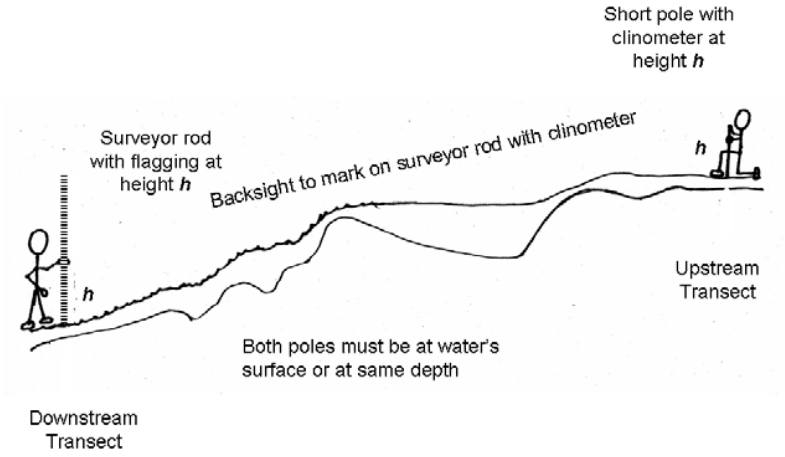


Figure 10.0. 7 Modified procedure for measuring slope (US EPA, 2009)

Modified procedure for obtaining slope and bearing data

a. Stand in the center of the channel at the upstream cross-section transect. Determine if you can see the center of the channel at the next cross-section transect downstream without sighting across land (i.e., do not "short-circuit" a meander bend). If not, you will have to take supplementary slope and bearing measurements.
b. Mark a surveyor's rod and a calibrated rod (or meter ruler) at the same height. If a shorter pole or ruler is used, measure the height

from the ground to the opening of the clinometer when it is resting on top.

c. Have one person take the marked surveyor's rod to the downstream transect. Hold the rod vertical with the bottom at the same level as the water surface. If no suitable location is available at the stream margin, position the rod in the water and note the depth.

d. If you have determined in Step "a" that supplemental measurements are required for this segment, walk downstream to the furthest point where you can stand in the center of the channel and still see the center of the channel at the upstream cross-section transect. Remember that your line of sight cannot "cross land." Mark this location with a different color flagging than that marking the cross-section transects.

e. Place the base of the calibrated rod at the level as the surveyor's rod (either at the water surface or at the same depth in the water).

f. Place the clinometer on the calibrated rod at the height determined in Step b. With the clinometer, sight back downstream to the flagged height on the surveyor's rod at the downstream transect (or at the supplementary point).

- If you are sighting to the next downstream transect, read and record the percent slope in the MAIN section on the Slope and Bearing datasheet for the downstream transect (e.g., 10 < 11), which is at the bottom of the form (i.e., you are completing the form in reverse order). Record the PROPORTION as 100%.
- If you are back-sighting from a supplemental point, record the slope (%) and proportion (%) of the stream segment that is included in the measurement in the appropriate SUPPLEMENTAL section of the Slope and Bearing datasheet. The last sighting to a downstream transect (from either the upstream transect or the nearest upstream supplemental point) is always recorded as the MAIN reading.

g. Stand in the middle of the channel at the upstream transect (or at a supplemental point), and sight with your compass to the middle of the channel at the downstream transect (or at a supplemental point). Record the bearing (degrees) in the same section on the Slope and Bearing datasheet (Supplemental or Main) as you recorded the slope in Step "f" (Appendix G, Table G-5).

h. Proceed to the next cross-section transect (or to a supplementary point), and repeat Steps c through g above.

i. Use this procedure if you are starting at the upstream transect (11), after completing cross-section measurements at transects "1" through "11".

Site Map

a. Using the Section E Site Map worksheet (Appendix G, Table G-6 and Figure 10.0. 8), draw a map of the site with monitoring site location, locations of all "11" transects upstream (Transect 11) through the most downstream (Transect 1) and sampling site locations (L – left, R – right and C – center). Habitat types as described in Table 10.0. 2 should be included on the map to include riffle locations and lengths, large woody debris locations (Appendix G, Table G-8, Section G), along with pools and pool forming elements. General landuse and riparian features to include streams and dry draws entering the reach should be indicated on the site map (Appendix G, Table G-6).

Photographic Documentation

a. Include locations of photographic points on the Section E-Site Map, direction of photograph, and frame number for reference. Upstream and downstream photographs need to be taken with some identifying landscape features, i.e. large trees or farmstead. A sign showing the following should also be located somewhere in the frame of the photograph (see below). Include locations of photographic points, direction of photograph, and frame number.

- Stream Name
- Site
- Date
- Transect Number
- Looking Upstream or Downstream

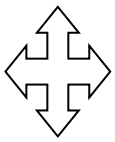
This information should be written in the Project/Field Notebook and signed off by lead personnel at the end of the each work day!

Section E. Site Map

Draw a map of the site with monitoring site locations, locations of all 11 transects upstream (Transect 11) through the most downstream (Transect 1) and sampling site locations (L – left, R – right and C – center). Include locations of photographic points, direction of photograph, and frame number. Include habitat types, riffle locations, and pools.

	Width Number					Mean River/Stream Width (MRSW)*	
	1	**2**	**3**	**4**	**5**	**Sum (1 through 5)**	**MRSW (Sum/5)***
Width (0.1m)							
Transect Spacing from monitoring site (MRSW x 3)					(m)	**Total Reach Length (MRSW x 30)**	(m)

***=**If MRSW width is <3.3 m, use 10 m transect spacing and 100 m as a **minimum** reach length. If MRSW is > 10 m and watershed > 500 km^2 transect spacing is MRSW x 2



Approximate Distance

Figure 10.0. 8 SD DENR WPP Site map, slope measurements, and photo documentation sheet

7. Bed Substrate Composition – (Section F)

Bed substrate data is collected using the modified Wolman "pebble count" by visually dividing a transect into eight "cells" (Figure 10.0. 9). Within each cell, substrate size is measured and the class size recorded. A pole is placed randomly within the cell and the substrate first touched is sized according to the classes listed on the datasheet in Section F (Appendix G, Table G-7 or Table 10.0. 3). This method objectively classifies substrate in clear streams and is essential in turbid streams where visual estimates are not possible.

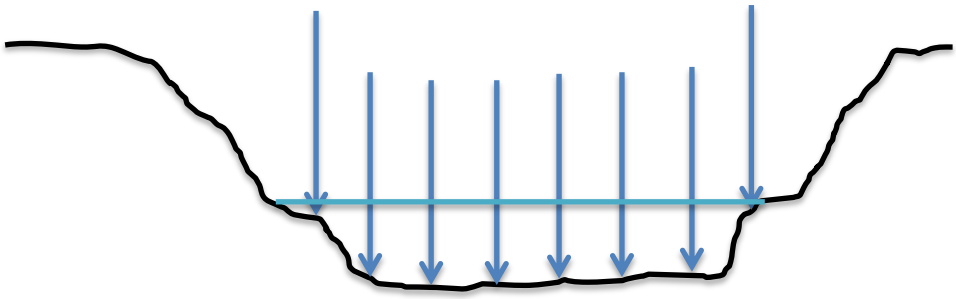
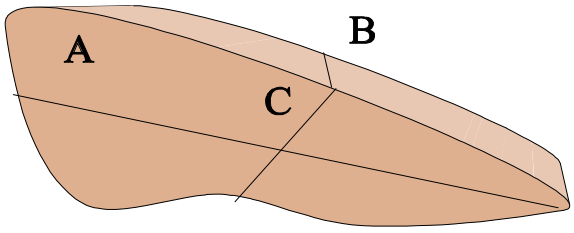


Figure 10.0. 9 Modified estimated substrate locations (Milewski, 2001)

a. Within each transect, a total of eight particles are measured, spanning the stream channel wetted width (see Figure 10.0.19) for the definition of bankfull). Particles are measured with calipers along the intermediate axis as illustrated in Figure 10.0.10. A hash mark is made on the datasheet in the appropriate transect column and in the appropriate size class (Table 10.0. 3). A total of 88 particles (11 transects x 8 particles/transect) are counted throughout the Reach Of Interest (ROI).

b. Particles are selected at equally spaced intervals along the transect. Thus, if the transect is 8 m wide, then a particle is selected for analysis at approximately one meter intervals. This can be estimated by eye or a tape can be drawn across the channel to guide particle selection.



A = Long Axis
B = Short Axis
C = Intermediate Axis

Figure 10.0. 10 Location of Axis for determining substrate size.

c. When selecting a particle, the operator does not look down, in order to avoid bias. Looking straight ahead, reach down with the index finger extended. Pick up the first particle encountered by that leading finger and measure as described in step "a".

d. The total number of particles counted is checked in the field. A total of 88 particles must be counted for the entire reach.

e. When all transects have been sampled at the site, sum up the substrate at each transect (organic and inorganic, should total 8) and write total in the Total Count row for each transect (Table 10.0. 3). For each transect, sum the organic matter (Muck-Mud (FPOM) and detritus (CPOM)) identified in the transect, if any, and divide by 8 (total particles possible per transect) x 100 and write in the percentage in the organic percentage box for that particular transect. Continue this procedure for all 11 transects.

f. Then sum the total substrate counts for each row (numbers will vary) and write each count under the respective Total column. Sum the Total column and write the total in the Total Count box (Total Count row and Total column should both total 88).

g. Sum the total of the organic matter rows (shaded) and write it in the ∑ type column in the margin, then subtract that number from the total count (88) to get the total count of inorganic matter particles sampled in the reach, and write it in the ∑ type column in the margin. Divide the organic total (shaded box) from the total sampled (88) to get overall organic matter percentage for the ROI.

Table 10.0. 3 Section F **SD DENR WPP Bed Substrate Composition**

Project Site ID: _____ Stream Name: _____Sampler(s): _____ Date: _____ Time: _____

Organic and Inorganic Substrates															
	Description		Tally by Transect												
Substrate Type	Diameter (mm)	Description	downstream 1	2	3	4	5	6	7	8	9	10	upstream 11	Total	∑ Type
Muck-Mud	FPOM	black, very fine particulate organic matter													
Detritus	CPOM	sticks, wood, plant material, coarse particulate organic matter													
Clay (slick)	<0.004	Not Gritty													
Silt	0.004-0.062	Not Gritty													
Sand (gritty)	0.062-2	Gritty up to Ladybug size													
Very Fine Gravel	>2-4	Ladybug													
Fine Gravel	>4-8	Pencil Eraser													
Medium Gravel	>8-16	Marble													
Coarse Gravel	>16-32	Marble to Watch Face													
Very Coarse Gravel	>32-64	Watch Face to Tennis Ball													
Cobble	>64-128	Tennis Ball to Height of a Soda Can													
Large Cobble	>128-250	Height of a Soda Can to Basketball													
Small Boulder	>250-1000	Basketball to Width of a Microwave Oven													
Large Boulder	>1000-4000	Larger than a Microwave Oven													
Bedrock	>4000	Rough or smooth surface bigger than a car													
Total Count	#	#													
Organic Percentage	%	%													

SHADED = Organic matter

8. Large Woody Debris Tally – (Section G)

Methods for Large Woody Debris (LWD) measurement were adapted from Robison and Beschta (1990). Both the EMAP Physical Habitat Characterization and methods used by Milewski (2001) allow quantitative estimates of the number, size, total volume and distribution of wood within the stream reach. LWD is defined as woody material with a small end diameter of at least 10cm (4 in.) and a length of at least 1.5 m (5 ft.) (Peck et al., 2001).

The procedure for tallying LWD is presented in the following bulleted section. The tally includes all pieces of LWD that are at least partially in the baseflow channel, the "active channel" (flood channel up to bankfull stage), or spanning above the active channel (Figure 10.0. 11). The active (or "bankfull") channel is defined as the channel that is filled by moderate-sized flood events that typically recur every one to two years. LWD in the active channel is tallied over the entire length of the reach, including the area between the channel cross-section transects. Pieces of LWD that are not at least partially within Zones 1, 2, or 3 are not tallied.

For each LWD piece, first visually estimate its length and its large and small end diameters in order to place it in one of the diameter and length categories (see below). The diameter class on the datasheet (Table 10.0. 4) refers to the large end diameter. Sometimes LWD is not cylindrical, so it has no clear "diameter". In these cases visually estimate what the diameter would be for a piece of wood with a circular cross section that would have the same volume. When evaluating length, include only the part of the LWD piece that has a diameter greater than 10 cm (4 in). Count each of the LWD pieces as one tally entry and include the whole piece when assessing dimensions, even if part of it is in Zone 4 (outside of the bankfull channel) (Figure 10.0. 11). For both the Zone 1-2 wood and the Zone 3 LWD, the field form (Appendix G, Table G-8, Section G) asks for transect spacing (Transects 1-2, 2-3, etc.), log jam number (if present), meander location, habitat association, angle (Table 10.0. 4), and the length and diameter of the LWD by using the 12 different categories for tallying debris pieces visually estimated within three length and four diameter class combinations. Each LWD piece is tallied in only one box. There are 12 size classes for wood at least partially in Zones 1 and 2, and 12 for wood partially within Zone 3. Wood that is not at least partially within those zones is not tallied.

a. Procedure for Large Woody Debris Tally

Note: Tally pieces of large woody debris (LWD) within each segment of stream as you complete the densiometer and substrate measurements. Include all pieces whose large end is located within the segment in the tally. When filling out the LWD form (Table 10.0.4, Appendix G, Table G-8, Section G) use Figures

10.0. 11 and 10.0.12 to determine the zone or location and the orientation of LWD relative to the stream flow.

b. Scan the stream segment (transect spacing) between the two cross-section transects as you move between transects.

ii. Tally all log jams within the segment. If one is present go through steps iii through viii for each piece of LWD within the log jam.

iii. Tally all LWD pieces within the segment that are at least partially within the bankfull channel (Zone 2). Determine if a piece is LWD (small end diameter ≥10 cm [4 in.]; length ≥1.5 m [5 ft.])

iv. Determine the Zone the LWD occupies (Zone 1, 2 or 3) (Figure 10.0. 11).

v. Determine the meander location of the LWD: IM=inside meander, OM=outside meander, CO=crossover, SS=straight section.

vi. Identify the dominant habitat type for the LWD (pool, riffle, or run).

vii. The angle of the LWD relative to the stream flow should be determined using Figure 10.0. 12 (based on the diameter of the large end). If the large end is facing upstream the angle should be documented as $0^{o,}$ whereas, if it were facing downstream, the angle would be 180^{o}. If the LWD is perpendicular to the flow regardless of which bank (left or right) the large end is facing the angle would be 90°

viii. For each piece of LWD, determine the class based on the diameter of the large end (0.1m to < 0.3 m, 0.3 m to <0.6 m, 0.6 m to <0.8 m, or >0.8 m, and the class based on the length of the piece (1.5m to <5.0m, 5m to <15m, or >15m). Use one of the 12 class designations identified at the bottom of the datasheet (Table 10.0. 4 and Appendix G, Table G-8, Section G).

- If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with a circular cross section that would have the same volume.
- When estimating length, include only the part of the LWD piece that has a diameter greater than 10 cm (4 in.).

ix. Repeat steps i through viii for the next stream segment, using the same form. Add additional LWD forms as necessary and number them consecutively and identify the site location and date.

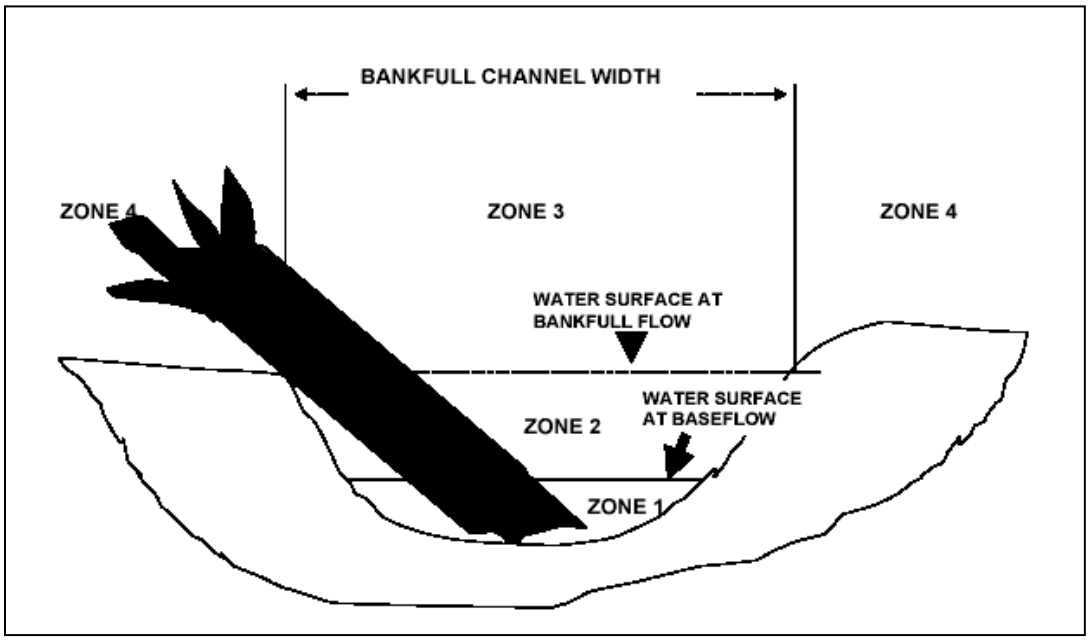


Figure 10.0. 11 Large woody debris influence zones from Peck et al., 2001 (Modified from Robison and Beschta, 1990).

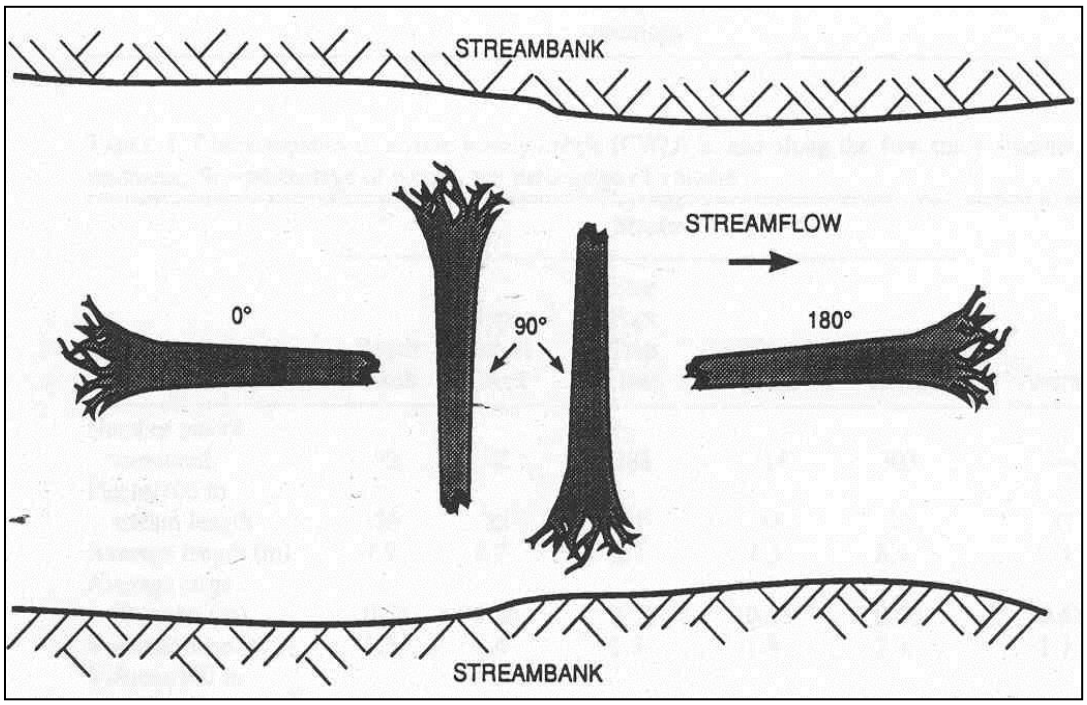


Figure 10.0. 12 Horizontal Orientation for Large Woody Debris from Robison and Beschta (1990).

Table 10.0. 4 Section G Large Woody Debris Datasheet

Project Site ID: _____ Stream Name: _____

Sampler(s): _____ Date: _____ Time: _____ Page: ____of____

Transect Spacing	Log Jam Number	LWD Number	Zone	Meander Location	Habitat Association	Angle	Length	Diameter

Zone:
- **Zone 1 is water surface at base flow,**
- **Zone 2 is between base flow surface and bankfull flow surface,**
- **Zone 3 is bankfull channel width above bankfull flow surface.**

Meander Location:
- **IM=inside meander,**
- **OM=outside meander,**
- **CO=cross over,**
- **SS=straight section**

Habitat Association:
- **PL=pool,**
- **RF=riffle,**
- **RN=run**

LARGE WOODY DEBRIS CATEGORIES (≥10 cm small end diameter; ≥1.5 m length)				
Categories	**1**	**2**	**3**	**4**
Diameter Large End	0.1-<0.3m	0.3-0.6m	0.6-0.8m	>0.8m
Length	>1.5-5m	5-15m	>15m	-

9. Canopy Cover - (Section H)

Riparian canopy cover over a stream is important not only in its role in moderating stream temperatures through shading, but also as an indicator of conditions that control bank stability and the potential for inputs of coarse and fine particulate organic matter. Organic inputs from riparian vegetation become food for stream organisms and structure to create and maintain complex channel habitat.

Canopy cover over the stream is determined at each of the 11 cross-section transects. A Convex Spherical Densiometer (model B) is used (Lemmon, 1957). The densiometer must be taped exactly as shown in Figure 10.0. 14. This limits the number of square grid intersections to 17. Densiometer readings can range from 0 (no canopy cover) to 17 (maximum canopy cover). Six measurements are obtained at each cross-section transect (four measurements in four directions at mid-channel and one facing each bank). The mid-channel measurements are used to estimate canopy cover over the channel. The two bank measurements complement your visual estimates of vegetation structure and cover within the riparian zone itself, and are particularly important in wide streams, where riparian canopy may not be detected by the densiometer when standing midstream.

The procedure for obtaining canopy cover data is presented below. Densiometer measurements are taken at 0.3 m (1 ft) above the water surface, rather than at waist level, to (1) avoid errors because people differ in height; (2) avoid errors from standing in water of varying depths; and (3) include low overhanging vegetation more consistently in the estimates of cover. Hold the densiometer level (using the bubble level) 0.3 m above the water surface with your face reflected just below the apex of the taped "V", as shown in Figure 10.0. 14. Concentrate on the 17 points of grid intersection on the densiometer that lie within the taped "V". If the reflection of a tree or high branch or leaf overlies any of the intersection points, that particular intersection is counted as having cover. For each of the six measurement points, record the number of intersection points (maximum=17) that have vegetation covering them on the "Stream Shade and Canopy Cover Datasheet" section of the form as shown in (Table 10.0. 5 and Appendix G, Table G-9, Section H).

This method measures canopy cover at 11 evenly spaced transects over a length of stream 30 times the MRSW Mean River Stream Width with a 100-meter minimum reach length. Six canopy measurements are taken at each transect. Four measurements are taken facing different directions from the center of the stream and one facing each stream bank (both left and right), 1-foot away from edge of water and 1-foot above the water surface (see Figure 10.0. 13). It is important to consider the seasonal flow and riparian vegetation conditions when measuring cover using this method since stream widths and deciduous vegetation cover measurements will differ seasonally. Ideally, measurements would be taken during seasonal low flow periods

each time to minimize the effects of varying wetted widths. Low flow conditions are usually a time of critical temperature stress to aquatic organisms and stream shade is important. Also, measurements should be taken during a time of year when deciduous plants have leaves. Usually canopy measurements will not vary during the low flow season unless the canopy is predominantly rapidly growing vegetation (grasses). The densiometer reflects vegetation to the sides as well as overhead. Multiple measurements taken in different directions from the same point will overlap vegetation measurements on the sides. The method described here is a modification of the instructions that come with the densiometer that corrects for this bias by using only a portion of the mirror surface.

Equipment

- Convex spherical densiometer (Model A)
- Tape the densiometer mirror exactly as shown in Figure 10.0. 15.
- Tape measure
- Flagging
- Forms – Section H SD DENR WPP Stream Shade and Canopy Cover Datasheet

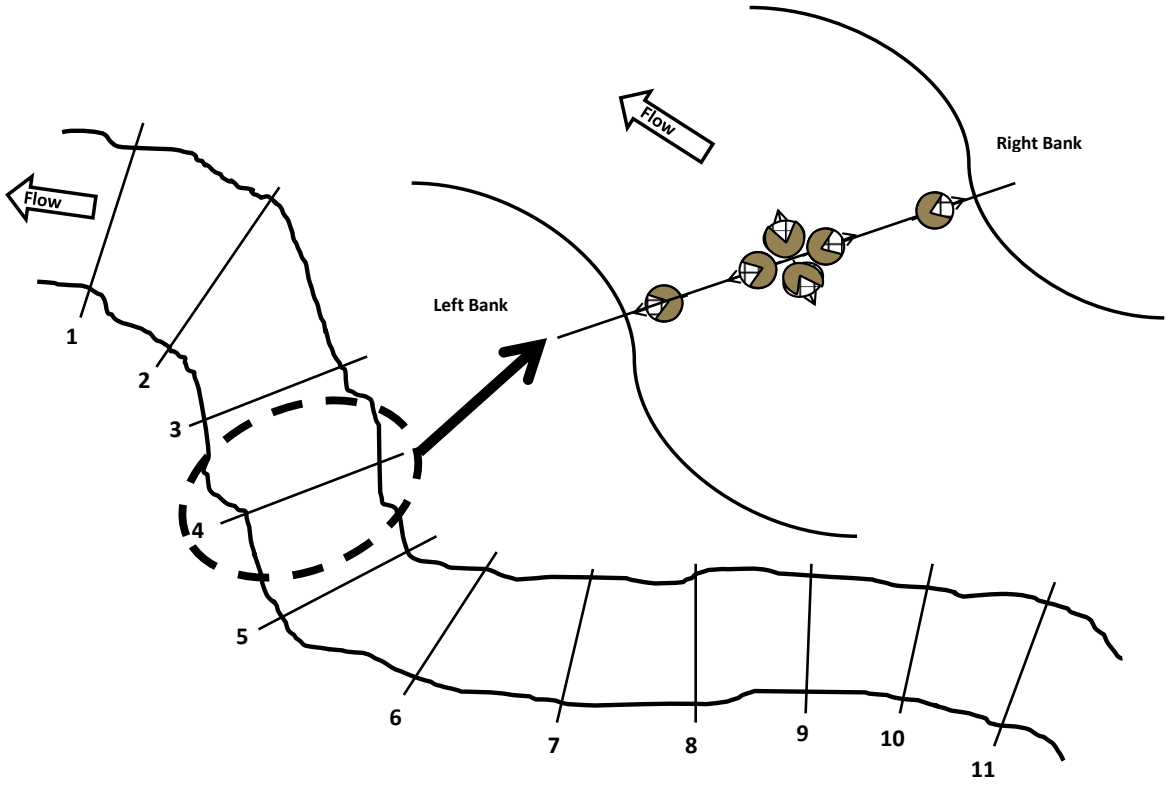


Figure 10.0. 13 Study reach with 11 transects and examples of the six densiometer measurements taken at each transect.

a. Field Methods (spherical densiometer)

The procedure described in this section uses a convex densiometer to measure stream canopy cover. The device used in this procedure is a spherical convex densiometer Model A (Lemmon, 1957). The procedure is taken from the Environmental Monitoring and Assessment Program monitoring manual for streams (Kaufmann and Robison, 1998) and derived from Platts et al., (1987).

The densiometer is a small, convex, spherical mirror with an engraved ¼ inch grid that reflects the canopy over the stream. Canopy cover is measured by counting the grid intersections covered by vegetation.

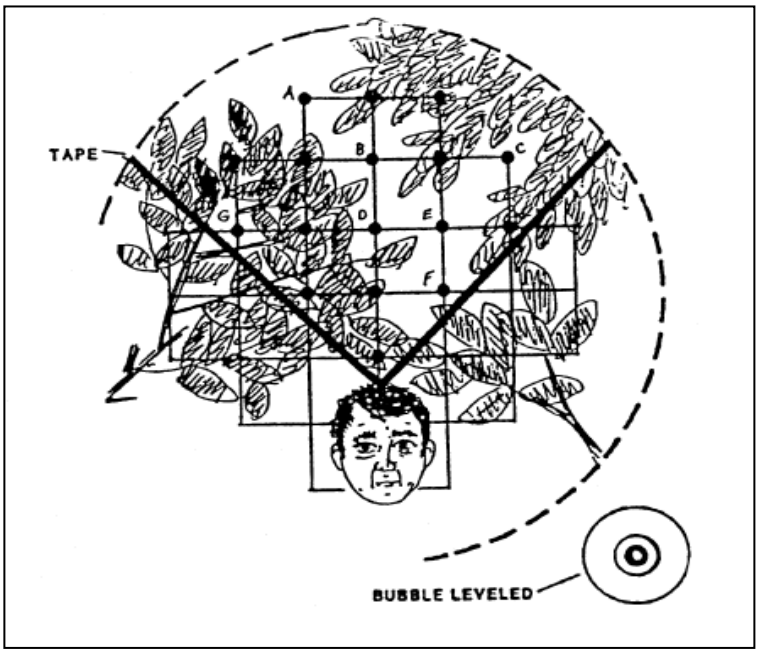


Figure 10.0. 14 Schematic of modified convex spherical canopy densiometer (From Mulvey et al., 1992). In this example, 10 of the 17 intersections show canopy cover, giving a densiometer reading of 10. Note proper positioning with the bubble leveled and face reflected at the apex of the "V." Taken from Peck et al., 2001 USEPA EMAP: Western Pilot Field Operations Manual.

i. Measurements are taken by holding the densiometer level and 0.3 meter (1 ft) above the surface of the water. This standard height helps to minimize the potential to get different results from people of different heights and to

include the contribution of low hanging vegetation to stream cover.

ii. Following the procedures described in the study design establishes 11 evenly spaced transects along the sample reach (Figure 10.0. 13). Transects should have been flagged ahead of time during the initial site setup.

iii. Stand on the transect at mid-channel facing upstream.

iv. Hold the densiometer 0.3 meters (1 foot) above the water surface.

Hold the densiometer so that it is level using the level bubble indicator and the top of your head just touches the point of the "V" as in Figure 10.0. 14.

v. Count the number of points covered by vegetation. Values will be between 0 for completely open and 17 for completely covered canopy.

vi. Record the value on the stream shade and canopy cover form under "Center-Upstream" (Table 10.0. 5, SD DENR WPP Stream Shade and Canopy Cover Datasheet, Appendix G, Table G-9).

vii. Repeat steps iii through vi at the channel center facing towards the "Center Right", "Downstream" and "Center Left". Record measurements on the canopy cover form (Table 10.0. 5) with the left and right directions determined when facing downstream.

viii. Stand on the transect facing the bank with the densiometer 0.3 meter (1 ft) from the "Left Bank" and 0.3 meter (1 ft) above the water surface. Repeat steps iv through vi and record on the SD DENR WPP canopy cover form.

ix. Repeat for the "Right Bank". At this point you should have six measurements for the transect: four from the center and one at each bank (Figure 10.0. 13).

x. Repeat steps i through x, for each transect and record on a separate line of the canopy cover form (Table 10.0. 5, SD DENR WPP Stream Shade and Canopy Cover Datasheet) m.

xi. Sum each column and write each total at the bottom of each column. For the center positions, sum each of the total positions and write the total in the total by center positions (TCP) box. Divide the total of each bank (TBB) by the total number of observations possible by bank (numbers provided on data sheet) to calculate the percent cover by bank, based on the number of transects collected at the site (circle values used on datasheet). Then calculate percent total cover by summing right TBB, the left TBB, and the total of center positions TCP; and then divide the sum by the total number of observations possible for the reach based on the total number of transects collected (provided on datasheet).

xii. Canopy cover is usually represented as an average percent for either the center and/or margins separately or combined for a single canopy cover measurement for the entire stream reach.

Table 10.0. 5 Section H SD DENR WPP Stream Shade and Canopy Cover Datasheet

Site ID Name:				**Date:**		**Time:**	
Reach Length:			**Transect Interval:**			**Initials:**	
Transect	**Left Bank***	**Right Bank***		**Center Upstream**	**Center Right**	**Center Downstream**	**Center Left**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
X 1							
X 2							
X 3							
Total by bank (TBB) **(total each bank)**			**Total by Position (TBP)**				
			Total Center Positions (TCP) **(sum all TBP)**				
Percent Cover by Bank **[Divide TBB by] 187 for 11 transects, 204 for 12 transects, 221 for 13 transects, 238 for 14 transects**			**Percent Cover for Center** **[Divide TCP by] 748 for 11 transects, 816 for 12 transects, 884 for 13 transects, 952 for 14 transects**				
Total Percent Cover (Reach) **LB+RB+TCP/1122 for 11, LB+RB+ TCP/1224 for 12, LB+RB+ TCP/1326 for 13, LB+RB+ TCP/1428 for 14**							

*** = Left and right banks are determined looking downstream**

b. Complex Channels: Islands, Bars and Side Channels

Sections of streams with side channels, mid-channel bars or islands, or complex braided channels are treated differently. In part, it depends if a bar or an island forms the side channel. Bars are stream channel features below bankfull flow height and may be dry during summer field surveys. Bars are wet during bankfull flows. Islands are channel features that are as high as or higher than the bankfull height. Islands are dry during bankfull flows. Bars are considered part of the wetted channel and densiometer readings are taken over bars and boulders, just as if they were a part of the wetted channel.

- Island-formed side channels are treated differently than those created by bars. Visually estimate the percent of flow in the smaller side channel. No canopy measurements are taken on the side channel if the side channel carries < 15% of the total stream flow.
- If the side channel carries >16% of the steam flow, then six densiometer measurements are taken on the main channel and an additional six are taken on the side channel.

If extra transects are required (island-formed side channels with > 16 % of the stream flow) they are designated as "X 1", "X 2", etc. and are provided on the canopy cover form (Table 10.0. 5, SD DENR WPP Stream Shade and Canopy Cover Datasheet).

c. Data Analysis

The 66 densiometer measurements for the stream reach are typically analyzed separately for the stream center and margins. The 44 center channel measurements are averaged and reported as a percent of total possible stream cover. The center channel average is more independent of seasonal flow changes than the margin measurements and is a better overall indicator of stream cover. The average percent cover of the 22 stream margin measurements is a better indicator of riparian vegetation density and is independent of stream size.

If additional transects are recorded for island-formed side channels, incorporate data in the into the overall center channel, stream margin and overall reach percentages for the segment.

10. Streambank and Riparian Features (Section I and Section J)

This suite of data focused on stream bank and riparian features and is measured using a graduated pole and angle finder for both right and left bank (looking downstream) at each of the 11 transects. It is necessary as part of these measurements you find the break point between the channel bank and channel bottom. At this point you may or may not notice a break in slope where the bank ends and the actual main part of the channel begins (Figure 10.0.15). This can be somewhat ambiguous and subjective in some streams. It may take some practice before you are consistently able to locate this point. The following measurements are made on either side of the bank for each of the 11 transects. The individual standing in the stream should work from the left bank to right bank (see Table 10.0. 6, Section I and Section J of the data sheet).

When first arriving at each transect, stakes should be placed on either side of the channel to attach a tape measure across the stream (if possible) to determine various measurements at each transect (Section I). If the bank isn't too high or too long, the tape can be left in place while most of the other measurements that require a tape measurement can be made with the tape measure left in place. The tape measure should be placed directly on the ground to insure an accurate measure of bank height. The subsequent measurements discussed below are dependent on the location of the break that occurs where the bank ends and bed of the channel begins. All of the following measurements must be completed using the data sheet identified in (Table 10.0. 6, Section I and Section J). All length measurements should be made to 0.1 m. When placing the tape on top of the bank to measure left bank terrace to right bank terrace, the tape should be reasonably level. If one side is out further than the length of tape, estimates on bank length, angle and bank vegetation length may have to be made (Figure 10.0.20).

a. Bank Substrate (dominant) - Estimate the dominant substrate particle size along the bank where the transect intercepts each bank (left and right banks). Use the same size classes identified with the modified US EPA, National River/Stream Assessment, 2013 and modified Wolman Pebble Count (Section F, Table 10.0. 3, SD DENR WPP Bed Substrate Composition Datasheet). Write the dominant substrate type for each bank (Left and Right) in Section I of the datasheet (see Appendix G, Table G-10 or Table 10.0. 6).
b. Bank Slumpage (present, "p" or absent, "a") – On either side of the transect, note whether there is any portion of either bank slumping or has fallen to the toe of the bank present (presence, p or absent, a). Slumping would be defined as a large portion of the top of the bank that has fallen to the toe of the bank or partially submerged by the stream course. Write down if there is bank slumpage "p" or not "a" for each bank (Left and Right) in Section I of the datasheet (see Table 10.0. 6).

Table 10.0. 6 Habitat Transect Datasheet for streambank riparian features, visual riparian structure, transect station, bankfull, and depth data.

Project Site ID:_____ **Stream Name:**_____ **Date:**_____ **Sampler(s):**_____ **Transect Number:**___ **of** ___

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank			Right Bank		
cropland	shrub	woodland/forested	cropland	shrub	woodland/forested
pasture/rangeland		barnyard	pasture/rangeland		barnyard
prairie		urban/developed	prairie		urban/developed
wetland		other-specify:	wetland		other-specify:
_____			_____		

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)
D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

c. Bank Angle (degrees)

To measure bank angle, lay a meter ruler or stadia rod down against the left bank (determined as you face downstream), with one end at water's edge (see Figure 10.0. 15). At least 0.5 m of the ruler or rod should be resting comfortably on the ground to determine bank angle. If the ground adjacent to the water's edge is not indicative of the predominant angle of the 1 meter shoreline, it may be necessary to move the end of the rod away from the water's edge to correctly measure the predominant angle of the 1 meter shoreline. Lay the clinometer on the rod and read the bank angle in degrees from the external scale on the clinometer. Record the angle in the field for the left bank in the "Bank Angle" section of the habitat assessment form or spreadsheet (Table 10.0.6).

1. A vertical bank is 90 degrees, overhanging banks have angles > 90 degrees approaching 180 degrees, and more gradually sloped banks have angles < 90 degrees. To measure bank angles > 90 degrees, turn the clinometer (which only reads 0 to 90 degrees) over and subtract the angle reading from 180 degrees.
2. If there is a large boulder or log present at the transect, measure bank angle at a nearby point where conditions are more representative.

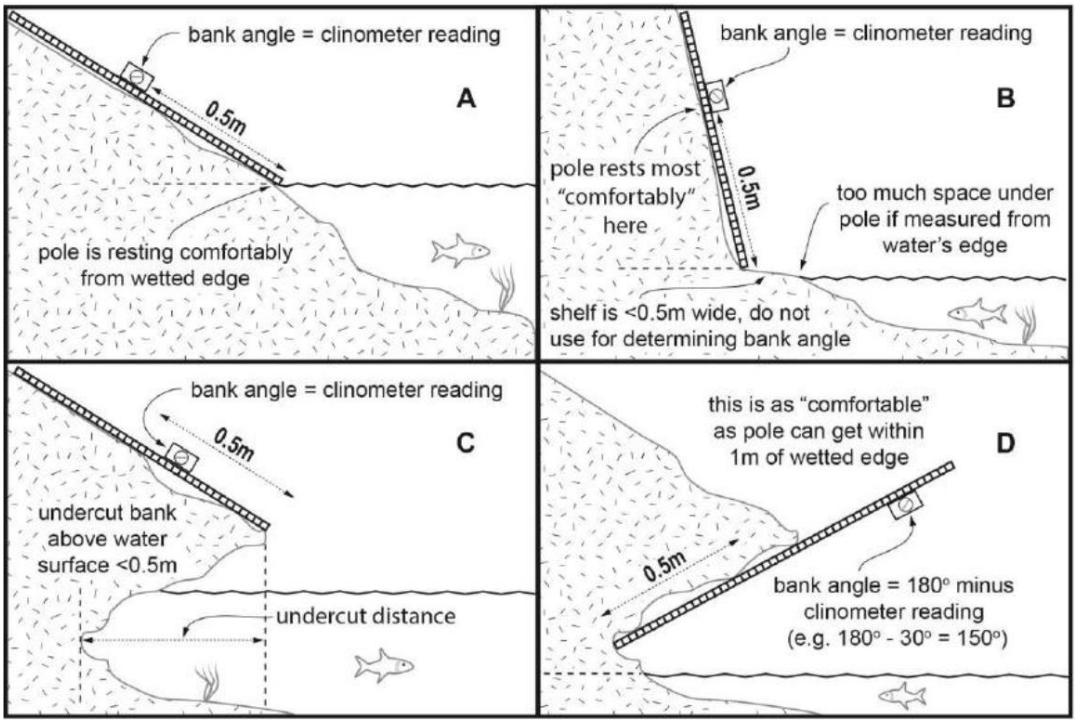


Figure 10.0. 15 A variety of habitat measurements including bank angle and height.

If the bank is undercut, measure the horizontal distance of the undercutting to the nearest 0.01 m. The undercut distance is the distance from the deepest point of the undercut out to the point where a vertical plumb line from the bank would hit the water's surface (see Figure 10.0.15). Record the distance on the field data form. Measure submerged undercuts by thrusting the rod into the undercut and reading the length of the rod that is hidden by the undercutting.

Repeat steps 1 and 2 on the right bank, then repeat at the remaining transect.

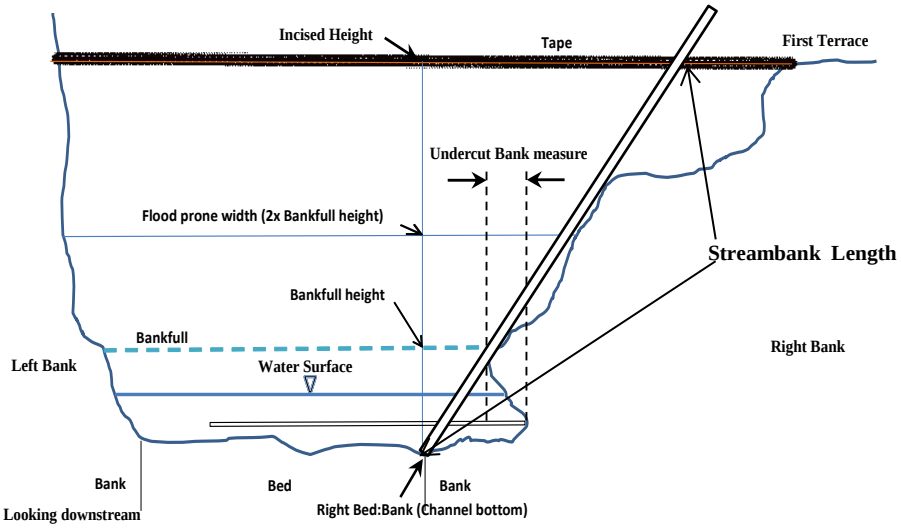


Figure 10.0. 16. Streambank length and incised height

d. **Streambank Length to Incised Height** (0.1 m) - Leave the stadia rod or tape measure in place after completing the bank angle measurement for the next three measurements. Determine the actual length of the bank in 0.1 meters. This would be the length from the edge of the first terrace, which in some cases can be >10 m, to the break between the bank and bed (Figure 10.0.16). Write the total length in meters for each bank (Left and Right) in Section I of the datasheet (see Table 10.0. 6). The next three measurements (length bank vegetated, eroded, and deposited) should total the entire streambank length.

e. **Length of Streambank Vegetated** (0.1m) – Leaving the graduated pole or tape measure in place to determine the length of the streambank that is vegetated; remember vegetated areas can be discontinuous along the streambank be sure to sum measurements to determine total streambank length that is vegetated. Vegetated portions include grass, shrubs, and trees including those areas where root structure is contributing to bank stability. Both left bank and right bank (determined when facing downstream) are recorded (0.1 m) in Section I of the datasheet (Appendix G, Table G-10 or Table 10.0. 6).

f. **Length of Streambank Eroded** (0.1m) – A measurement of bank instability along the transect line measured as the linear distance of exposed and eroded bank soils having very little or no structural support from vegetation during high flows. This does not include areas of deposition where soils can be bare. Write the total length in meters (0.1) for each bank (Left and Right) in Section I of the datasheet (see Table 10.0. 6).

g. **Length of Streambank Deposition** (0.1m) – This would be the length of the stream bank where depositional portions were or that length where recent deposition dominated the bank's surface. This can be below the current water level. Write the total length of streambank that shows deposition in meters (0.1) for each bank (Left and Right) in Section I of the datasheet (see Table 10.0. 6).

h. **Buffer Width** (m) – Using a metered tape measure, measure the buffer widths horizontal distance along the transect line from the stream's edge out to the end of the riparian buffer for the left and right banks to the nearest meter. Record these distances in Section I of the transect datasheet (see Table 10.0. 6). If the land is completely disturbed (cropped), then the distance is "0" m. If the land is completely undisturbed, then the buffer width is recorded as the measured distance. It may be appropriate to approximate buffer widths beyond 10m x 10m riparian plot using laser rangefinder.

i. **Undercut Bank** (0.1m) – If the bank is undercut on either bank, measure the horizontal distance of the undercutting to the nearest 0.1 m. Record these distances in Section I of the transect datasheet (see Appendix G, Table G-10 or Table 10.0. 6). The undercut distance is the distance from the deepest part of the undercut bank to the point where a vertical plumb line from the bank would hit the horizontal stadia rod (Figure 10.0.16).

j. **Overhanging Vegetation** (0.1m) – Measure (length) the immediate portion of riparian zone with overhanging vegetation that shades the streambed providing fish with cover and reduces the amount of sun light (solar energy) that gets to the water (temperature). Record overhanging vegetation distances for the left and right banks in Section I of the transect datasheet (see Table 10.0. 6).

k. **Submergent Macrophytes** (%) - If submergent macrophytes are present anywhere along the transect, estimate or measure the total coverage of submerged macrophytes along the transect line. Visually compare the coverage to the wetted width of the stream as a percent or divide the measured total width of submerged macrophyte coverage by the total wetted width of the transect to get the percentage (i.e., estimated or measured coverage of submerged macrophytes was 2 meters and the total wetted width of the transect was 6 meters = 33.3 percent total submerged macrophyte coverage for this transect). Record this percentage in Section I of the transect datasheet (see Table 10.0. 6).

l. **Emergent Macrophytes** (%) – If emergent macrophytes are present anywhere along the transect, estimate or measure the total coverage of emergent macrophytes along the transect line. Visually compare the coverage to the wetted width of the stream as a percent or divide the measured total width of emergent macrophytes coverage by the total wetted width of the transect to get the percentage (i.e., estimated or measured coverage of emergent macrophytes was 3 meters and the total wetted width of the transect was 6 meters = 50 percent total emergent macrophytes coverage for this transect). Record this percentage in Section I of the transect datasheet (see Table 10.0. 6).

m. **Floating Macrophytes** (%) – Similar to submergent and emergent macrophytes, If floating macrophytes (i.e., duckweeds) mats are present on the edges of stream, around rocks, in-between emergent macrophytes or mostly cover the stream estimate or measure the total coverage along the transect line. Visually compare the coverage to the wetted width of the stream as a percent or divide the measured total width of floating macrophytes coverage by the total wetted width of the transect to get the percentage (i.e., estimated or measured coverage of floating macrophytes totaled 1 meter and the total wetted width of the transect was 6 meters = 16.6 percent total emergent macrophytes coverage for this transect). Record this percentage in Section I of the transect datasheet (see Appendix G, Table G-10 or Table 10.0. 6).

n. **Dominant Landuse** – The upland area in line with the transect that is the area of bank vegetation (or lack thereof) that would intercept overland flow. This area can influence erosion and bank stability. The landuse in this area can greatly influence bank stability and water quality. Based on the choices given on the datasheet (see Section I, Table 10.0. 6) circle the type of dominant landuse adjacent to the stream corridor and the transect line that best describes the landuse on both the left and right bank.

o. **Visual Riparian Vegetation Structure Estimates** – The following visual estimation procedures supplement those measurements with a semi-quantitative evaluation of the type and amount of various types of riparian vegetation.

p. Riparian vegetative cover observations apply to the riparian area upstream 5 meters and downstream 5 meters from each bank of each of the 11 cross-section transects. They include the visible area from the stream back a distance of 10m (~30 ft.) shoreward from both the left and right banks, creating a 10 m x 10 m riparian plot on each side of the stream (Figure 10.0.17). The riparian plot dimensions are estimated, not measured. On steeply sloping channel margins, the 10 m x 10 m plot boundaries are defined as if they were projected down from an aerial view. Section 10 (n) (1) outlines the procedure for characterizing riparian vegetation structure and composition (Section I continued). Figure 10.0. 6 illustrate how measurements are recorded on the Visual Riparian

Structure Estimates section of the SD DENR WPP transect datasheet.

Conceptually divide the riparian vegetation into 3 layers: the *Canopy* layer (> 5 m high), the *Understory* layer (0.5 to 5 m high), and the *Ground cover* layer (< 0.5 m high). Note that several vegetation types (e.g., grasses or woody shrubs) can potentially occur in more than one layer. Similarly note that some things other than vegetation are possible entries for the *Ground cover* layer (e.g., barren ground).

Before estimating the areal coverage of the vegetation layers, record the type of *woody* vegetation (*broadleaf Deciduous, Coniferous, broadleaf Evergreen, Mixed,* or *None*) in each of the two taller layers (Canopy and Understory). Consider the layer *Mixed* if more than 10% of the areal coverage is made up of the alternate vegetation type. If there is no woody vegetation in the understory layer, record the type as *None*.

Estimate the areal cover separately in each of the three vegetation layers. Note that the areal cover can be thought of as the amount of shadow cast by a particular layer alone when the sun is directly overhead. *The maximum cover in each layer is 100%, so the sum of the areal covers for the combined three layers could add up to 300%*. The four areal cover classes are *Absent*, *Sparse* (<10%), *Moderate* (10 to 40%), *Heavy* (40 to 75%), and *Very Heavy* (>75%). These cover classes and their corresponding codes are shown on the SD DENR WPP field data form (Figure 10.0. 6, Section I (continued)). When rating vegetation cover types for a single vegetation layer, mixtures of two or more subdominant classes might all be given *Sparse* (*1*), *Moderate* (*2*), or *Heavy* (*3*) ratings. One *Very Heavy* cover class with no clear subdominant class might be rated *4* with all the remaining classes rated as either *Moderate* (*2*), *Sparse* (*1*) or *Absent* (*0*). Note that within a given vegetation layer, two cover types with 40-75% cover can both be rated *3*, but no more than one cover type could receive a rating of *4*.

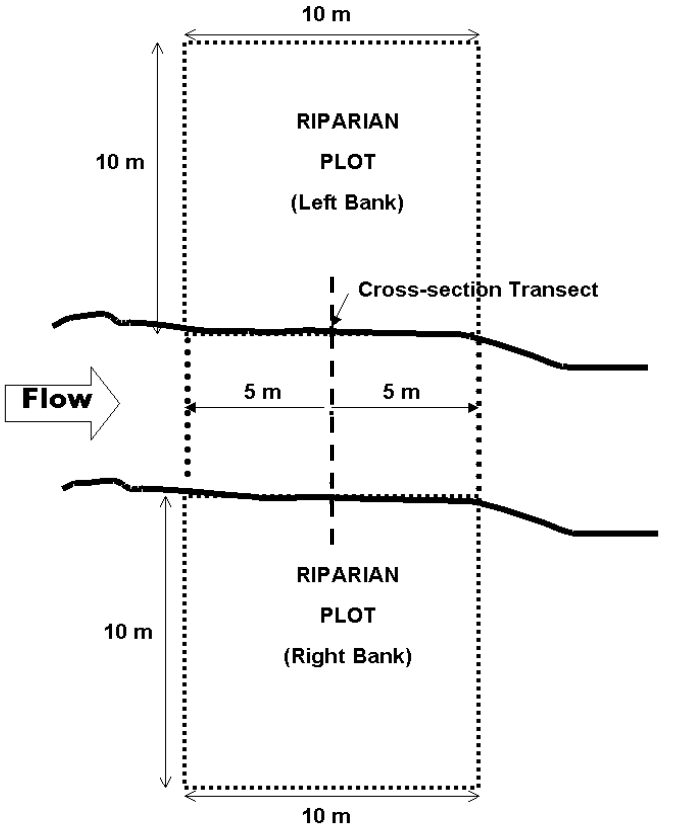


Figure 10.0. 17 Riparian zone for a stream cross-section transect (Adapted from US EPA, 2012).

1) The procedure for Characterizing Visual Riparian Vegetation Structure Estimates are as follows.
2) Standing in mid-channel at a cross-section transect, estimate a 5 m distance upstream and downstream (10 m total length).
3) Facing the left bank (left as you face downstream), estimate a distance of 10 m back into the riparian vegetation. On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.
4) Within this 10 m x 10 m area, conceptually divide the riparian vegetation into 3 layers: a *Canopy Layer* (>5 m high), an *Understory* (0.5 to 5 m high), and a *Ground Cover* layer (<0.5 m high).
5) Within this 10 m x 10 m area, determine the dominant vegetation type for the *Canopy Layer* (vegetation >5 m high) as; Deciduous, *Coniferous*, *broadleaf Evergreen*, *Mixed*, or *None*. Consider the layer *Mixed* if more than 10%

of the areal coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the Visual Riparian Vegetation Structure Estimates section of the SD DENR WPP Transect Datasheet (Appendix G, Table G-10 or Table 10.0. 6).

6) Determine separately the areal cover class of large trees (≥0.3 m [1 ft] Diameter at Breast Height [DBH]) and small trees (<0.3 m DBH) within the canopy layer. Estimate areal cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form (*0=absent*: zero cover, *1=sparse*: <10%, *2=moderate*:10-40%, *3=heavy*: 40-75%, or *4=very heavy*: >75%).
7) Look at the Understory Layer (vegetation between 0.5 and 5 m high). Determine the dominant woody vegetation type for the understory layer as described in Step 6 for the canopy layer. If there is no woody vegetation in the understory layer, record the type as *None.*
8) Determine the areal cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described in Step 6 for the canopy layer.
9) Look at the *GROUND COVER* layer (vegetation <0.5 m high). Determine the areal cover class for woody shrubs and seedlings, non-woody vegetation, and the amount of bare ground present as described in Step 6 for large canopy trees.
10) Repeat Steps 2) through 9) for the right bank.
11) Repeat Steps 2) through 9) for all cross-section transects (including any additional side channel transects established when islands are present). Use a separate field data form at each transect. A full set of datasheets for each transect are available in Appendix G, Table G-10, (transects "1" of "11" through "11" of "11").

11 Transect Station, Bankfull, and Depth Data (Section J)

The third suite of data will focus on the horizontal and vertical point measurements, which are used to calculate stream width, depth, flow velocity, bankfull depth, bankfull width, flood prone elevation, flood prone width, and width:depth ratio. Point data is obtained by staking the ends of a tape measure on the left and right banks at the flood prone elevation and stringing the tape horizontally across the stream. Moving from left to right, key channel features are identified and measured and the distance from the left stake recorded. Measurements include bankfull depth, flood prone width, water depth, and water velocity. Water depths are measured at seven points within the stream, "Left Edge of Water", "Left Channel Bottom", "¼", "½", and "¾" of the distance across the stream, "Right Channel Bottom", and "Right Edge of Water" measured

from the left stream bank. (Table 10.0.6). Velocities are measured at "¼", "½", and "¾" distances across the wetted width and are measured and recorded by separate personnel on a separate datasheet (Section J, (Velocities), Table 10.0. 7).

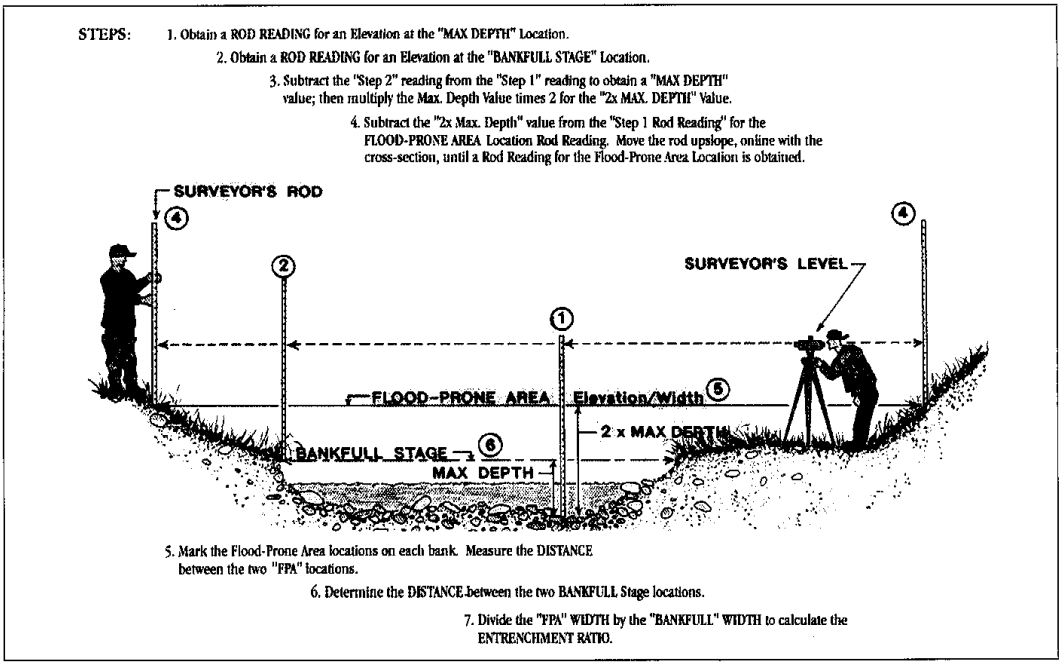


Figure 10.0. 18 Illustration for using a surveyor's level and rod to collect transect data (Rosgen, 1996).

First, find the deepest point in the channel along the transect line and measure the water depth using a stadia rod or marked measuring stick and record this value in the lower right box of Section J on the stream habitat datasheet (Table 10.0. 6) under "Max Water Depth". Next, measure the vertical distance from the water surface to the bankfull indicator and record this value on the datasheet as "Bankfull Height." Sum the values recorded as "Max Water Depth" and "Bankfull Height" and record the resulting value on the datasheet as "Max Bankfull Depth". Multiply the Max Bankfull Depth value by 2 and record the resulting value as "Flood Prone Elevation" on the datasheet. Figure 10.0.18 shows transect data collection using surveyor's level and rod.

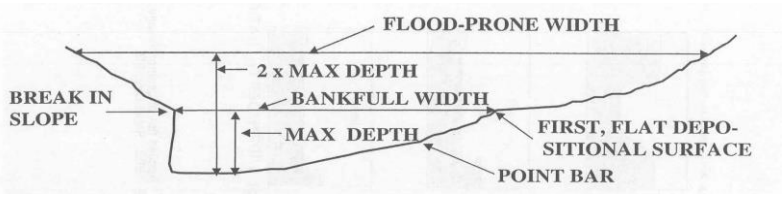
While holding the stadia rod vertically with the bottom of the rod at the deepest point of the channel, run a tape measure along the transect toward each bank and hold the tape such that the tape is taught and runs reasonably horizontal (level) across the stream at the Flood Prone Elevation (height) with the zero end of the tape on the left bank. At the point where the tape intersects dry land on each side of the stream, stake the tape to the ground at the flood prone elevation. Record the horizontal distance on the tape between the stakes as the Flood Prone Width (Appendix G, Table G-10 or Table 10.0. 6). This width represents the area where an approximately 50 year flood event would inundate the

floodplain. If the distance is greater than can be reasonably measured with a tape, tie the tape off around the shaft of the stake so that the tape runs horizontally at the flood prone elevation but does not intersect land. Using a rangefinder, measure the distance from the stake to where an imaginary horizontal line at the flood prone elevation would intersect land. Record this value as the Flood Prone Width. The tape is used to measure horizontal measurements (stations) and depths which are outlined below.

a Left Flood Prone Width (LFP) Station – Using the datasheet locate this point along the tape set at the flood prone width (Station on the datasheet and should be zero meters as the stake for the tape measure was placed at the LFP flag location. If the tape was placed above this location, place a surveyor's rod on the left bank where the LFP width flag was placed and keeping the rod level read the distance on the tape measure where the rod intersects the tape and record to the nearest 0.01 meters (cm) as the LFP station in Section J (Appendix G, Table G-10 or Table 10.0. 6).

b Left Bankfull (LBF) Station – Bankfull should have been identified using the indicators located in Figure 10.0.19 and were flagged during initial site and transect layout and setup. Using the tape setup at flood prone width and a graduated pole (surveyor's rod), position the pole vertically at that point along the bank where left bankfull begins (example, 4 m in Figure 10.0.20) and record it to the nearest 0.01 meters (cm) in Table 10.0. 6.

BANKFULL STAGE (APPROX. 1.5 YR OR 67% CHANCE)



BANKFULL INDICATORS

1. First, flat depositional surface
2. Lowest extent of woody vegetation
3. Top of washed roots zone
4. Topographic break in slope
5. Top of point bar or other deposits
6. Change in nature and amount debris deposits
7. Change in size of substrate materials
8. Zone of washed rock

Entrenchment Ratio (ER) = Flood Prone Width / Bankfull Width

Width/Depth Ratio = Bankfull Width / Average Bankfull Depth

(Steffen, Lyle, 2001. Fluvial Geomorphology Workshop. Spearfish, SD. May 2001.)

Figure 10.0. 19 Bankfull indicators for determining bankfull locations at each transect.

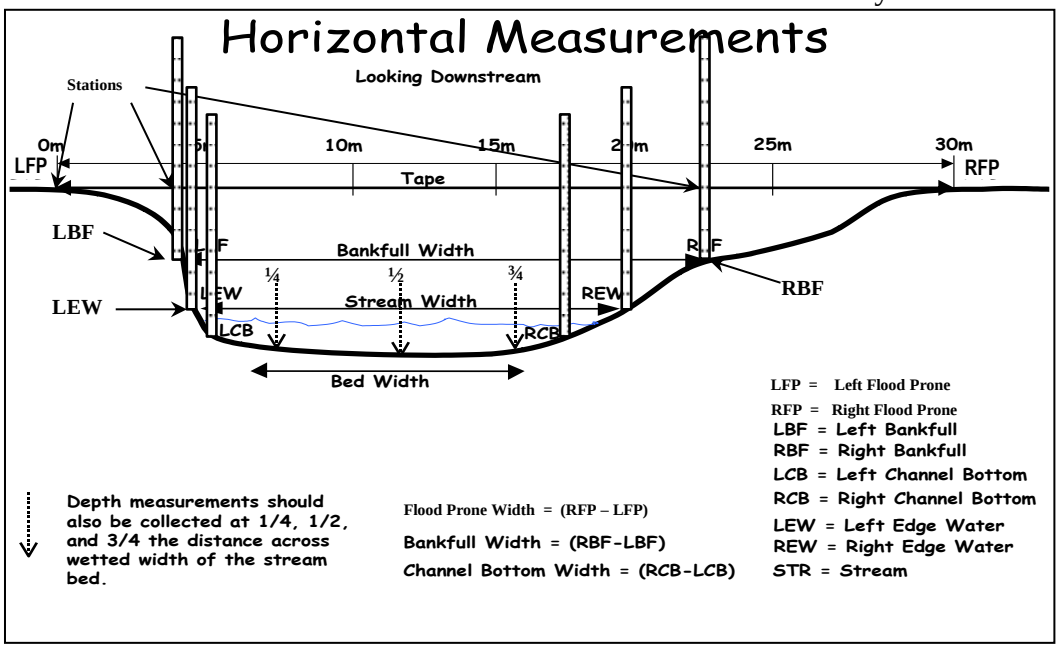


Figure 10.0. 20 Horizontal and vertical measurement locations measured for each transect (modified from Milewski).

c Left Edge Water (LEW) Station – Position the graduated pole at the left edge of the water. Keeping the pole straight, determine where it intersects the tape placed at the flood prone elevation and record it to the nearest 0.01 meters (cm) in Table 10.0. 6.

d Left Edge Water (LEW) Water Depth – Keeping the graduated pole straight determine the water depth at the LEW using your location of bankfull identified in step "b". Most of the time the depth is zero except where there is vertical or undercut channel or bank.

e Left Channel Bottom (LCB) Station – Position the graduated pole at the break between the bank and actual bed of the channel (see previous discussions in Section 10.0 (10) for locating this point). Keeping it rod straight (vertical), determine the point at where it intersects the tape placed at the flood prone elevation. Record this distance from the left flood prone station as LCB to the nearest 0.01 meters (cm) in Appendix G, Table G-10 or Section J, Table 10.0. 6).

f Left Channel Bottom (LCB) Water Depth – Keeping the graduated pole straight (vertical) determine the water depth at the LCB location and record this depth to the nearest 0.001 meter (mm) in Section J, Table 10.0. 6.

g Stream (STR) @ ¼, ½, and ¾ - Estimate the ¼, ½, and ¾ distances across the wetted width of the channel. At these points, using methods previously described and following the datasheet determine the following:

- Station – point at where the graduated pole and the tape intersect at the ¼, ½, and ¾ distances across the wetted of

the channel. These distances are from the left flood prone station and recorded it to the nearest 0.01 meters (cm) in Section J, Table 10.0. 6.

- Water Depth @ ¼, ½, and ¾ – at each in-channel location across wetted width, (¼, ½, and ¾) measure the water depth the nearest 0.001 meter (mm) and record them in the appropriate boxes in Section J, Table 10.0. 6.
- Velocity – average velocities (based on 40-second averaging period) will be collected by a third team member using Marsh McBirney, FlowTracker, or other appropriate flowmeter in cfs (cubic feet per second) at all in-stream channel transect locations throughout the reach. Each velocity measurement will be collected at 0.6 tenths of the total water depth measured from the surface at each location. Using a separate datasheet (Table 10.0. 7, Section J (velocities), Habitat Transect Velocities Table) document and record average velocity measurements within the reach period. When all velocities have been collected and recorded, sum all velocities in the reach and divide by the total number of velocities collected at the site to determine the overall average velocity for the reach and record.

h Right Channel Bottom (RCB) Station and (RCB) Water Depth – Review Steps "e" through "f". However, first locate your bankfull reference (Station) for Right Bankfull.

i Right Edge Water (REW) Station and (REW) Water Depth – Review Steps "c" to "d".

j Right Bankfull Station (RBF) – Review step "b". Use RBF distance in meters minus the LBF distance in meters to determine the Bankfull Width.

k Right Flood Prone (RFP) Station – Review step "a". Using the datasheet locate this point along the tape (Station on the datasheet). Place a surveyor's rod on the right bank where the Right Flood Prone width flag was placed and keeping rod level read the distance on the tape measure where the rod intersects the tape in meters and record as the RFP station distance. Use RFP distance in meters minus the LFP distance in meters to determine the Flood Prone width and record on datasheet (Appendix G, Table G-10).

Section J (Velocities)

Table 10.0. 7 **Habitat Transect Velocities Table (cfs)[1]**

Stream: _____ Date: _____, Time: _____

Sampler(s): _____, Meter used: _____ (use a 40 second averaging period)

[1] = Collect all water velocity measurements at 0.6 tenths of the total water depth at each location and write measurements on the table.

	Distance across wetted width		
Transect	0.25 (¼)	0.50 (½)	0.75 (¾)
(upstream) 11			
10			
9			
8			
7			
6			
5			
4			
3			
2			
(downstream) 1			
Sum (columns)			
	Sum all column measurements*		
	Reach Average Velocity (Sum/33)*		

*** = If less than 33 velocity measurements were collected in the reach divide the sum by the total number of measurements collected.**

Notes

Habitat Glossary and Definitions

Definitions and measurements procedures for site variables (adapted from Wolman. 1954. Hughes and Omernik. 1981; Platts et. al. 1983, Robison and Beschta. 1990; Gordon et al. 1992; Dolloff 1994; Simonson et al. 1994, and Milewski, 2001).

Transect – A line that extends from the left bank to the right bank, perpendicular to stream flow.

Channel bank (stream bank) – The sides of the channel (or stream) that typically restrict lateral movement of water and sediment.

Channel bottom (stream bed) – The bottom portion of the channel (or stream) that typically does not restrict lateral movement of sediment and water.

Bankfull – That point on the channel bank where flows begin to crest that bank and move onto the floodplain.

Incised – Describes channels or streams with bottoms that have or are in the process of downcutting into the landscape. High, steep, eroding banks are often associated with incised streams.

Channel Morphometry

Stream width (0.1 m) - Horizontal distance along transect, measured perpendicular to streamflow from left edge of water to right edge of water at existing water surface, to nearest 0.1 m.

Stream depth (0.1 m) - Vertical distance from existing water surface to channel bottom; measured at three equally spaced points along transect, to nearest 0.1 m.

Channel bottom depth (0.1 m) - Horizontal distance along transects, measured perpendicular to stream flow, measured as that section classified as stream bed not stream bank, to the nearest 0.1 m.

Bankfull width (0.1 m) - Horizontal distance along transects, measured perpendicular to stream flow, from top of low bank to a point of equal height on opposite bank, to nearest 0.1m. See Harrelson et al. (1994) or Steffen, 2001 for useful indicators of bankfull.

Bankfull depth (0.1 m) - Vertical distance from the plane of bankfull width to the channel bottom or bank, measured at a number of equally spaced points along the transect to adequately describe mean bankfull depth and cross-section, to the nearest 0.1 m.

Width:depth ratio - An index of cross-sectional shape, where both width and depth are measured at the bankfull level, unitless.

Bank height (0.1 m) - Vertical distance along transect from edge of channel bottom to level land on top of bank, measured to the nearest 0.1 m. Does not refer to bankfull height.

Stream surface slope (%) - The amount of vertical drop per unit of horizontal distance along the water surface, measured with surveyor's level.

Bed and Bank Material

It is very important to distinguish between clay and silt. Although both are composed of very fine particles, their properties are quite different. For example, clay can be very resistant to erosion, where particles of silt can be easily eroded. These properties can play a strong role in channel morphometry.

Channel Bed Substrate		
Substrate Type	Diameter (mm)	Description
Muck-Mud	FPOM	black, very fine particulate organic matter
Detritus	CPOM	sticks, wood, plant material, coarse particulate organic matter
Clay (slick)	<0.004	Not Gritty
Silt	0.004-0.062	Not Gritty
Sand (gritty)	0.062-2	Gritty up to Ladybug size
Very Fine Gravel	>2-4	Ladybug
Fine Gravel	>4-8	Pencil Eraser
Medium Gravel	>8-16	Marble
Coarse Gravel	>16-32	Marble to Watch Face
Very Coarse Gravel	>32-64	Watch Face to Tennis Ball
Cobble	>64-128	Tennis Ball to Height of a Soda Can
Large Cobble	>128-250	Height of a Soda Can to Basketball
Small Boulder	>250-1000	Basketball to Width of a Microwave Oven
Large Boulder	>1000-4000	Larger than a Microwave Oven
Bedrock	>4000	Rough or smooth surface bigger than a car

Stream bed substrate - If the channel is not completely inundated, then this is the composition of bed material with the wetted channel classified into size categories similar to Wolman's Pebble Count. A substrate particle is selected off the inundated bed surface at 8 equal distances along each transect in the stream and placed into one of the categories listed above.

Bank substrate - Composition of bank material classified into size categories similar to modified Wolman's Pebble Count categories.

Streambank and Riparian Characteristics

Streambank length (0.1 m) - the linear distance along the transect from the junction of the stream bed and the stream bank to the top of the bank, measured to the nearest 0.1 m.

Length of Streambank Vegetated (0.1 m) - A measurement of bank resistance to erosion due to vegetation, measured as the linear distance along the streambank length, which is vegetated by perennial herbaceous plants (grasses, forbs and aquatic species), shrubs or trees.

Length of Streambank Eroded (0.1 m) - A measurement of bank instability along the transect line measured as the linear distance of exposed and eroded bank soils having very little to no structural support from vegetation during high flows. This does not include area of deposition where soils can be bare.

Length of Streambank Deposition (0.1m) – This measurement is the length of the stream bank where depositional portions were or that length where recent deposition dominated the bank's surface and can be below the current water level.

Streambank slope (degree) - The angle formed by the downward slope of the stream bank and the channel bottom.

Buffer Width (m) –Measure the buffer widths horizontal distance along the transect line from the stream's edge out to the end of the riparian buffer for the left and right banks to the nearest meter. If the land is completely disturbed (cropped), then the distance is "0" m. If the land is completely undisturbed, then the buffer width is recorded as the measured distance. It may be appropriate to approximate buffer widths beyond the 10m x 10m riparian plot using laser rangefinder.

Dominant Landuse – The upland area in line with the transect that is the area of bank vegetation (or lack thereof) that would intercept overland flow. This area can influence erosion and bank stability. The landuse in this area can greatly influence bank stability and water quality. Based on the choices given on the datasheet circle the type of dominant landuse adjacent to the stream corridor and the transect line that best describes the landuse on both the left and right bank.

Streamflow Characteristics

Streamflow (Q, cfs) - The volume of water moving past a given stream cross section per unit of time.

Physical Fish Cover

Overhanging vegetation (0.1 m) - If present, the bankside, banktop, and non-inundated vegetation that currently overhangs the water surface. Measured as the horizontal distance along the transect line from the water's edge to the furthest point over the water surface that the vegetation protrudes, to the nearest 0.1 m.

Undercut bank (0.1 m) - If present, the horizontal distance along the transect line from the furthest point of bank protrusion and the furthest undercut of the bank, to the nearest 0.1 m.

Instream vegetation (0.1 m) - If present, the inundated macrophytic vegetation (submergent, emergent, or floating) within the stream channel. Measured as the total horizontal distance along the transect that has instream vegetation present as described, to the nearest 0.1 m.

Large woody debris (LWD), occurrence of - Generally, LWD are pieces of wood that are minimally 10 cm in diameter and 3 m long that occur within the bankfull channel providing potential cover for organisms. Measured along the transect and within one mean stream width separately as the number of pieces within the stream's different zones.

Large woody debris (LWD), volume and orientation - Volume (cubic meters) of those same pieces within four zones calculated by measuring length and diameter of each piece of LWD. Orientation is recorded as the degrees to which the woody debris is predominately orientated with respect to the channel. Woody debris orientated completely upstream (i.e., root wad on downstream end) would be recorded as 180 degrees while that orientated perpendicular to the channel would be recorded as 90 degrees, and that orientated completely downstream (i.e., root wad on upstream end) would be recorded as 0 degrees. See Robison and Beshta (1990).

11.0 HABITAT CONDITION INDEX PROTOCOL

A. Equipment List

Stadia Rod (metric)
Spherical Densiometer
Electric Fence Posts/stakes
Long Tape Measure (Metric)
Clinometer

B. Procedure

Reach Length

Mean River Stream Width/Transect Spacing

1. Measure stream width at 5 locations typical of the stream and record on datasheet (Appendix H, Table H-1 or Table 11.0. 1).
2. Calculate average of the 5 measurements and record on data sheet.
3. If MRSW is less than 10 meters, multiply MRSW by 30 to get reach length and record on datasheet.
4. If MRSW is greater than 10 meters, multiply MRSW by 20 to get reach length and record on data sheet.
5. Divide Reach Length by 10 to get transect spacing distance. Record transect spacing distance on the datasheet.
6. Set flags at 11 transects using the transect spacing distance (reach length/10) to determine the distance between transects.

Table 11.0. 1 Mean River/Stream width datasheet.

Mean River/Stream Width (MRSW)							
	Width Number					**MRSW**	
	1	**2**	**3**	**4**	**5**	**Sum (1 through 5)**	**MRSW(Sum/5)***
Width (0.1m)							
Transect Spacing from Monitoring site (MRSW x 3)*							
***If MRSW width is < 3 m, use 100 m as a minimum reach length. If MRSW is > 10m and watershed area is >500 km^2 then space transects 2 MRSW apart.**							
Total Reach Length: < 10m MRSW x 30 =			**> 10m and >500km^2 MRSW x 20 =**				

Riffle Length

1. Using metric tape measure, measure the length of each riffle area in the stream and write them on the datasheet (Appendix H, Table H-2).

Table 11.0. 2 Riffle length field datasheet.

Transect spacing	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**	**9-10**	**10-11**	**Total (Sum (m))**
Riffle Length (m)											
Notes											

2. Combine length of all riffles by adding all transect riffle lengths together and record the sum on the datasheet (Table 11.0. 2).

Canopy Cover

1. At the left bank, hold a convex spherical densitometer approximately 1 foot above the water surface and 1 foot from the bank. Count the number of line intersections on the face of the densiometer where vegetation or other materials obscure the intersection of the lines (Table 11.0. 3). Record the number of intersections on the Canopy Cover field datasheet (Appendix H, Table H-3 or Table 11.0. 3). The maximum number for each measurement is 17. Repeat on the right bank and also in the center of the stream while looking upstream, downstream, toward the right bank, and toward the left bank (see below). Complete this procedure for every transect. *To determine left and right bank of the stream, face downstream and the left bank is on your left.*

Table 11.0. 3 Canopy Cover field datasheet

Site ID Name:				**Date:**		**Time:**	
Reach Length:			**Transect Interval:**			**Initials:**	
Transect	**Left Bank***	**Right Bank***		**Center Upstream**	**Center Right**	**Center Downstream**	**Center Left**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
Total by bank (TBB) (total each bank)			**Total by Position (TBP)**				
			Total Center Positions (TCP) (sum all TBP)				
Percent Cover by Bank [Divide each TBB by 187]			**Percent Cover for Center** [Divide TCP by 748]				
Total Percent Cover (Reach) TBB(L)+TBB(R)+TCP/1122							

*** = Left and right banks are determined looking downstream**

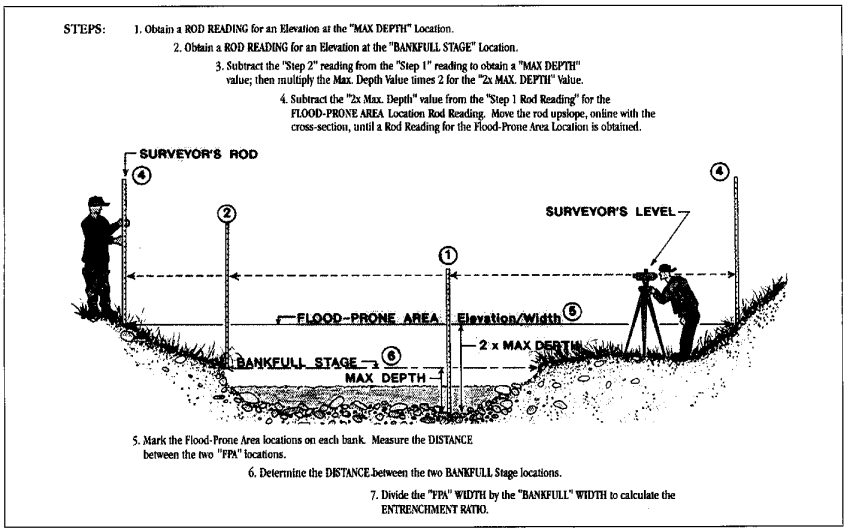
Rosgen Measurements

1. Identify the bankfull scar on both banks. *To identify the bankfull scar, look for a consistent change along the bank from terrestrial vegetation to exposed bank or aquatic vegetation. There is also usually a slight change in bank angle*. Measure the distance from the water surface to the bankfull scar using the stadia rod (see Figure 11.0. 1). Locate the deepest spot in the channel and measure the water depth. Add the two values (distance from the water surface to bankfull scar and maximum water depth) and record on the data sheet as bankfull height (Appendix H, Table H-4 or Table 11.0. 4).

Table 11.0. 4 Rosgen measurements field datasheet.

Transect	**1**	**2**	**3**
Bankfull Width:			
Max Bankfull Height:			
Width:Depth Ratio: (Bankfull Width/Max Bankfull Height)			
2 X Max Bankfull Height:			
Flood Prone Width: (width of floodplain inundated at elevation 2 X max bankfull height)			
Entrenchment Ratio: (Flood prone width/bankfull width)			

2. At bankfull height, measure channel width from one bank to the other. Record on datasheet as bankfull width (Appendix H, Table H-4 or Table 11.0. 4).
3. Divide the bankfull width by the max bankfull height to get width:depth ratio. Record value on datasheet (Appendix H, Table H-4 or Table 11.0. 4).



***To determine left bank and right bank, face downstream.**

Figure 11.0. 1 Rosgen (1996) data acquisition using surveyor's level and rod.

4. To determine flood prone width, measure a vertical distance 2 times the maximum bank full depth from the stream bottom using the stadia rod. At this elevation (2 X max depth), use the clinometer to eyeball a straight line perpendicular to the flow of the stream. Mark the two points where the imaginary line at this elevation intersects the floodplain. Measure the distance between these points with the tape and record on the datasheet as the flood prone width. (Appendix H, Table H-4 or Table 11.0. 4). This is an estimation of how much distance on each side of the stream is inundated during a ~50 year flood.
5. To calculate entrenchment ratio, divide the flood prone width by the max bankfull height and record this value on the datasheet.

Bed Substrate

1. Moving from one bank to another, randomly sample substrate at 8 locations along the transect (perpendicular to the direction of flow) within the wetted width of the stream. At the first random location, reach down into the water and grasp a piece of substrate encountered. Identify the substrate size class according to the datasheet and make a tally mark for the proper substrate class in the column for transect 1 (Appendix H, Table H-5 or Table 11.0. 5). Repeat at the other 7 random locations along the transect. Complete these procedures for each transect. If water is too deep to reach substrate by hand, use your foot to estimate substrate size class.

Table 11.0. 5 HCI bed substrate field datasheet.

SD DENR WPP Bed Substrate Composition

Project Site ID: _____ Stream Name: _____Sampler(s): _____ Date: _____ Time: _____

Organic and Inorganic Substrates														
	Description		Tally by Transect											
Substrate Type	Diameter (mm)	Description	downstream 1	2	3	4	5	6	7	8	9	10	upstream 11	Total
Clay (slick)	<0.004	Not Gritty												
Silt	0.004-0.062	Not Gritty												
Sand (gritty)	0.062-2	Gritty up to Ladybug size												
Very Fine Gravel	>2-4	Ladybug												
Fine Gravel	>4-8	Pencil Eraser												
Medium Gravel	>8-16	Marble												
Coarse Gravel	>16-32	Marble to Watch Face												
Very Coarse Gravel	>32-64	Watch Face to Tennis Ball												
Cobble	>64-128	Tennis Ball to Height of a Soda Can												
Large Cobble	>128-250	Height of a Soda Can to Basketball												
Small Boulder	>250-1000	Basketball to Width of a Microwave Oven												
Large Boulder	>1000-4000	Larger than a Microwave Oven												
Total Count	#	#												

12.0 SURVEY GRADE RADIO AND GPS ANTENNA SETUP, POWER UP PROCEDURES, AND CONDUCTING A REAL TIME KINEMATIC (RTK) SURVEY

Purpose
This section outlines an alternate way to setup and layout transects for habitat, fish, macroinvertebrate, periphyton, phytoplankton collection for analysis.

General Notes:
Be sure to use a fresh (fully charged) car battery every day for the base station and take extra batteries to swap out during the day and carry some for the rover. Charge controllers and rover batteries every night which takes approximately 8 hours and when done EXPLICITLY TURN GPS RECEIVERS OFF! Connect batteries last when setting up base station and make sure radio antenna bag is stored on top in car. Be gentle with all cords and especially gentle with the pole tip as breaking it affects height measurement.

A Setting up the Radio Antenna

1. Set up orange tripod roughly level (can step on corners and press them into ground).
2. Put antenna together and screw onto tripod
    a. you will need a cord in antenna set-up, has funny piece in the middle of it
    b. choose longer tip for antenna
    c. add the antenna extension for more height if desired.
3. Hang amplifier (yellow box with ridges on one side, labeled Trimmark 3) on tripod.
4. Plug in radio antenna to the port marked "Radio antenna" on the amplifier using the antenna cable (yellow with blue connectors); THIS CONNECTION MUST BE MADE BEFORE THE BATTERY IS CONNECTED TO THE AMPLIFIER (otherwise, it *fries!*).
5. Attach car battery.
6. Attach the black coaxial cable having the 6-pin Lemo connector to the I/O port of the amplifier.

B Setting up the base GPS Antenna:

1. Set up the yellow tripod with center pole set at 2m level and centered over benchmark
2. Connect Y lemo cable and com cable to base GPS receiver and screw on the 0.25m extension and adapter mount.
3. Mount base GPS receiver battery to antenna tripod and connect one of the Y lemo ends to the battery.
4. Turn on base GPS receiver and mount on the tripod.
5. Connect controller to base receiver and start base receiver.

C Conducting a GPS Survey:

A base station will be needed to survey for habitat to run a RTK survey. Set the base station as close to the site to be surveyed as possible. This will help with accuracy, and radio signal. It is a lot easier to do the survey and collect all the points needed if the "rubber ducky" antenna can be used since it is a lot smaller and lighter than the antennas needed for longer range.

1. Powering up

    a. Attach the power cable to the back of the radio (big, 2-pin Lemo).
    b. Attach the radio lemo cable to the remaining open end on base GPS receiver Y lemo cable.
    c. Attach the power cable to the leads on the battery (make sure to connect to the correct terminals).
    d. Now check that the displays on radio turn on.

2. Connect yellow handheld TSC2 controller to base GPS receiver using short black 6-pin com cable or through Bluetooth.
3. Turn on the TSC2 controller (navigate the TSC2 by tapping the screen with your finger or a stylus)

    a. Confirm that the receiver and TSC2 controller are communicating by checking the upper right corner of the screen – the number of satellites will be displayed there if communication is occurring.
    b. Create a new job or open desired job: Double-tap *Files*; Select *New job* or *Open job*.

        i. If new, Assign a job name, choose the appropriate *Coordinate. Systems* and hit *Accept*.
        ii. If opening an existing job, tap the desired project. The top of the main screen should now display the job name.

    c. Begin base-station transmission: Select *Survey / RTK / Start base receiver*; Screen reads *Starting survey*. Enter a point name, ether from the list, if the benchmark has already been entered or hit *Key In*, followed by *Here*, and then *Store*. Type base GPS receiver antenna height measured under *Antenna height*, typically 2.25m. Confirm that transmit delay = 0 ms. Hit *Enter*. The screen will read *Starting Survey* again; then disconnect the TSC2 controller when prompted.

4. Connect the TSC2 controller to the rover GPS receiver through Bluetooth. Attach the desired antenna and confirm connection by checking for the display of the number of satellites in the upper-right corner of the screen. There should also be a symbol for the base station in the upper-right corner.

5. Start Survey

   a. Select *Survey* / *RTK* / *Start survey*.
   b. Highlight the base station on the list, and hit *Enter*.
   c. Stay in place until the rover initializes (seconds to minutes). Confirm that the RMS misfit is ~ 1-2 cm before storing this value. Now record the observation: Give the point a name (preferably the last digit is numerical) and a code; Confirm height is set to desired pole height. Make sure that the rod is level, Hit *Measure*. When observation is complete, hit *Store*.
   d. To begin a survey, determine Mean River/Stream Width (MRSW) to layout transects using (Section B) of the habitat assessment section of this document (Section 10.0). Set the controller to take continuous topo points with the distance set to the transect spacing divided by ten (see Figure 1). Walk the stream placing transects at every ten points collected. Starting point name and code for these points are not critical, and can be as user desires.

Figure 12.0. 1 Controller set to take Continuous Topo

   e. To collect positions for the habitat survey, set the controller to measure points (Figure 12.0.2). Enter a Point Name for the first point to be taken for the survey as described in Figure 12.0.3. Only the 8th and 9th digit (4th segment in Figure 3) will need to be changed in the Point Name each time a different transect is surveyed to separate the

transacts. The Point Name will not need to be changed when surveying the same transect, the last number in the Point Name will increase by one for each new point

6.

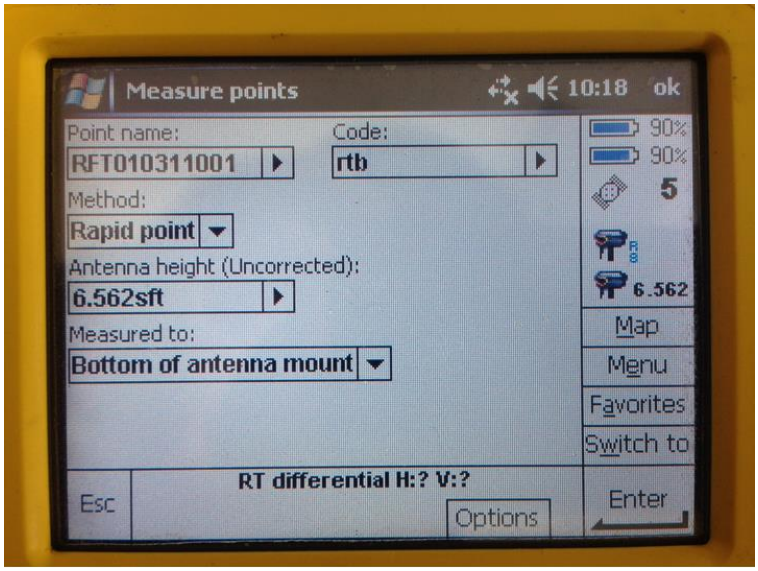
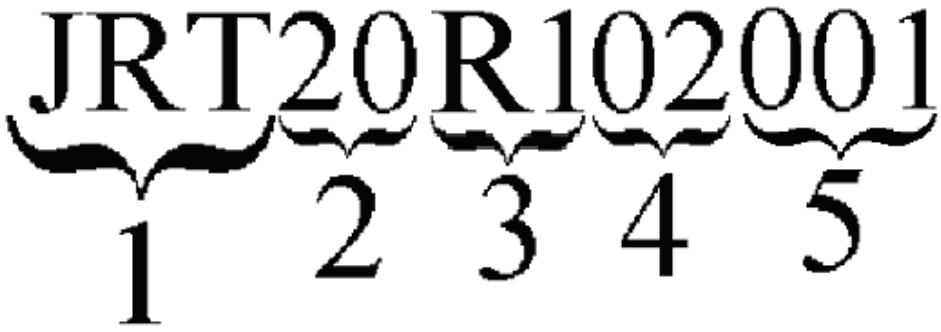


Figure 12.0. 2 Controller set to Measure Points



1. The first three spaces is the abbreviation of the stream or tributary.
2. The next two spaces is the site number.
3. The next two spaces describe what rover unit is used (ex. R2 for Rover 2).
4. The next two spaces are the transect number (01 thru 11).
5. The last three numbers always starts with 001 for each new transect and will automatically increase for each point.

Figure 12.0. 3 Point Name naming convention.

f. The Code for these points must be those found in Table 12.0. 1. The code is either two or three letters to describe the position being collected. Having the correct Point Name and Code is critical when process the points in the habitat database. In the wrong name or code is entered, it

usually can be corrected back at the office, but can be time consuming if there are many errors.

Table 12.0. 1 Transect codes for habitat assessment survey

Transect Attribute Library					
Left side			Right Side		
11	LTB	Left Top Bank	21	RTB	Right Top Bank
12	LBF	Left Bank Full	22	RBF	RIght Bank Full
13	LEW	Left Edge Water	23	REW	Right Edge Water
14	LCB	Left Channel Bottom	24	RCB	Right Channel Bottom
15	LSL	Left Slumpage	25	RSL	Right Slumpage
Profile			Erosional		
34	CB	Channel Bottom	41	LSE	Left Start Erosion
35	WS	Water Surface	42	LEE	Left End Erosion
36	BF	Bank Full	43	RSE	Right Start Erosion
37	TH	Thalweg	44	REE	Right End Erosion
Vegetation			Deposition		
51	LSV	Left Start Vegetation	61	LSD	Left Start Deposition
52	LEV	Left End Vegetation	62	LED	Left End Deposition
53	RSV	Right Start Vegetation	63	RSD	Right Start Deposition
54	REV	Right End Vegetation	64	RED	Right End Deposition
Buffer			Miscellaneous		
71	LSB	Left Start Buffer	81	INT	Intermediate
72	LEB	Left End Buffer			
73	RSB	Right Start Buffer			
74	REB	Right End Buffer			

g. Collect points for all key positions in the transect profile as seen in Figure 12.0.4 below. It doesn't matter where collection starts or ends on the profile nor which transect is completed first. Use only one point code for each position that describes left or right (ex. LTB, REW) multiple points for other positions may be required to accurately show the transitions in the profile (ex. CB, INT).

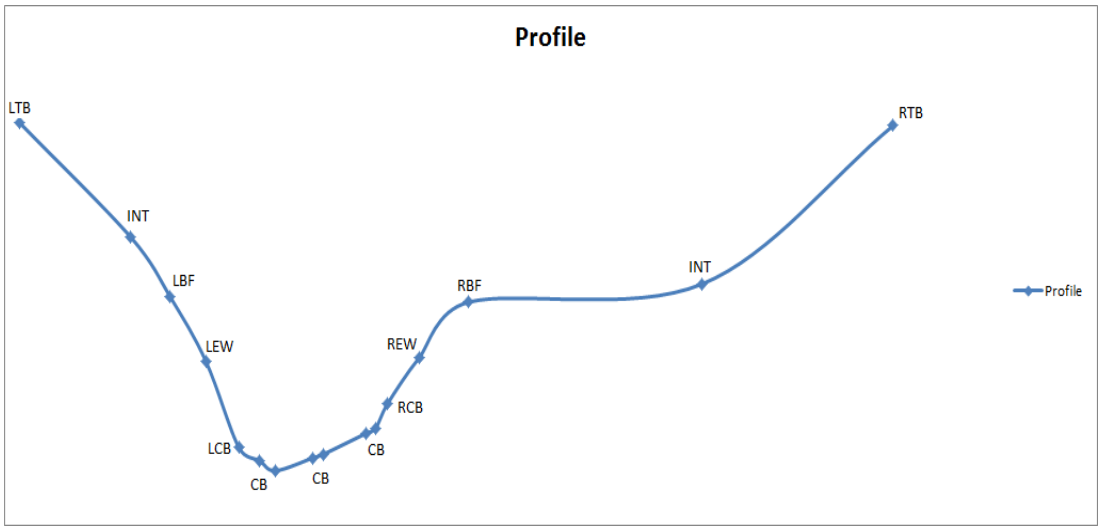


Figure 12.0. 4 Key positions in the Transect Profile.

h. Positions for the thalweg can be collected between collecting positions for transects or at any time during the survey. The Point Name does not need to be changed when these positions are collected between transects. Generally ten positions should be collected with one shot for thalweg (code: TH) and one for water surface (code: WS) at each position between transects. Figure 12.0.5 shows the results of points collected for the thalweg.

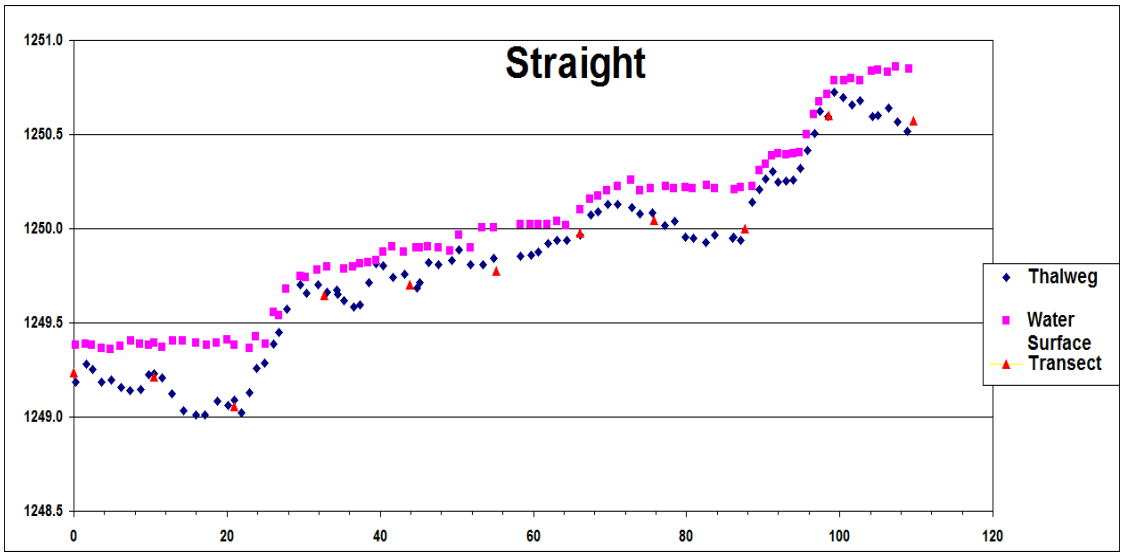


Figure 12.0. 5 Thalweg and water surface profile.

6. **End Survey**

a. Hit *Esc* to go to the main screen.
b. Select *Survey / RTK / End GNSS survey.*
c. This will turn off the rover GPS receiver. Double check and if not turned off, do so manually.

d. Connect to base GPS receiver, select *Survey / RTK / End GNSS survey.*

e. This will turn off the base GPS receiver. Double check and if not turned off, do so manually.

f. Pack and stow everything into the yellow suitcases and cloth bags.

g. Return to the office or home and prepare to transfer the data from the TBC or the controller using the procedures outlined in the following Section (Section 12.0 (D) below).

D. Habitat Survey Data Transfer for entry into the Habitat Database, Database editing and use

1. Data Transfer

a. Points from the habitat survey must be transferred into Excel from TBC or the controller. The format must be in South Dakota South (or North depending on the area that the survey was completed) and in meters. It is recommended to have the time stamp for the point along with the Name, Northing, Easting, Elevation and Feature code. Table 12.0.2 is an example of points to be put into the Habitat database. The database can be found on the SD DENR computer system at: N:\WATRSHED\Habitat. The database should be labeled HabitatNew.mdb.

Table 12.0. 2 Example of data formatting for points to be transferred to the Habitat Database

Name	Northing(y)	Easting(x)	Elevation	Feat_Code1	Date Taken
bat030301001	170366.19	366541.607	1005.871	rtb	09/12/2012 12:36
bat030301002	170366.746	366542.245	1005.646	int	09/12/2012 12:37
bat030301003	170367.176	366542.83	1005.527	int	09/12/2012 12:37
bat030301004	170367.631	366543.502	1005.265	int	09/12/2012 12:37

2. Data Entry and Editing

a. After opening the habitat database, the screen below will appear (Figure 12.0.6). The right side of the screen shows all points by site that have already been entered to the database, and on the left are command buttons and a dropdown. To view a site that has already been entered, find the desired site in the “Stream and Site” dropdown, and click “Edit Points”. To get started with entering a new site leave the “Stream and Site” drop down empty and click “Edit Points”. If a site must be deleted, click “Delete Site”. This is the only way to totally eliminate a site from the database.

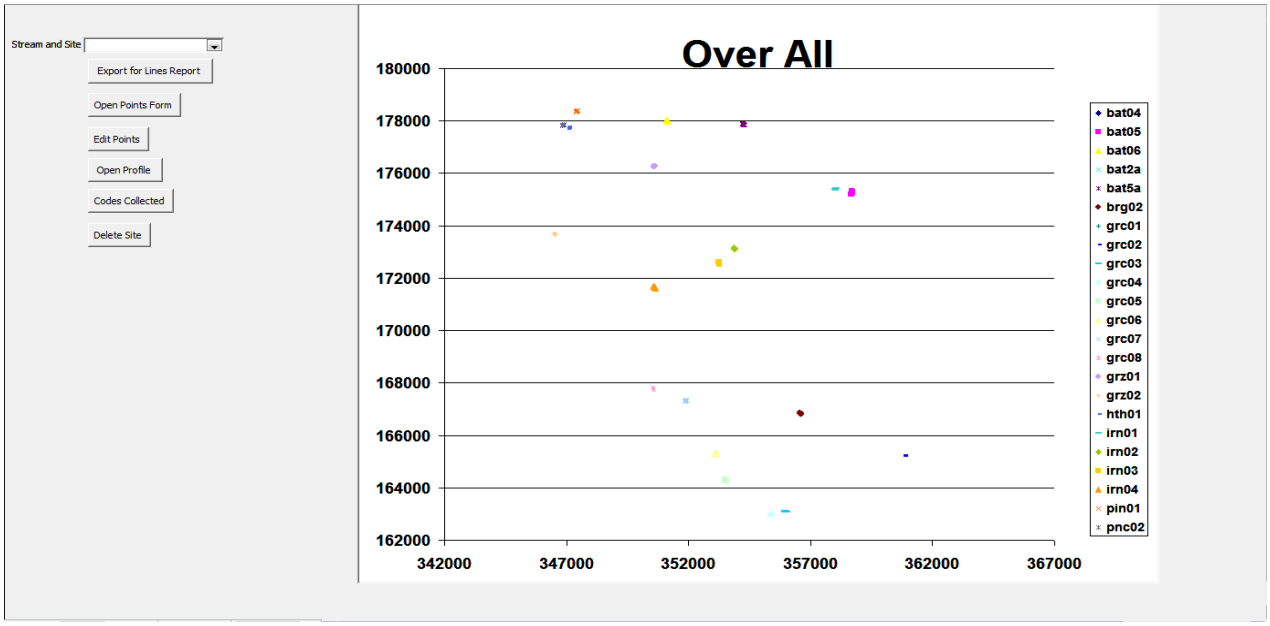


Figure 12.0. 6 Opening screen of the habitat database with points entered into the database on the right and command buttons and a dropdown on the left.

b. Below is a blank "Edit Points" form to enter points into. The raw data must be entered and processed though this screen. To get started, copy and paste all the point information into the form with all the headings matching the order of data in the excel columns. This can be done by copying all the data in the excel form, then right click the * in front of the "Name" column and select "Paste".

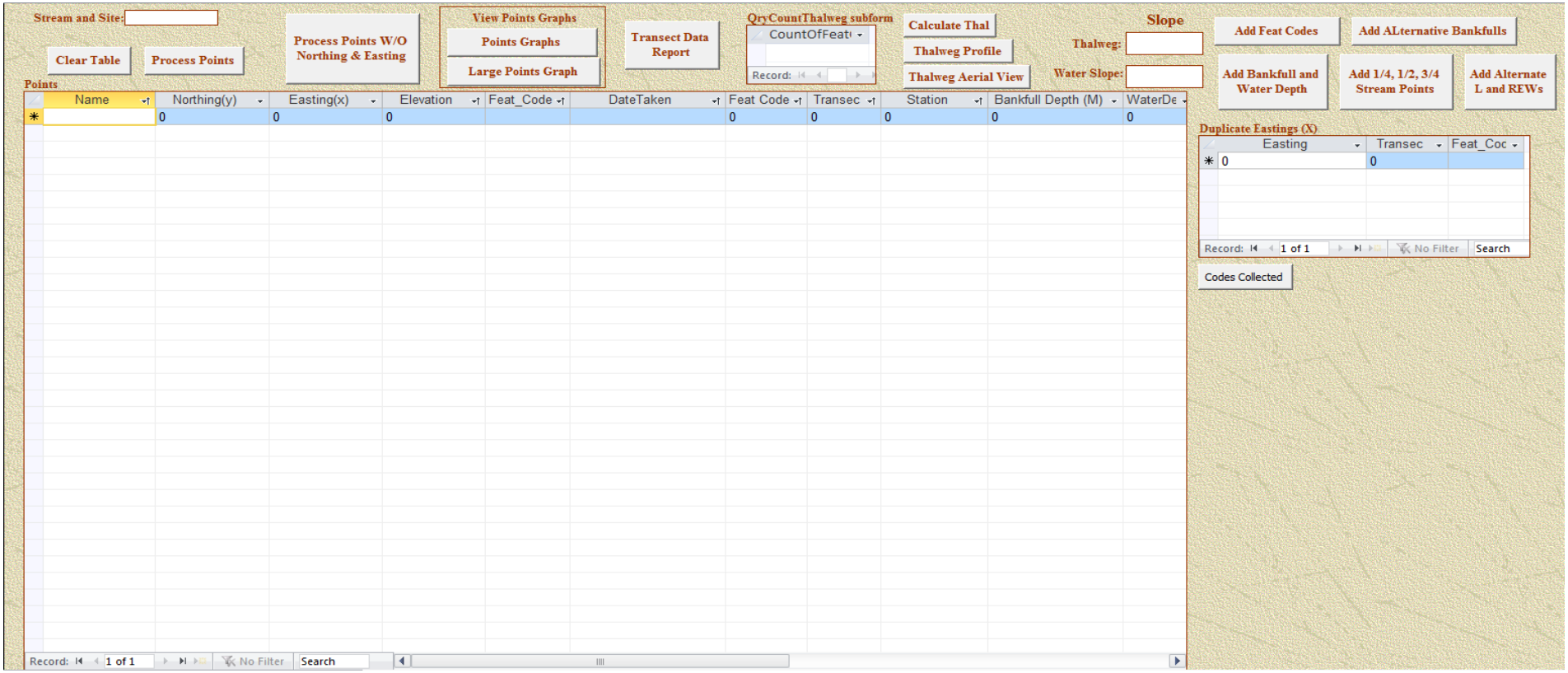


Figure 12.0. 7 "Edit Points" form for entering and processing raw data

c. To process the points will take a few different steps going back and forth to make sure all the points needed were collected and entered correctly.

i. Click "Add Feat Codes" in the upper right part of the screen. This will add a number into the "Feat Code" column for all points. Check to make sure that there is no "0" in this column.

ii. Click "Process Points" in the upper left part of the screen. This should re-order the table on the screen in order of "Transect" and "Station". Make sure all segments look correct. Sometimes a code could be entered wrong, and the order of transects could be incorrect. All transect stations should start on the left and increase as it moves to the right. Typically the first point should have a LTB in the "Feat Code" column.

iii. Check the "Duplicate Easting (X)" table in the upper right of the screen. If there are any points in this box go into the Points table and change the Easting by .001 for one of the duplicates. A duplicate easting could affect the layout of the graphs. Click the "Points Graphs" at the top of the form.

d. From the Points Graph form below, each transect profile can be seen in the upper left "Straight On" graph, the raw transect points can be seen in the "Areal Before Straight" graph, and the processed points can be seen in the "Aerial After Straight" graph (Figure 12.0.8). The graph in the upper right shows all transects and thalweg points. In this graph it will be easier to see if there is a point from one transect in a different transect (very common mistake). There is a right and left arrow in the upper right part of this form that can be used to navigate to different transects.

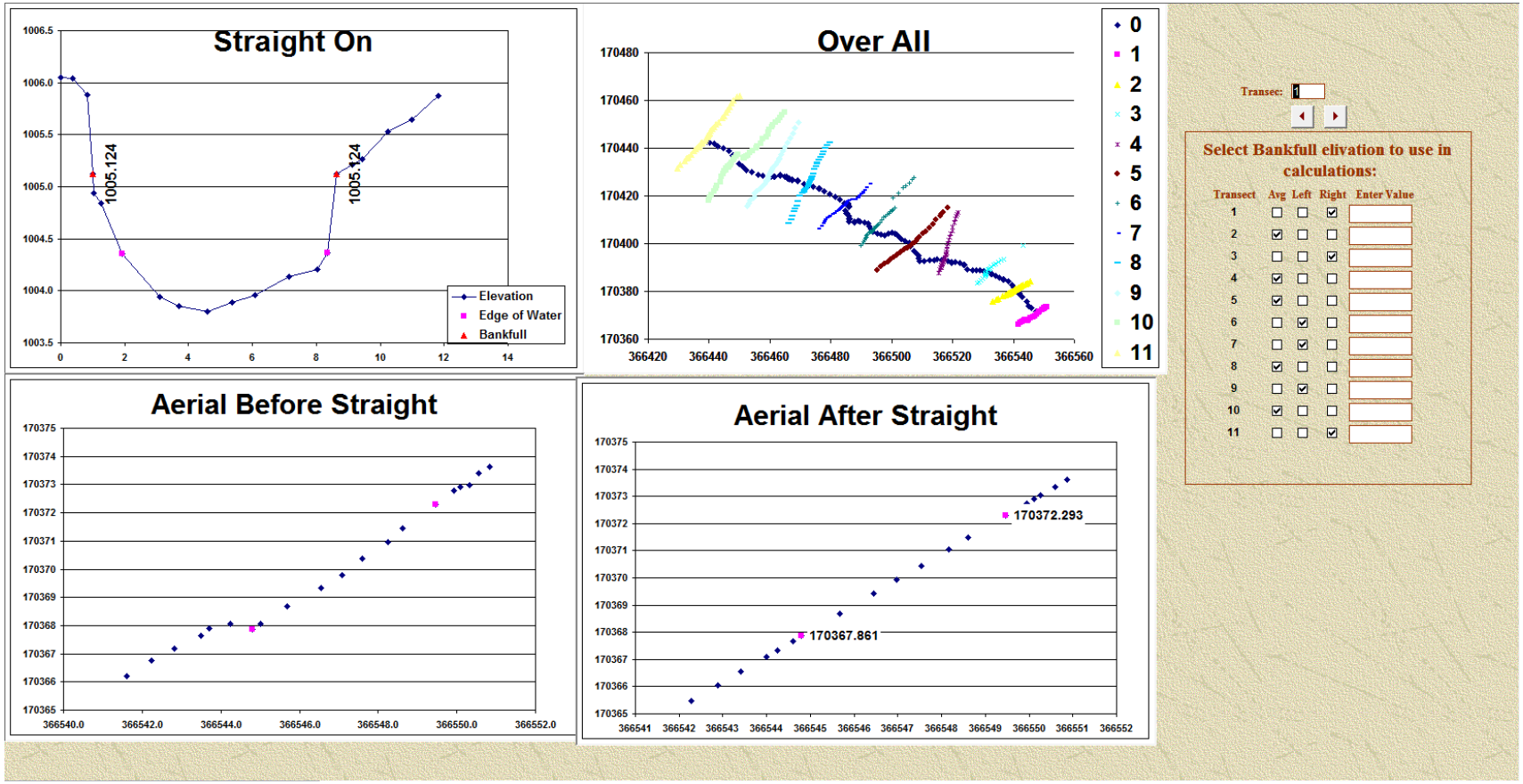
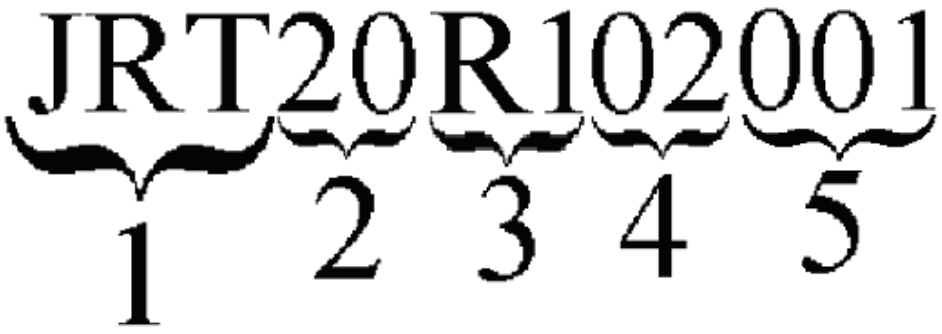


Figure 12.0. 8 Example of the Points Graph form from the Habitat Database.

e. While checking transects on the Points Graphs page, there is a "Select Bankfull Elevation" box on the right side of the screen. Select a bankfull point for each transect that best represents the site. The bankfull points can be seen in the "Straight On" graph. Either side can be selected or select average to use an elevation in the middle. If a one side is missing, make sure to select the side that is present. A value can also be entered to represent the desired elevation if neither side happens to be available. Click the X in the top right corner of the screen to close this form when completed. If any corrections to a point are needed, they will need to be corrected in the "Edit Points" form and then reprocessed. If there is a point, or multiple points in the wrong transect, the numbers over "4" in the figure below must be changed to the correct transect for those points in the point name (Figure 12.0.9).



6. The first three spaces is the abbreviation of the stream or tributary.
7. The next two spaces is the site number.
8. The next two spaces describe what rover unit is used (ex. R2 for Rover 2).
9. The next two spaces are the transect number (01 thru 11).
10. The last three numbers always starts with 001 for each new transect and will automatically increase for each point.

Figure 12.0. 9 "Point Name" naming convention and locations.

f. It is very important to make sure that there is a point for all the required positions in a transect. Sometimes there could positions missing if a point is labeled wrong, or possibly not able to collect the point in the field. A report to list all transects and positions can be generated by clicking "Codes Collected" in the central right side of the Edit Points form. This report can be seen below (Figure 12.0. 10). There must be 1 and only 1 position for all of the three lettered positions (several positions are allowed for Channel Bottoms (CB)). Several different methods can be used to generate or correct the points.

Feature Codes Collected for:

bat03

Transec	LTB	LBF	LEW	LCB	CB	RCB	REW	RBF	RTB
1	1	0	1	1	5	1	1	1	1
2	1	1	1	1	6	1	1	1	1
3	1	1	1	1	5	1	1	1	1
4	1	1	1	1	3	1	1	1	1
5	1	1	1	1	4	1	1	1	1
6	1	1	1	1	6	1	1	0	1
7	1	1	1	1	4	1	1	0	1
8	1	1	1	1	6	1	1	1	1
9	1	1	1	1	10	1	1	0	1
10	1	1	1	1	6	1	1	1	1
11	1	0	1	1	7	1	1	1	1

Figure 12.0. 10 Summary list of all codes collected for reference

g. Point labeled incorrectly: find the point and change its feature codes on the Enter Points page. If the "Feat_Code" for a point is changed, the "Feat Code" must also be changed to correspond to that position. If an Edge of water point is changed, go back to step 2 in this document.

h. Missing bankfull: fill in information needed in the "Select Bankfull Elevation" box on the "Points Graphs" form, and then click "Add Alternative Bankfulls" on the Edit Points form to generate the missing points.

i. Missing Edge of Water: use "Add Alternate L and REW's" in the upper right corner of the screen. There must at least be one edge of water point collected to make this command work. If an alternate edge of water is generated, go back to step 2 in this document

   i. After all points have been fixed, and the Codes Collected report is complete, the stream points need to be added. This is done by clicking "Add ¼, ½, ¾ Stream Points" in the upper right corner of the Edit Points form. After clicking this, all transects should have these points added.

   ii. The "Add Bankfull and Water Depth" button can now be pressed, which is also in the upper right sided of the Edit points form. This will give a bankfull depth and a water depth for all points that fall between the LBF and RBF positions.

j. If everything is entered correctly, the "Transect Data Report" can be opened, and will look like the figure below (Figure 12.0. 11). This report is generated by clicking the button with the corresponding name in the top center of the Enter Points form. If a position is missing on any transect for the site, the report will more than likely error out. Data from these reports (one report per transect (11 reports per reach)) should be transcribed on to

the transect specific Habitat Assessment transect datasheet Section I and Section J. These data along with data filled in the field should complete each transect datasheet form.

Transec	Code	Station	Bankfull De	WaterDepth
11				
	LTB	7.21	0.00	0.00
	LBF	18.01	0.00	0.00
	LEW	20.11	0.08	
	LCB	20.37	0.67	0.59
	STR1/4	21.42	0.84	0.76
	STR1/2	22.73	0.82	0.74
	RCB	23.62	0.72	0.64
	STR3/4	24.04	0.32	0.24
	REW	25.34	0.08	0.00
	RBF	25.75	0.00	0.00
	RTB	31.56	0.00	0.00

BTW	24.35	BFW	7.75	CBW	3.24	SW	5.23	LBH	1.21	RBH	1.52

Left Bank Height:	1.21	Right Bank Height:	1.52
Left Bank Angle:	5.25	Right Streambank Length:	8.09
Left StreambankLength:	13.22	Right Bank Angle:	10.83

Figure 12.0. 11 An example of the transect data report

k. Processing the thalweg. Click "Calculate Thal" at the top central part of the Edit Points form. The processing may take a couple minutes to complete, and the countdown may stop, but should come to an end. After the processing is done, close and reopen the Edit Points form. There should now be a station for all the water surfaces (WS) and thalwegs (TH). There should also be a slope calculated in the two corresponding text boxes at the top of the page.

l. Clicking "Thalweg Profile" will generate a report similar to the figure below (Figure 12.0. 12). This shows the site in a straight line and shows where pools and riffles are located. The ▲ are locations for the transects.

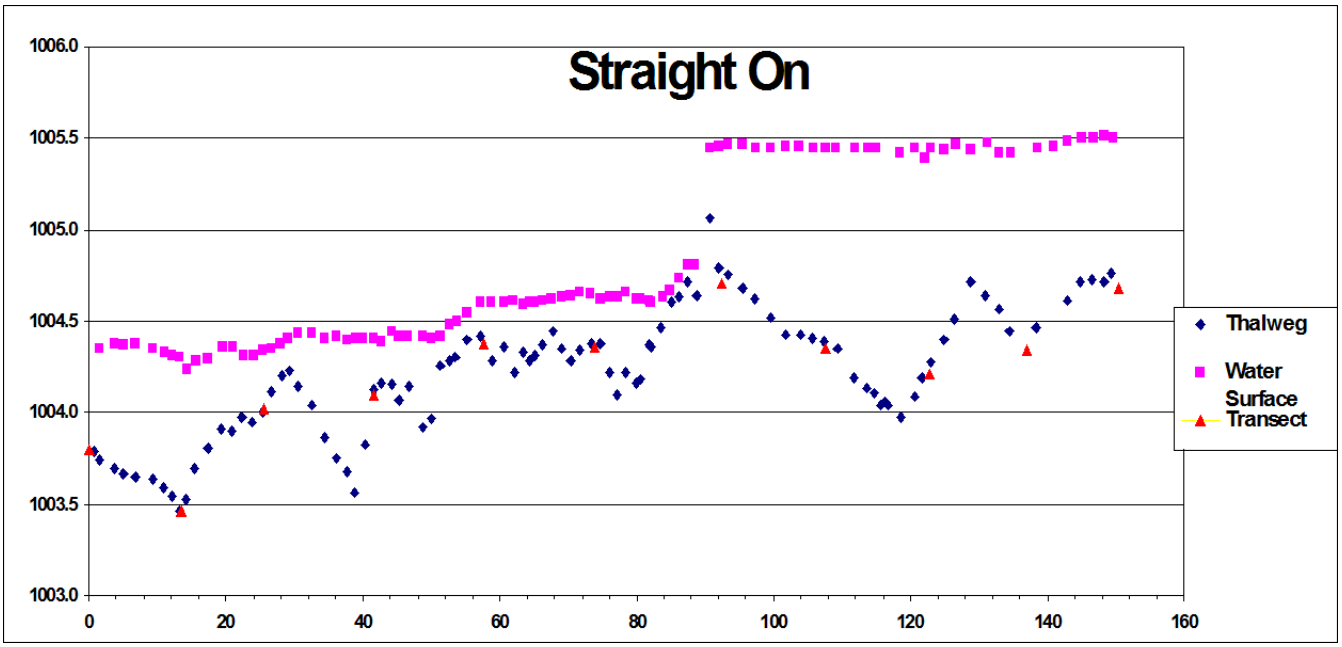


Figure 12.0. 12 Example thalweg, water surface and transect location report

m. Clicking "Thalweg Aerial View" will generate a report similar to the figure below (Figure 12.0. 13). This figure would be similar to a map done in GIS. This shows the meandering of the stream segment, and again the ▲ are the locations of transects.

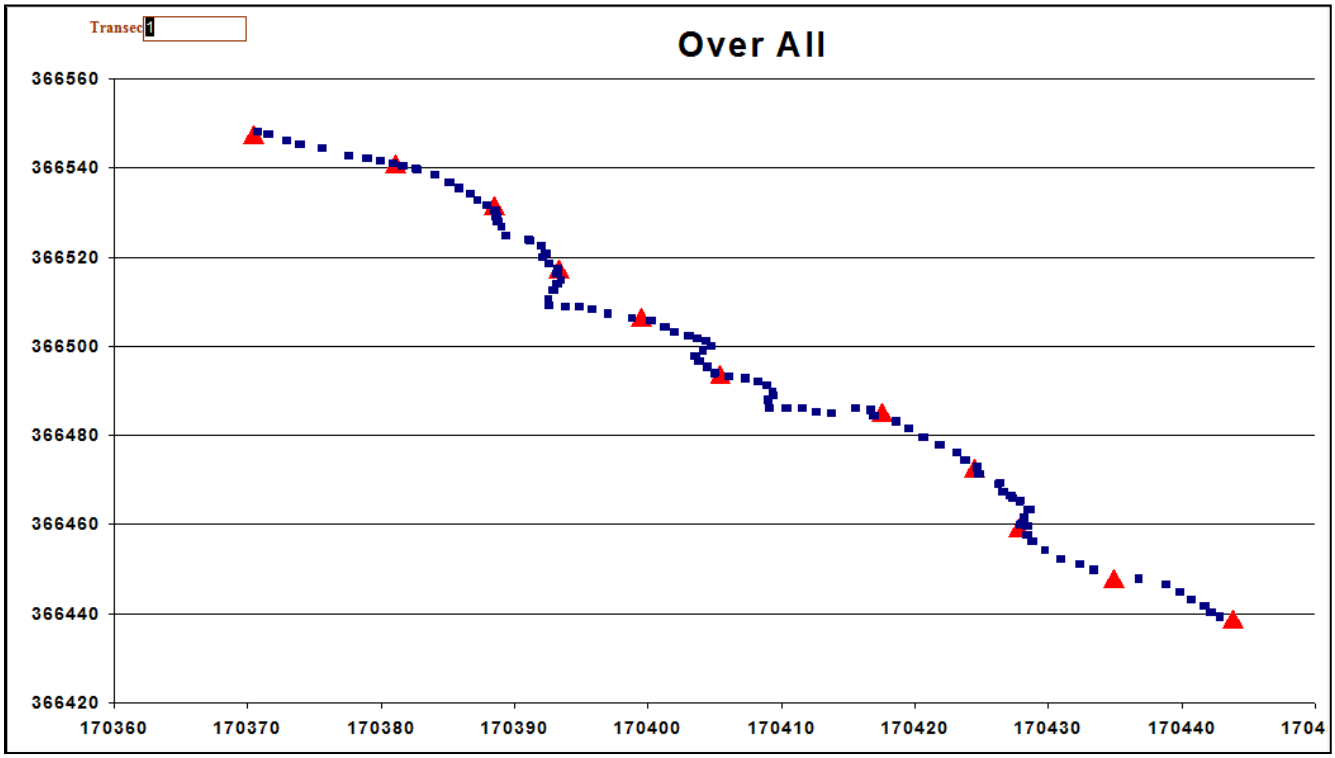
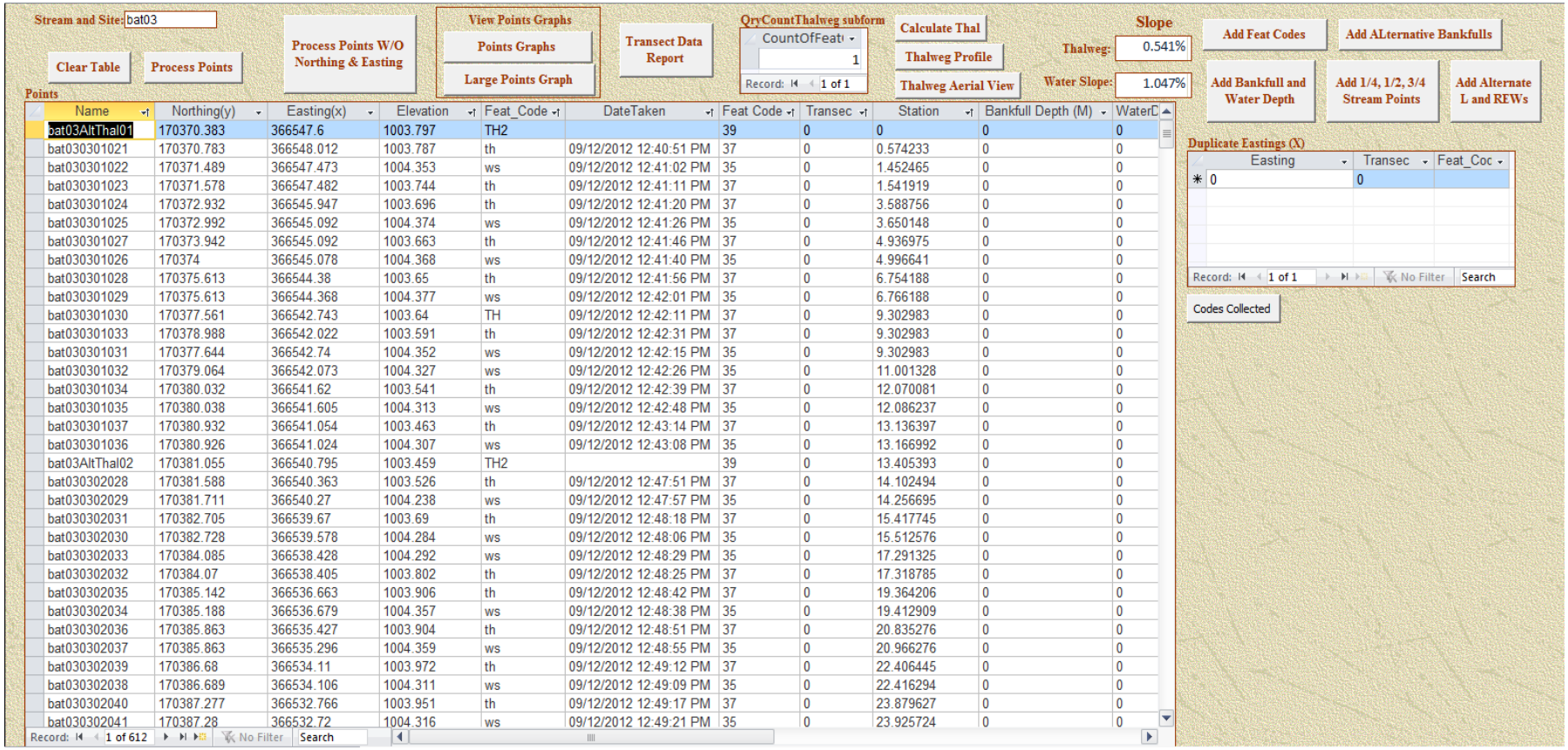


Figure 12.0. 13 A example of the thalweg aerial view showing the meandering of the stream in the segment

Below is a screen shot of a completed site (Figure 12.0. 14). The main causes for errors are incorrect labeling of points and not having collected all the points needed to make up a transect set. If there were two data collectors that gathered the data, it could be possible that the site name (first 5 letters of the point Name) were different, and some of the points would be processed as a different site.



Name	Northing(y)	Easting(x)	Elevation	Feat_Code	DateTaken	Feat Code	Transec	Station	Bankfull Depth (M)	WaterD
bat03AltThal01	170370.383	366547.6	1003.797	TH2		39	0	0	0	0
bat030301021	170370.783	366548.012	1003.787	th	09/12/2012 12:40:51 PM	37	0	0.574233	0	0
bat030301022	170371.489	366547.473	1004.353	ws	09/12/2012 12:41:02 PM	35	0	1.452465	0	0
bat030301023	170371.578	366547.482	1003.744	th	09/12/2012 12:41:11 PM	37	0	1.541919	0	0
bat030301024	170372.932	366545.947	1003.696	th	09/12/2012 12:41:20 PM	37	0	3.588756	0	0
bat030301025	170372.992	366545.092	1004.374	ws	09/12/2012 12:41:26 PM	35	0	3.650148	0	0
bat030301027	170373.942	366545.092	1003.663	th	09/12/2012 12:41:46 PM	37	0	4.936975	0	0
bat030301026	170374	366545.078	1004.368	ws	09/12/2012 12:41:40 PM	35	0	4.996641	0	0
bat030301028	170375.613	366544.38	1003.65	th	09/12/2012 12:41:56 PM	37	0	6.754188	0	0
bat030301029	170375.613	366544.368	1004.377	ws	09/12/2012 12:42:01 PM	35	0	6.766188	0	0
bat030301030	170377.561	366542.743	1003.64	TH	09/12/2012 12:42:11 PM	37	0	9.302983	0	0
bat030301033	170378.988	366542.022	1003.591	th	09/12/2012 12:42:31 PM	37	0	9.302983	0	0
bat030301031	170377.644	366542.74	1004.352	ws	09/12/2012 12:42:15 PM	35	0	9.302983	0	0
bat030301032	170379.064	366542.073	1004.327	ws	09/12/2012 12:42:26 PM	35	0	11.001328	0	0
bat030301034	170380.032	366541.62	1003.541	th	09/12/2012 12:42:39 PM	37	0	12.070081	0	0
bat030301035	170380.038	366541.605	1004.313	ws	09/12/2012 12:42:48 PM	35	0	12.086237	0	0
bat030301037	170380.932	366541.054	1003.463	th	09/12/2012 12:43:14 PM	37	0	13.136397	0	0
bat030301036	170380.926	366541.024	1004.307	ws	09/12/2012 12:43:08 PM	35	0	13.166992	0	0
bat03AltThal02	170381.055	366540.795	1003.459	TH2		39	0	13.405393	0	0
bat030302028	170381.588	366540.363	1003.526	th	09/12/2012 12:47:51 PM	37	0	14.102494	0	0
bat030302029	170381.711	366540.27	1004.238	ws	09/12/2012 12:47:57 PM	35	0	14.256695	0	0
bat030302031	170382.705	366539.67	1003.69	th	09/12/2012 12:48:18 PM	37	0	15.417745	0	0
bat030302030	170382.728	366539.578	1004.284	ws	09/12/2012 12:48:06 PM	35	0	15.512576	0	0
bat030302033	170384.085	366538.428	1004.292	ws	09/12/2012 12:48:29 PM	35	0	17.291325	0	0
bat030302032	170384.07	366538.405	1003.802	th	09/12/2012 12:48:25 PM	37	0	17.318785	0	0
bat030302035	170385.142	366536.663	1003.906	th	09/12/2012 12:48:42 PM	37	0	19.364206	0	0
bat030302034	170385.188	366536.679	1004.357	ws	09/12/2012 12:48:38 PM	35	0	19.412909	0	0
bat030302036	170385.863	366535.427	1003.904	th	09/12/2012 12:48:51 PM	37	0	20.835276	0	0
bat030302037	170385.863	366535.296	1004.359	ws	09/12/2012 12:48:55 PM	35	0	20.966276	0	0
bat030302039	170386.68	366534.11	1003.972	th	09/12/2012 12:49:12 PM	37	0	22.406445	0	0
bat030302038	170386.689	366534.106	1004.311	ws	09/12/2012 12:49:09 PM	35	0	22.416294	0	0
bat030302040	170387.277	366532.766	1003.951	th	09/12/2012 12:49:17 PM	37	0	23.879627	0	0
bat030302041	170387.28	366532.72	1004.316	ws	09/12/2012 12:49:21 PM	35	0	23.925724	0	0

Easting	Transec	Feat_Coc
0	0	

Figure 12.0. 14 A completed "Edit Points" form with errors to use for reference

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Appendix A

Lake Habitat Assessment and Macrophyte Survey Field Datasheet Set

Table A-1. Lake Habitat and Macrophyte survey sheet.

SD DENR WPP Lake Habitat Assessment Field Data Sheet—Macrophyte Survey

Lake Name:	Lake ID:	Date:	Time:
Acres/Hectares:	Station #	Transect _____ of _____	
Sampling Personnel:			

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Bank Stability	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE _	10 9	8 7 6	5 4 3	2 1 0
2. Vegetative Protection	More than 90% of the bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the bank surfaces covered by vegetation; disruption of bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___	10 9	8 7 6	5 4 3	2 1 0
3. Riparian Vegetative Zone Width	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ____	10 9	8 7 6	5 4 3	2 1 0

Total Score _____ Maximum Depth of Plant Colonization_____ (m)

Density Rating Chart					
Rake Recovery of Aquatic Plant Type	Density	Descriptive Term	Rake Recovery of Aquatic Plant Type	Density	Descriptive Term
Taken in all 4 casts (teeth of rake full)	5	Dense	Taken in 2 casts	2	Scattered
Taken in 4 casts	4	Heavy	Taken in 1 cast	1	Sparse
Taken in 3 casts	3	Moderate			

Location A		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

Location B		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

Location C		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

Location D		Secchi				
Lake Depth		Position				
Species		12	3	6	9	Density

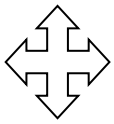
Table A-1.1 Lake Habitat and Macrophyte survey Map.

SD DENR WPP Lake Habitat Assessment Field Data Sheet—Macrophyte Survey Lake Map

Macrophyte Survey Lake Map

Lake ID:	Lake Name:	Acres/Hectares:
Date:	Time:	Sampler(s)

Draw a sketch of the lake with transect numbers and locations. Include the location of the deepest part of the lake, macrophyte beds not on survey transects, locations of photographic points, direction of photograph, and frame number.



Approximate Distance

Appendix B

SD DENR WPP In-lake Sampling Field Data Collection Sheet Set

Table B-1. In-Lake Field Datasheet.

South Dakota DENR WPP In-lake Sampling Field Data Collection Sheet

Lake Name _____ **Lake ID** _____

Sampler(s) _____ **Date** _____ **Time** _____

Secchi Site A	Secchi Site B	Secchi Site C
Dis-Appearance Depth:_____(0.1 m) (if DAP < 1.0 m, then depth to 0.05 m)	Dis-Appearance Depth:_____(0.1 m) (if DAP < 1.0 m, then depth to 0.05 m)	Dis-Appearance Depth:_____(0.1 m) (if DAP < 1.0 m, then depth to 0.05 m)
Re-Appearance Depth:_____(0.1 m)	Re-Appearance Depth:_____(0.1 m)	Re-Appearance Depth:_____(0.1 m)
Euphotic Zone (RAD x 2) _____m	Euphotic Zone (RAD x 2) _____m	Euphotic Zone (RAD x 2) _____m
EZ = < 2.0 m, sample within EZ only	EZ = < 2.0 m, sample within EZ only	EZ = if < 2.0 m, sample within EZ only
EZ = ≥ 2.0 m, samples from top 2.0 m of water column	EZ = ≥ 2.0 m, samples from top 2.0 m of water column	EZ = ≥ 2.0 m, samples from top 2.0 m of water column

Total Depth Site A:_____(m) _____(ft) Total Depth Site B:_____(m) _____(ft) Total Depth Site C:_____(m) _____(ft)

Lake Profile

Site A					Site B					Site C				
Depth	Temp.	SpCond	pH	DO	Depth	Temp.	SpCond	pH	DO	Depth	Temp.	SpCond	pH	DO

Table continued on back of sheet

Surface Temp._____ Bottom Temp._____ Surface DO_____ Bottom DO_____ Surface pH _____ Bottom pH _____ Surface Sp. Cond _____ Bottom Sp. Cond _____

Surface Temp._____ Bottom Temp._____ Surface DO_____ Bottom DO_____ Surface pH _____ Bottom pH _____ Surface Sp. Cond _____ Bottom Sp. Cond _____

Surface Temp._____ Bottom Temp._____ Surface DO_____ Bottom DO_____ Surface pH _____ Bottom pH _____ Surface Sp. Cond _____ Bottom Sp. Cond _____

Average Depth _____(m)

Average Surface Temp._____(°C)

Average Surface DO _____(mg/L)

Average Surface pH _____(s.u.)

Average Surface Conductivity _____ (µS/cm)

Average Secchi Depth _____(m)

Average Bottom Temp. _____(°C)

Average Bottom DO _____(mg/L)

Average Bottom pH _____(s.u.)

Average Bottom Conductivity _____(µS/cm)

Notes:

Table B-1.1. In-Lake Field Datasheet.

SD DENR WPP In-lake Sampling Field Data Collection Sheet

Lake Name ____ Lake ID ________________

Sampler(s) __________________________ Date _____________ Time _____________

Lake Profile (continued)

Site A					Site B					Site C				
Depth	Temp.	SpCond	pH	DO	Depth	Temp.	SpCond	pH	DO	Depth	Temp.	SpCond	pH	DO

Notes:

Table B-2. In-lake Phytoplankton and Zooplankton Field Collection Datasheet.

SD DENR WPP In-lake Phytoplankton[1]/Zooplankton[2] Field Data Collection Sheet

Lake Name _____ **Lake ID** _____

Sampler(s) _____ **Date** _____ **Time** _____

Type of Sampling Device: (Circle one) Wisconsin Net Student Net 0.5 or 1.0 meter Plankton Net

Site _____	Site _____	Site _____
Aperture Size _____(m)	Aperture Size _____(m)	Aperture Size _____(m)
Mesh Size _____(µm)	Mesh Size _____(µm)	Mesh Size _____(µm)
Tow Length _____(m)	Tow Length _____(m)	Tow Length _____(m)
Number of Tows _____(m)	Number of Tows _____(m)	Number of Tows _____(m)
Total Depth _____(m)	Total Depth _____(m)	Total Depth _____(m)
Secchi Depth _____	Secchi Depth _____	Secchi Depth _____

Total Tow Length (for composite phytoplankton and/or zooplankton samples) _____ (m)

Average Depth: _____ (m) Average Secchi Depth: _____ (m)

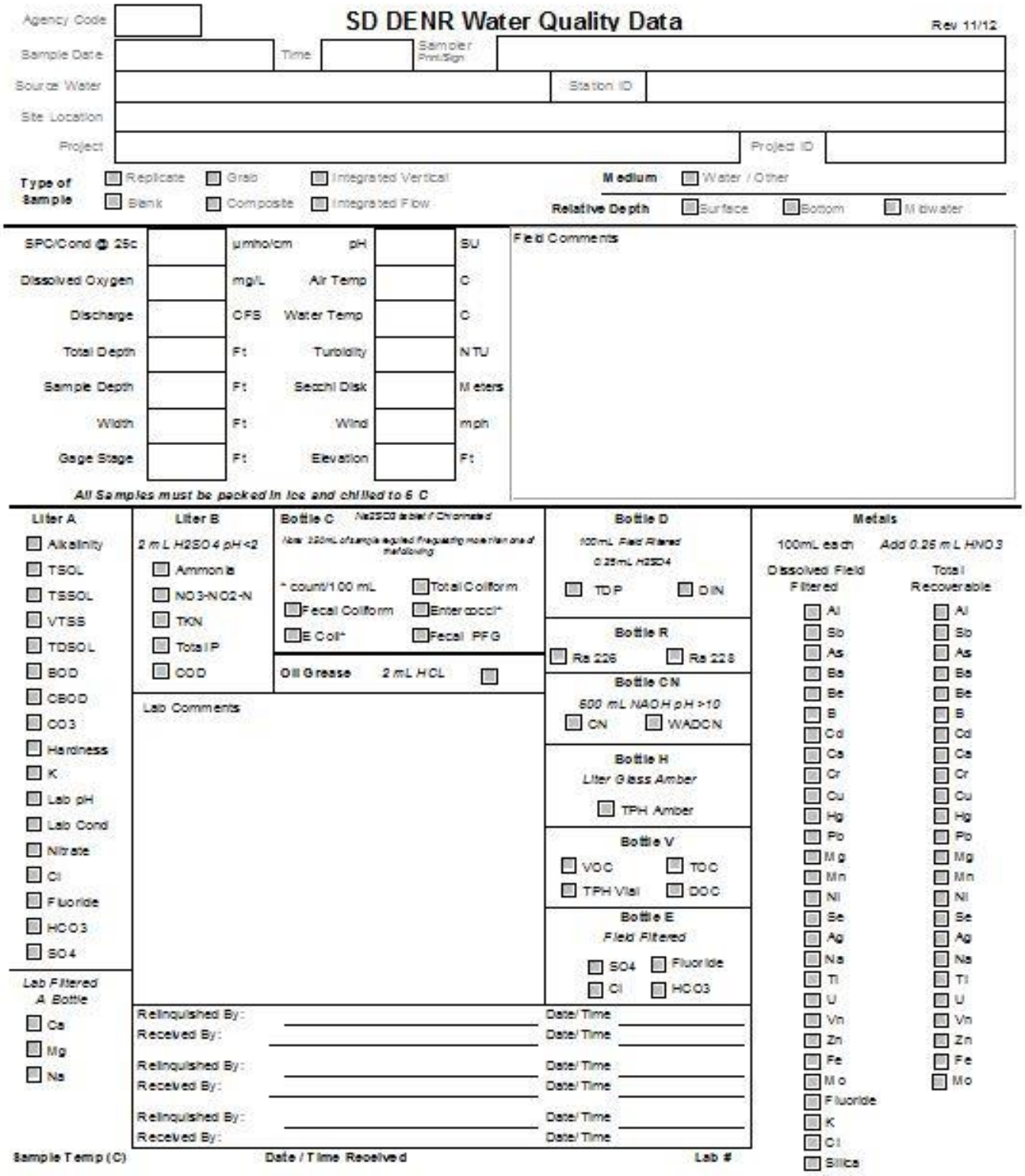
[1] = Preserve Phytoplankton samples with 2 to 5 mL Lugols solution (sample should look like weak tea when finished.
[2] = Preserve Zooplankton samples with 95 % ethanol solution.

Field Notes and Observations:

Appendix C

SD DENR WPP Water Quality Datasheet

Table C-1. SD DENR WPP Water Quality Datasheet



SD DENR Water Quality Data

Rev 11/12

Agency Code

Sample Date | Time | Sampler Print/Sign

Source Water | Station ID

Site Location

Project | Project ID

Type of Sample: Replicate, Grab, Integrated Vertical, Blank, Composite, Integrated Flow

Medium: Water / Other

Relative Depth: Surface, Bottom, Midwater

SPC/Cond @ 25c		µmho/cm	pH		SU
Dissolved Oxygen		mg/L	Air Temp		C
Discharge		CFS	Water Temp		C
Total Depth		Ft	Turbidity		NTU
Sample Depth		Ft	Secchi Disk		Meters
Width		Ft	Wind		mph
Gage Stage		Ft	Elevation		Ft

Field Comments

All Samples must be packed in Ice and chilled to 6 C

Liter A
- Alkalinity
- TSOL
- TSSOL
- VTSS
- TDSOL
- BOD
- CBOD
- CO3
- Hardness
- K
- Lab pH
- Lab Cond
- Nitrate
- Cl
- Fluoride
- HCO3
- SO4

Lab Filtered A Bottle
- Ca
- Mg
- Na

Liter B — *2 mL H2SO4 pH <2*
- Ammonia
- NO3-NO2-N
- TKN
- Total P
- COD

Bottle C — *Na2SO3 label if Chlorinated*

Note: 250mL of sample required if requesting more than one of the following

* count/100 mL | Total Coliform | Fecal Coliform | Enterococci* | E Coli* | Fecal PFG

Oil Grease — *2 mL HCL*

Lab Comments

Bottle D — *100mL Field Filtered, 0.25mL H2SO4*
- TDP
- DIN

Bottle R
- Ra 226
- Ra 228

Bottle CN — *500 mL NAOH pH >10*
- CN
- WADCN

Bottle H — *Liter Glass Amber*
- TPH Amber

Bottle V
- VOC
- TDC
- TPH Vial
- DOC

Bottle E — *Field Filtered*
- SO4
- Fluoride
- Cl
- HCO3

Metals — 100mL each — *Add 0.25 mL HNO3*

Dissolved Field Filtered	Total Recoverable
Al	Al
Sb	Sb
As	As
Ba	Ba
Be	Be
B	B
Cd	Cd
Ca	Ca
Cr	Cr
Cu	Cu
Hg	Hg
Pb	Pb
Mg	Mg
Mn	Mn
Ni	Ni
Se	Se
Ag	Ag
Na	Na
Tl	Tl
U	U
Vn	Vn
Zn	Zn
Fe	Fe
Mo	Mo
Fluoride	
K	
Cl	
Silica	

Relinquished By: _____ Date/Time _____
Received By: _____ Date/Time _____
Relinquished By: _____ Date/Time _____
Received By: _____ Date/Time _____
Relinquished By: _____ Date/Time _____
Received By: _____ Date/Time _____

Sample Temp (C) | Date / Time Received | Lab #

Appendix D

SD DENR WPP Periphyton Sampling Datasheets Set

Table D-1.

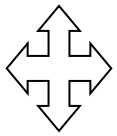
SD DENR WPP Periphyton Map, Measurements and Documentation Datasheet

Project Site ID:	Stream Name:	Date:	Sampler(s)
_____	_____	_____	_____

Draw a map of the site with locations of all 11 transects upstream (Transect K) through the most downstream (Transect A) and sampling site locations (L – left, R – right and C – center). Include locations of photographic points, direction of photograph, and frame number.

	Width Number					Mean River/Stream Width (MRSW)*	
	1	**2**	**3**	**4**	**5**	**Sum (1 through 5)**	**MRSW (Sum/5)***
Width (0.1m)							
Transect Spacing from monitoring site (MRSW x 3)						**Total Reach Length (MRSW x 30)**	

***=**If MRSW width is <4 m, use 10 m transect spacing and 100 m as a **minimum** reach length



Notes and calculations

Data for Periphyton AFDM and Chlorophyll-a analysis

Composite Sample Volume:_____ mL, Volume filtered:_____ mL, Area Scraped:_____ cm^2 , # Transects ___

Approximate Distance

Table D-2. **Periphyton Ash Free Dry Mass (AFDM) Datasheet**

Date: ________________ Analyst: _________________________

					Volume (mL)		Weight (0.1 g)			
Sample type	Waterbody	Station ID	Date Collected	AFDM Date Analyzed	Composite	Subsample	Initial		Final	
							1	2	1	2

Appendix E

SD DENR WPP Macroinvertebrate Sampling Datasheets set

Table E-1

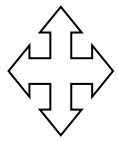
SD DENR WPP Macroinvertebrate Map, Measurements and Documentation Datasheet

Project Site ID:	Stream Name:	Date:	Sampler(s)

Draw a map of the site with locations of all 11 transects upstream (Transect K) through the most downstream (Transect A) and sampling site locations (L – left, R – right and C – center). Include locations of photographic points, direction of photograph, and frame number.

	Width Number					Mean River/Stream Width (MRSW)*	
	1	2	3	4	5	Sum (1 through 5)	MRSW (Sum/5)*
Width (0.1m)							
Transect Spacing from monitoring site (MRSW x 3)						**Total Reach Length (MRSW x 30)**	

***=**If MRSW width is <4 m, use 10 m transect spacing and 100 m as a **minimum** reach length and if the width is >100 m, use 4 km as a **maximum** length.



Notes and calculations **Downstream** **Upstream**

Transect	1	2	3	4	5	6	7	8	9	10	11
Location (R, L, C) or (R, L)											
Substrate Type											
Habitat Type											
Velocity (40 seconds)											
Average Velocity (cfs)											

Substrate type: **F/S** = **F**ine **S**and (<0.06 mm dia. to 2.0 mm), **GR** = **GR**avel fine to course gravel (2 mm to 64 mm), **CO** = **CO**urse cobble to boulder (64 mm to 4,000 mm), **OT** = **OT**her (>4,000 mm) hardpan (firm consolidated fine substrate), wood of any size and aquatic vegetation.

Habitat Type: **P** = **P**ool (still water, low velocity, usually deep relative to other parts of the stream); **GL** = **GL**ide (water moving slowly with smooth unbroken surface, low turbulence); **RI** = **Ri**ffle (water moving with small ripples, wave and eddies (waves not breaking and surface tension not broken) "babbling" or "gurgling" sound); **RA** = **RA**pid (water movement is rapid and turbulent, intermittent white water with breaking waves, continuous rushing sound).

Comments:

For macroinvertebrate samples composite sample volume and # Transects only

Number of sample jars _____, number of Transects _____

Approximate Distance

Table E-2 Internal labels for inside macroinvertebrate sample bottles.

SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____	SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____
SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____	SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____
SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____	SD DENR WPP Stream Reference Fishes Site Code:_____ Site Name:_____ Date:_____ Time:_____ Habitat Types:_____ Method:_____ Sample ____of____ Collector:_____
SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____	SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____
SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____	SD DENR WPP Internal Macroinvertebrate sample label Site ID:_____ Collector initials:_____ Type of sampler:_____ Mesh size:_____ Transects sampled:_____ Site Name:_____ Date:_____ Sample ____of____

Appendix F

SD DENR WPP Fish Collection Datasheets Set

Table F-1

SD DENR WPP Fish Datasheet	Page: __1___ of _____

Site ID:	Stream Name:	
Date:	Habitat Sample ID #	Pass# _____ of _____
Gear Type: (circle one) Backpack	Seine (blocknet: Yes or No)	Boat Mounted Shocker
Gear Style: (i.e. Halltech, model #, 3/16 inch, etc)		
Record Shocking Information below		
Water Conductivity (µS/cm):	Water Temperature (°C):	Peak Voltage:
Peak Amperes:	Wave Form (ac, dc or pdc):	Duration (sec):

Common Name	Length (mm)	Weight (g)	Disease	Common Name	Length (mm)	Weight (g)	Disease

*Parasites & Anomalies Code: D=deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=black spot, EM=emaciated, O=other

Version 2018

Table F-1 **(continued)**

SD DENR WPP Fish Data Sheet	Page:_____ of _____

Site ID:	Stream Name:	Date:

Common Name	Length (mm)	Weight (g)	Disease	Common Name	Length (mm)	Weight (g)	Disease

***Parasites & Anomalies Code: D=deformed, EF=eroded fin, FG=fungus, LE=lesions, AW=anchor worm, BS=black spot, EM=emaciated, O=other**

Version 2018

Table F-2

Site ID:	Stream Name:			Date:		
Fish Counts (after first 50, for species with less than 100 total individuals)						
Species Common Name	**Count1**	**Count2**	**Count3**	**Count4**	**Count5**	**Count Total**

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Table F-3

Site ID:	Stream Name:			Date:		
Fish Bulk Weights (weights after first 50, for species with more than 100 individuals)						
Species Common Name	**Weight1 (g)**	**Weight2 (g)**	**Weight3 (g)**	**Weight4 (g)**	**Weight5 (g)**	**Total Weight (g)**

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Table F-4

Fish Photo Vouchering Log			
Site ID:	**Stream Name:**		**Date:**

Count	Species Common Name	Photo frame number (ID)	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			

Table F-5

South Dakota Fishes			
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
American eel	*Anguilla rostrata*	**mirrror carp**	*Cyprinus carpio*
banded killifish	*Fundulus diaphanus*	**mountain sucker**	*Catostomus platyrhynchus*
Black Buffalo	*Ictiobus niger*	**muskellunge**	*Esox masquinongy*
blue catfish	*Ictalurus furcatus*	**northern hogsucker**	*Hypentelium nigricans*
blackside darter	*Percina maculata*	**northern pike**	*Esox lucius*
blacknose shiner	*Notropis heterolepis*	**northern redbelly dace**	*Phoxinus eos*
bluegill x green sunfish	*L. macrochirus x L. cyanellus*	**orangespotted sunfish**	*Lepomis humilis*
Bigmouth Buffalo	*Ictiobus cyprinellus*	**other**	
bigmouth shiner	*Notropis dorsalis*	**paddlefish**	*Polyodon spathula*
brook trout	*Salvelinus fontinalis*	**pallid sturgeon**	*Scaphirhynchus albus*
black bullhead	*Ameiurus melas*	**pearl dace**	*Margariscus margarita*
black crappie	*Pomoxis nigromaculatus*	**plains killifish**	*Fundulus zebrinus*
blacknose dace	*Rhinichthys atratulus*	**plains minnow**	*Hybognathus placitus*
bluegill	*Lepomis macrochirus*	**plains topminnow**	*Fundulus sciadicus*
bluntnose minnow	*Pimephales notatus*	**pumpkinseed**	*Lepomis gibbosus*
blackchin shiner	*Notropis heterodon*	**quillback sucker**	*Carpiodes cyprinus*
brown bullhead	*Ameiurus nebulosus*	**rainbow smelt**	*Osmerus mordax*
brown trout	*Salmo trutta*	**rainbow trout**	*Oncorhynchus mykiss*
Bonneville Cisco	*Prosopium gemmifer*	**redhead**	*Cichlasoma synspilum*
bowfin	*Amia calva*	**red shiner**	*Cyprinella lutrensis*
brassy minnow	*Hybognathus hankinsoni*	**redfin shiner**	*Lythrurus umbratilis*
brook stickleback	*Culaea inconstans*	**river carpsucker**	*Carpiodes carpio*
Blue Sucker	*Cycleptus elongatus*	**rock bass**	*Ambloplites rupestris*
blue sucker	*Cycleptus elongatus*	**rosyface shiner**	*Notropis rubellus*
burbot	*Lota lota*	**smallmouth buffalo**	*Ictiobus bubalus*
channel catfish	*Ictalurus punctatus*	**smallmouth buffalo**	*Ictiobus bubalus*
central mudminnow	*Umbra limi*	**sauger**	*Sander canadensis*
common shiner	*Luxilus cornutus*	**sand shiner**	*Notropis stramineus*
common carp	*Cyprinus carpio*	**spotfin shiner**	*Cyprinella spiloptera*
coho salmon	*Oncorhynchus kisutch*	**shortnose gar**	*Lepisosteus platostomus*
creek chub	*Semotilus atromaculatus*	**shorthead redhorse**	*Moxostoma macrolepidotum*
cutthroat trout	*Oncorhynchus clarkii*	**shovelnose sturgeon**	*Scaphirhynchus platorynchus*
emerald shiner	*Notropis atherinoides*	**sicklefin chub**	*Macrhybopsis meeki*
european rudd	*Scardinius erythrophthalmus*	**silver lamprey**	*Ichthyomyzon unicuspis*
flathead catfish	*Pylodictis olivaris*	**mississippi silvery minnow**	*Hybognathus nuchalis*
chinook salmon	*Oncorhynchus tshawytscha*	**silverband shiner**	*Notropis shumardi*
fathead minnow	*Pimephales promelas*	**skipjack herring**	*Alosa chrysochloris*
finescale dace	*Phoxinus neogaeus*	**slenderhead darter**	*Percina phoxocephala*
flathead chub	*Platygobio gracilis*	**slender madtom**	*Noturus exilis*
freshwater drum	*Aplodinotus grunniens*	**smallmouth bass**	*Micropterus dolomieu*
goldeye	*Hiodon alosoides*	**sturgeon chub**	*Macrhybopsis gelida*
goldfish	*Carassius auratus*	**spottail shiner**	*Notropis hudsonius*
golden redhorse	*Moxostoma erythrurum*	**splake**	*S. fontinalis* x *S. namaycush*
golden shiner	*Notemigonus crysoleucas*	**silver chub**	*Macrhybopsis storeriana*
grass carp	*Ctenopharyngodon idella*	**southern redbelly dace**	*Phoxinus erythrogaster*
green sunfish	*Lepomis cyanellus*	**stonecat**	*Noturus flavus*
gizzard shad	*Dorosoma cepedianum*	**central stoneroller**	*Campostoma anomalum*
hatchery brown trout	*Htc Salmo trutta*	**steelhead trout**	*Oncorhynchus mykiss*
hornyhead chub	*Nocomis biguttatus*	**suckermouth minnow**	*Phenacobius mirabilis*
hatchery rainbow trout	*Htc Oncorhynchus mykiss*	**saugeye**	*S. canadensis* x *S. vitreus*
iowa darter	*Etheostoma exile*	**tadpole madtom**	*Noturus gyrinus*
jack dempsey	*Cichlasoma octofasciatum*	**tiger trout**	*S. trutta* x *S. fontinalis*
johnny darter	*Etheostoma nigrum*	**tiger muskellunge**	*E. lucius* x *E. masquinongy*
kokanee salmon	*Oncorhynchus nerka*	**topeka shiner**	*Notropis topeka*
lake chub	*Couesius plumbeus*	**trout-perch**	*Percopsis omiscomaycus*
lake herring	*Coregonus artedi*	**walleye**	*Sander vitreus*
lake trout	*Salvelinus namaycush*	**white bass**	*Morone chrysops*
lake whitefish	*Coregonus clupeaformis*	**white crappie**	*Pomoxis annularis*
largemouth bass	*Micropterus salmoides*	**white sucker**	*Catostomus commersonii*
longnose dace	*Rhinichthys cataractae*	**wiper**	*M. chrysops* x *M. saxatilis*
longnose gar	*Lepisosteus osseus*	**yellow bullhead**	*Ameiurus natalis*
logperch	*Percina caprodes*	**yellow perch**	*Perca flavescens*
longnose sucker	*Catostomus catostomus*	**zander**	*Sander lucioperca*

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Table F-6

SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________	SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________
SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________	SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________
SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________	SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________
SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________	SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________
SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________	SD DENR WPP Stream Reference Fishes Site Code:____________________________ Site Name:____________________________ Date:_____________ Time:____________ Habitat Types:_________________________ Method:______________________________ Sample ____of____ Collector:_________

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Appendix G

SD DENR WPP Habitat Field Collection Datasheets Set

SD DENR WPP On Site Watershed Description Data

Table G-1

Section A

Station ID:		Project ID: _____		Date:
Stream Name:				Time:
GPS Coordinates				
UTM:	Lat:	Long:	Northing:	Easting:
Samplers:				

Table G-2

Section B

Mean River/Stream Width (MRSW)							
	Width Number					MRSW	
	1	2	3	4	5	Sum (1 through 5)	MRSW(Sum/5)*
Width (0.1m)							
Transect Spacing from Monitoring site (MRSW x 3)*							
*If MRSW width is < 3 m, use 100 m as a minimum reach length. If MRSW is > 10m and watershed area is >500 km^2 then space transects 2 MRSW apart.							
Total Reach Length: < 10m MRSW x 30 =				> 10m and >500km^2 MRSW x 20 =			

Table G-3

Section C

Water Quality						Discharge and Average Velocity		
Reading	Time (2400)	Water Temperature(°C)	pH (s.u.)	Dissolved Oxygen (mg/L)	Specific Conductance (µS/cm)	(If no staff, use max depth within transect) Stage (ft)	Discharge (from section K) (cfs)	Average Velocity (sum of all 11 transects / 33) (ft/s)
Morning								

Visual Observations			
Weather Conditions:	Current	Past 24 hrs	Field Comments:
Clear/sunny	☐	☐	
Partly cloudy	☐	☐	
Intermittent showers	☐	☐	
Steady rain	☐	☐	
Heavy rain	☐	☐	

Table G-4

Section D

Habitats Available number of each (also place on map Section E)	Pool_____, Run/Glide_____, Riffle_____, Other (describe) _____ (Table 10.0.1) Lengths of Riffle(s):_____, _____, _____, _____, _____. (meters) Nearest Transect # :_____, _____, _____, _____, _____. Total Length (riffles) =_____ Pool Forming Elements = _____ (Table 10.0.1)

Notes:

Table G-5

Section E. SD DENR WPP Wadeable Physical Habitat Slope and Bearing Datasheet

Project Name:_____ Stream Name:_____ Site ID:_____ Date:_____ Time:_____

Main				First Supplemental		Second Supplemental	
Transect	Slope (%) or Elev. Difference. (cm) (mark units for every transects)	Bearing 0°- 359°	Proportion %	Bearing 0°- 359°	Proportion %	Bearing 0°- 359°	Proportion %
1 < 2	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
2 < 3	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
3 < 4	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
4 < 5	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
5 < 6	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
6 < 7	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
7 < 8	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
8 < 9	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
9 < 10	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
10 < 11	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____
Total Slope	_____ ☐ % _____ ☐ cm	_____	_____	_____	_____	_____	_____

Notes and Calculations:

Slope and Bearing Notes and Calculations (continued)

Table G-6

Section E (continued) SD DENR WPP Map, and Photo-Documentation Datasheet

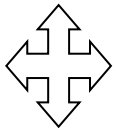
Project Site ID: _____ Stream Name: _____

Sampler(s): _____ Date: _____ Time: _____

Draw a map of the site with locations of all 11 transects upstream (Transect K) through the most downstream (Transect A) and sampling site locations (L – left, R – right and C – center). Include locations of photographic points, direction of photograph, and frame number. Transect spacing _____(m), Total reach length _____(m)

	Width Number					Mean River/Stream Width (MRSW)*	
	1	**2**	**3**	**4**	**5**	**Sum (1 through 5)**	**MRSW (Sum/5)***
Width (0.1m)							
Transect Spacing from monitoring site (MRSW x 4)						**Total Reach Length (MRSW x 40)**	

***=If MRSW width is <4 m, use 15 m transect spacing and 150 m as a **minimum** reach length and if the width is >100 m, use 4 km as a **maximum** length.



Approximate Distance

Table G-7
Section F

SD DENR WPP Bed Substrate Composition

Project Site ID: _____ Stream Name: _____Sampler(s): _____ Date: _____ Time: _____

Organic and Inorganic Substrates															
	Description		Tally by Transect												
Substrate Type	Diameter (mm)	Description	downstream 1	2	3	4	5	6	7	8	9	10	upstream 11	Total	∑ Type
Muck-Mud	FPOM	black, very fine particulate organic matter													
Detritus	CPOM	sticks, wood, plant material, coarse particulate organic matter													
Clay (slick)	<0.004	Not Gritty													
Silt	0.004-0.062	Not Gritty													
Sand (gritty)	0.062-2	Gritty up to Ladybug size													
Very Fine Gravel	>2-4	Ladybug													
Fine Gravel	>4-8	Pencil Eraser													
Medium Gravel	>8-16	Marble													
Coarse Gravel	>16-32	Marble to Watch Face													
Very Coarse Gravel	>32-64	Watch Face to Tennis Ball													
Cobble	>64-128	Tennis Ball to Height of a Soda Can													
Large Cobble	>128-250	Height of a Soda Can to Basketball													
Small Boulder	>250-1000	Basketball to Width of a Microwave Oven													
Large Boulder	>1000-4000	Larger than a Microwave Oven													
Bedrock	>4000	Rough or smooth surface bigger than a car													
Total Count	88	#													
Organic Percentage	%	%													

Table G-8
Section G

SD DENR WPP Large Woody Debris Datasheet

Project Site ID: _____ Stream Name: _____

Sampler(s): _____ Date: _____ Time: _____ Page: ____of____

Transect Spacing	Log Jam Number	LWD Number	Zone	Meander Location	Habitat Association	Angle	Length	Diameter

Zone:
Zone 1 is water surface at baseflow,
Zone 2 is between baseflow surface and bankfull flow surface,
Zone 3 is bankfull channel width above bankfull flow surface.

Meander Location:
IM=inside meander,
OM=outside meander,
CO=crossover,
SS=straight section

Habitat Association:
PL=pool,
RF=riffle,
RN=run

LARGE WOODY DEBRIS CATEGORIES (≥10 cm small end diameter; ≥1.5 m length)				
Categories	**1**	**2**	**3**	**4**
Diameter Large End	0.1-<0.3m (0.33-<0.98ft)	0.3-0.6m (0.98-1.97ft)	0.6-0.8m (1.97-2.62ft)	>0.8m (>2.62ft)
Length	>1.5-5m (>4.92-16.4ft)	5-15m (16.4-49.2ft)	>15m (>49.2ft)	-

Table G-9
Section H

SD DENR WPP Stream Shade and Canopy Cover Data Sheet

Project Site ID: _____ Stream Name: _____

Sampler(s): _____ Date: _____ Time: _____ Transect Spacing _____

Transect	Left Bank	Right Bank		Center Upstream	Center Right	Center Downstream	Center Left
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
X 1							
X 2							
X 3							
Total by bank			**Total**				
			Total of Center Positions				
Percent Cover by Bank [Divide by] 187 for 11 transects, 204 for 12 transects, 221 for 13 transects, 238 for 14 transects			**Percent Cover for Center** [Divide by] 748 for 11 transects, 816 for 12 transects, 884 for 13 transects, 952 for 14 transects				
Total Cover % (Reach) LB+RB+Center/1122 for 11, LB+RB+Center/1224 for 12, LB+RB+Center/1326 for 13, LB+RB+Center/1428 for 14							

Right and left banks determined while facing downstream
The maximum value in each cell is 17

Table G-10

Project Site ID:_____	**Stream Name:**_____	**Date:**_____	**Sampler(s):**_____	**Transect Number:** _1_ **of** _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	**Left Bank** (m)	**Right Bank** (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Right Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Section J

Transect, Station, Bankfull and Depth Data

Location Code	**Station** ( )	**Water Depth** ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)
D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	**Left Bank**	**Right Bank**
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	**Stream Name:**_____	**Date:**_____	**Sampler(s):**_____	**Transect Number:** _2_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Right Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)
D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	**Stream Name:**_____	**Date:**_____	**Sampler(s):**_____	**Transect Number:** _3_ **of** _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

	Left Bank	Right Bank
Streambank and Riparian Features	(m)	(m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank	**Right Bank**
cropland shrub woodland/forested	cropland shrub woodland/forested
pasture/rangeland barnyard	pasture/rangeland barnyard
prairie urban/developed	prairie urban/developed
wetland other-specify:	wetland other-specify:
_____	_____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	**Left Bank**	**Right Bank**
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	**Stream Name:**_____	**Date:**_____	**Sampler(s):**_____	**Transect Number:** _4_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	**Left Bank** (m)	**Right Bank** (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Right Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Section J

Transect, Station, Bankfull and Depth Data

Location Code	**Station** ( )	**Water Depth** ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	**Left Bank**	**Right Bank**
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	**Stream Name:**_____	**Date:**_____	**Sampler(s):**_____	**Transect Number: 5 of 11**

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

	Left Bank	Right Bank
Streambank and Riparian Features	(m)	(m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)	**Left Bank**	**Right Bank**
	cropland shrub woodland/forested	cropland shrub woodland/forested
	pasture/rangeland barnyard	pasture/rangeland barnyard
	prairie urban/developed	prairie urban/developed
	wetland other-specify:	wetland other-specify:
	_____	_____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	**Left Bank**	**Right Bank**
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	Stream Name:_____	Date:_____	Sampler(s):_____	Transect Number:_6_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank	Right Bank
cropland shrub woodland/forested	cropland shrub woodland/forested
pasture/rangeland barnyard	pasture/rangeland barnyard
prairie urban/developed	prairie urban/developed
wetland other-specify:	wetland other-specify:
_____	_____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	Left Flood Prone
RFP	Right Flood Prone
LBF	Left Bankfull
RBF	Right Bankfull
LCB	Left Channel Bottom
RCB	Right Channel Bottom
LEW	Left Edge Water
REW	Right Edge Water
STR	Stream

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank	Understory (0.5 to 5 m high)	Left Bank	Right Bank	Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	Stream Name:_____	Date:_____	Sampler(s):_____	Transect Number:_7_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)	Left Bank	Right Bank
	cropland shrub woodland/forested	cropland shrub woodland/forested
	pasture/rangeland barnyard	pasture/rangeland barnyard
	prairie urban/developed	prairie urban/developed
	wetland other-specify: _____	wetland other-specify: _____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	Left Flood Prone
RFP	Right Flood Prone
LBF	Left Bankfull
RBF	Right Bankfull
LCB	Left Channel Bottom
RCB	Right Channel Bottom
LEW	Left Edge Water
REW	Right Edge Water
STR	Stream

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank	Understory (0.5 to 5 m high)	Left Bank	Right Bank	Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	**Stream Name:**_____	**Date:**_____	**Sampler(s):**_____	**Transect Number:** _8_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	**Left Bank** (m)	**Right Bank** (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Right Bank		
cropland	shrub	woodland/forested
pasture/rangeland		barnyard
prairie		urban/developed
wetland		other-specify:
_____		

Section J

Transect, Station, Bankfull and Depth Data

Location Code	**Station** ( )	**Water Depth** ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	**Left Flood Prone**
RFP	**Right Flood Prone**
LBF	**Left Bankfull**
RBF	**Right Bankfull**
LCB	**Left Channel Bottom**
RCB	**Right Channel Bottom**
LEW	**Left Edge Water**
REW	**Right Edge Water**
STR	**Stream**

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	**Left Bank**	**Right Bank**
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	**Left Bank**	**Right Bank**
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	Stream Name:_____	Date:_____	Sampler(s):_____	Transect Number:_9_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)	Left Bank	Right Bank
	cropland shrub woodland/forested	cropland shrub woodland/forested
	pasture/rangeland barnyard	pasture/rangeland barnyard
	prairie urban/developed	prairie urban/developed
	wetland other-specify:	wetland other-specify:
	_____	_____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	Left Flood Prone
RFP	Right Flood Prone
LBF	Left Bankfull
RBF	Right Bankfull
LCB	Left Channel Bottom
RCB	Right Channel Bottom
LEW	Left Edge Water
REW	Right Edge Water
STR	Stream

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)
D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	Stream Name:_____	Date:_____	Sampler(s):_____	Transect Number:_10_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)	Left Bank	Right Bank
	cropland shrub woodland/forested	cropland shrub woodland/forested
	pasture/rangeland barnyard	pasture/rangeland barnyard
	prairie urban/developed	prairie urban/developed
	wetland other-specify:	wetland other-specify:
	_____	_____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	Left Flood Prone
RFP	Right Flood Prone
LBF	Left Bankfull
RBF	Right Bankfull
LCB	Left Channel Bottom
RCB	Right Channel Bottom
LEW	Left Edge Water
REW	Right Edge Water
STR	Stream

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank	Understory (0.5 to 5 m high)	Left Bank	Right Bank	Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④	Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-10 (continued)

Project Site ID:_____	Stream Name:_____	Date:_____	Sampler(s):_____	Transect Number:_11_ of _11_

Section I

Major Habitat Type Along Transect (circle one): pool riffle run glide

Streambank and Riparian Features	Left Bank (m)	Right Bank (m)
Bank Substrate (dominant substrate type)		
Bank Slumpage (present, "p" or absent, "a")		
Bank Angle (degrees)		
Streambank length to Incised Height (0.1 m)		
Length of Streambank Vegetated (0.1 m)		
Length of Streambank Eroded (0.1 m)		
Length of Streambank Deposition (0.1 m)		
Buffer Width (1 m)		
Undercut Bank (0.1m)		
Overhanging Vegetation (0.1m)		
Submergent Macrophytes (%)		
Emergent Macrophytes (%)		
Floating Macrophytes (%)		

Dominant Landuse (circle one)

Left Bank			Right Bank		
cropland	shrub	woodland/forested	cropland	shrub	woodland/forested
pasture/rangeland		barnyard	pasture/rangeland		barnyard
prairie		urban/developed	prairie		urban/developed
wetland		other-specify: _____	wetland		other-specify: _____

Section J

Transect, Station, Bankfull and Depth Data

Location Code	Station ( )	Water Depth ( )
LFP		
LBF		
LEW		
LCB		
STR (@1/4) [1]		
STR (@1/2) [1]		
STR (@3/4) [1]		
RCB		
REW		
RBF		
RFP		

Location Codes:

LFP	Left Flood Prone
RFP	Right Flood Prone
LBF	Left Bankfull
RBF	Right Bankfull
LCB	Left Channel Bottom
RCB	Right Channel Bottom
LEW	Left Edge Water
REW	Right Edge Water
STR	Stream

Max Water Depth = _____

Bankfull Height (water surface to bankfull) = _____

Max Bankfull Depth (max water depth + bankfull height) = _____

Flood Prone Elevation (2 X max bankfull depth) = _____

Flood Prone Width (RFP-LFP) =_____

Bankfull Width (RBF-LBF)=_____

Stream Width (REW-LEW)=_____

1= Velocities for all three in stream positions by transects are recorded and listed on a separate datasheet (Section J (velocities)).

Section I (continued)

Visual Riparian Structure Form (10 x 10 m Plot)

0 = Absent (0%) **1** = Sparse (<10%) **2** = Moderate (10-40%) **3** = Heavy (40-70%) **4** = Very Heavy (>75%)

D = Deciduous **C** = Coniferous **E** = Broadleaf Evergreen **M** = Mixed **N** = None

Riparian Vegetation Cover

Canopy (>5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
BIG Trees (Trunk >0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④
SMALL Trees (Trunk <0.3 m DBH)	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Understory (0.5 to 5 m high)	Left Bank	Right Bank
Woody Vegetation Type	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ	Ⓓ Ⓒ Ⓔ Ⓜ Ⓝ
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Ground Cover (<0.5 m high)	Left Bank	Right Bank
Woody Shrubs & Saplings	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Non-Woody Herbs, Grasses, & Forbs	⓪ ① ② ③ ④	⓪ ① ② ③ ④
Barren, Bare Dirt or Duff	⓪ ① ② ③ ④	⓪ ① ② ③ ④

Notes:

Table G-11

Section J (Velocities)

Habitat Transect Velocities Table (cfs)

Stream: _____ Date: _____, Time: _____

Sampler(s): _____, Meter used: _____ (use a 40 second averaging period)

	Distance across wetted width		
Transect	0.25 (¼)	0.50 (½)	0.75 (¾)
(upstream) 11			
10			
9			
8			
7			
6			
5			
4			
3			
2			
(downstream) 1			
		Sum all measurements*	
		Average Velocity (Sum/33)*	

*** = If less than 33 velocity measurements were collected in the reach divide the sum by the total number of measurements collected.**

Notes

Table G-12

Discharge Datasheet for Section C

SD DENR WPP Discharge Datasheet (for Marsh-McBirney and/or Flowtracker flowmeters)

(Record units under the heading for each column)

Site:_____ **Page _____ of _____**

Date:_____ Time:_____ Sampler(s):_____

Meter:_____, Stage Before:_____, Stage After:_____

If meter is Marsh-McBirney Flo-mate Model 2000 was Zero Adjust Test performed at lab or site: Y / N ?
If meter is FlowTracker was Automatic QC Test Run at site: Y / N ?
If Yes, did it pass Y / N, If No do not use meter. Comments _____.

Row	Tape	Location	Width	Depth	Area (W*D)	Mean in Vertical	Discharge (W*D*MV)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
Total Discharge							

Number of Stations _____

Width _____(ft), Area _____ (ft^2), Water Temperature _____ (circle one °F or °C), Method _____. Uncertainty _____ (%),

Mean Velocity _____ (ft/s), Max Velocity _____ (ft/s), Average Depth _____ (ft), Max Depth _____ (ft).

APPENDIX H

SD DENR WPP Habitat Condition Index Datasheets Set

Habitat Condition Index Datasheet

Site:		**Date:**	
Stream Name:			
Samplers:			
Latitude:	**Longitude:**		

Table H-1

HCI Reach Length

Mean River/Stream Width (MRSW)							
	Width Number					MRSW	
	1	2	3	4	5	Sum (1 through 5)	MRSW(Sum/5) *
Width (0.1m)							
Transect Spacing from Monitoring site (MRSW x 3)							
*If MRSW width is < 3.3 m, use 100 m as a minimum reach length. If MRSW is > 10m and watershed area is >500 km^2 then space transects 2 MRSW apart.							
Total Reach Length: < 10m MRSW * 30 =					> 10m and >500km^2 MRSW * 20 =		

Table H-2 (continued)

HCI Riffle Length by Transect

Transect spacing	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	Total (Sum (m))
Riffle Length (m)											
Notes											

Table H-4

HCI Rosgen Measurements

Transect	1	2	3
Bankfull Width:			
Max Bankfull Height:			
Width:Depth Ratio: (Bankfull Width/Max Bankfull Height)			
2 X Max Bankfull Height:			
Flood Prone Width: (width of floodplain inundated at elevation 2 X max bankfull height)			
Entrenchment Ratio: (Flood prone width/bankfull width)			

Table H-3

HCI Canopy Cover Datasheet

SD DENR WPP Stream Shade and Canopy Cover Datasheet

Site ID Name:				**Date:**		**Time:**	
Reach Length:			**Transect Interval:**			**Initials:**	
Transect	**Left Bank***	**Right Bank***		**Center Upstream**	**Center Right**	**Center Downstream**	**Center Left**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
Total by bank (TBB) (total each bank)			Total by Position (TBP)				
			Total Center Positions (TCP) (sum all TBP)				
Percent Cover by Bank [Divide each TBB by 187]			Percent Cover for Center [Divide TCP by 748]				
Total Percent Cover (Reach) TBB(L)+TBB(R)+TCP/1122							

* = Left and right banks are determined looking downstream

Notes:

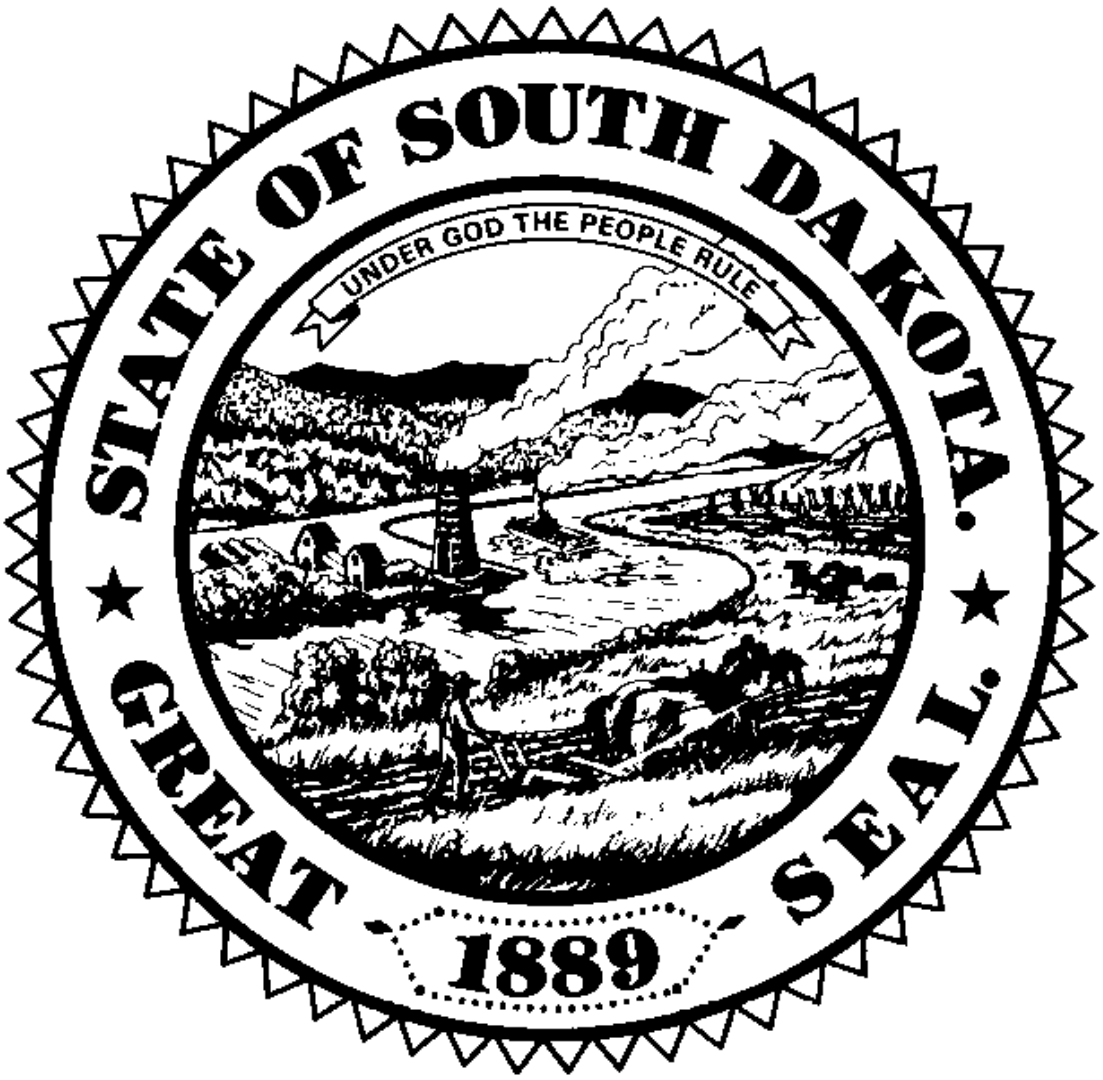
Table H-5

HCI Bed Substrate Datasheet

SD DENR WPP HCI Bed Substrate Composition

Project Site ID: _____ Stream Name: _____Sampler(s): _____ Date: _____ Time: _____

Organic and Inorganic Substrates													
	Description		Tally by Transect										
Substrate Type	Diameter (mm)	Description	downstream 1	2	3	4	5	6	7	8	9	10	upstream 11	Total
Clay (slick)	<0.004	Not Gritty												
Silt	0.004-0.062	Not Gritty												
Sand (gritty)	0.062-2	Gritty up to Ladybug size												
Very Fine Gravel	>2-4	Ladybug												
Fine Gravel	>4-8	Pencil Eraser												
Medium Gravel	>8-16	Marble												
Coarse Gravel	>16-32	Marble to Watch Face												
Very Coarse Gravel	>32-64	Watch Face to Tennis Ball												
Cobble	>64-128	Tennis Ball to Height of a Soda Can												
Large Cobble	>128-250	Height of a Soda Can to Basketball												
Small Boulder	>250-1000	Basketball to Width of a Microwave Oven												
Large Boulder	>1000-4000	Larger than a Microwave Oven												
Total Count	88	#												



South Dakota Department of Environment and Natural Resources,
Watershed Protection Program