Ontario

OSAP

Ontario Stream Assessment Protocol

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ONTARIO STREAM ASSESSMENT PROTOCOL
VERSION 8.0
2010

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ONTARIO STREAM ASSESSMENT PROTOCOL

VERSION 8.0

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General Introduction

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1.0 BACKGROUND

The Ontario Stream Assessment Protocol (OSAP) contains a series of standardized methodologies for identifying sites, evaluating benthic macroinvertebrates, fish communities, physical habitat; geomorphology; hydrology; and water temperature in wadeable streams. Protocols are organized into sections containing multiple methods (modules) which vary in the amount of effort required to collect that data, and the interpretations that can made. The modules are designed to be conducted individually or in combination.

The OSAP was designed to address a variety of stream assessment issues, ranging from very specific questions (e.g., determining maximum summer water temperature) to broader issues (e.g., changes in fish community composition over time). Study design will be determined by project managers and will indicate which modules should be completed.

The OSAP provides standardized methods that ensure data repeatability. Use of these standard methodologies allow data to be shared, used for multiple purposes and stored in a common database.

Protocols described in earlier versions are comparable to this version, however much of the background information and interpretation advice contained in earlier versions has been removed. Additional guidance on study design is provided in the compendium manual, “Guidelines for Designing and Interpreting Stream Surveys” (edited by Stanfield 2003), available from the Toronto Region Conservation Authority webpage (www.trca.on.ca/osap).

A new study design metadata module (S0.M1, Study Design Metadata) has also been developed in draft and is available for testing on the Toronto Region Conservation Authority webpage (as above). This module provides a process for documenting the major decisions associated with developing a study design for a project that collects field data. It is intended to be inclusive of most monitoring and research projects carried out on flowing waters, not just OSAP surveys. The module is not intended to provide a comprehensive description of a study rather; the intent is to provide background information on the factors that might influence the future use of the data for other purposes and by other users. Project managers are asked to document the project contacts and provide a brief background on study objectives. Study design factors used in scoping the study such as: spatial; management; administrative/political and temporal factors are documented. Guidelines used to define site locations and site boundary determinations are also documented. Discrete categories are provided for each of these factors to ease use of this module and to improve future querying capabilities. Information collected using this module will be posted on a Flowing Waters Information System

(FWIS) that is under development (see Section 6 for more information) intended to be a discovery portal and information management system for flowing waters data**.**

2.0 ORGANIZATION OF THE OSAP MANUAL

The OSAP is organized into sections i.e., for evaluating benthic macroinvertebrates, fish communities, physical habitat; and water temperature in wadeable streams. Each section contains multiple methods (modules) which are classified by the amount of effort required to conduct the survey (and the interpretations that can made from the data) according to the following:

- Screening Surveys: These methods enable users to perform rapid inventories. Screening surveys tend to be visually based. They are useful for the collection of information for ‘state of the resource’ reports and for identifying future collection efforts.

- Assessment Surveys: These methods require more effort than Screening Surveys. They are recommended for monitoring or impact assessment studies.

- Diagnostic Surveys: These methods provide detailed data and a higher degree of interpretative power than the Screening or Assessment Surveys, but require more effort to conduct.

The component sections include:

Section	Title
1	Site Identification and Documentation
2	Benthic Macroinvertebrate Assessment
3	Fish Community Sampling
4	Assessing Physical Processes and Channel Structure
5	Water Temperature Assessment
6	Data Management

Section 1: Site Identification and Documentation

This section describes a standard set of procedures for locating sites on streams, defining the boundaries of the sampling station and documenting landuses that may influence the biophysical conditions at a site. The first module, S1.M1, Defining Site Boundaries and Key Identifiers, must be completed when additional sampling modules used require site boundaries to be determined. Either the S1.M2 Screening Level Site Documentation or S1.M3 Standard Assessment Procedures for Site Feature Documentation must be completed with every visit to a site. Modules S1.M4 (Diagnostic Procedures for Site Feature Documentation) and S1.M5, Site Features for Water Quality Surveys, provide additional detail for evaluating land use and features that may influence the biophysical properties of a site. Study objectives will determine which modules to use.

Section 2: Benthic Macroinvertebrate Assessment

This section describes a number of standard tools for assessing benthic macroinvertebrate composition. Benthic macroinvertebrates can be used to evaluate water quality. Physical habitat conditions (depth, velocity and substrate) are measured to characterize background conditions and to assist in interpreting data.

Section 3: Fish Community Sampling

This section describes standard electrofishing methods for sampling fish communities in streams. The first module, Fish Community Sampling using Screening, Standard and Multiple Pass Electrofishing Techniques (S3.M1), describes three electrofishing approaches. The three approaches are described in one module, as the procedures are similar, with the exception of sampling effort.

Section 4: Assessing Physical Processes and Channel Structure

The modules in this section provide standard methodologies for assessing habitat in wadeable streams. The data collected will allow analysis of the channel structure (e.g., cover, substrate), channel processes (e.g., hydrology, sediment transport), and the stream’s suitability for biota. Standardizing data collection procedures enables comparisons to be made across spatial and temporal scales by reducing error and controlling biases. Providing standard methodologies that vary in the accuracy of the data collected offers flexibility for users to accommodate different study designs.

Section 5: Water Temperature Assessment

This section describes techniques for assessing water temperature and estimating summer maximum water temperatures. Water temperature strongly influences the composition of aquatic communities. Knowledge of aquatic thermal regimes is important for predicting species composition, activity level, behaviours and life cycle events.

Section 6: Data Management

This section provides detail on how to manage the data collected using the OSAP, specifically regarding data entry into a database (HabProgs), generating summary reports and exporting information. HapProgs is currently undergoing an overhaul and is scheduled to be replaced by a new information management system called FWIS. This new system will provide even more functionality than the current system and will be more stable and will be integrated into a GIS and web-based platform.

Section 7: Glossary and List of Acronyms

Section 8: Blank Field Forms

In each section, tips are provided to help with surveys and a general list of tips is presented at the end of this section (Appendix 1). Crew members are encouraged to review these periodically during the sampling season.

3.0 TRAINING

It is recommended that all crews complete OSAP training. The Ontario Ministry of Natural Resources, Fisheries Policy Section or Department of Fisheries and Oceans should be contacted for information on upcoming courses.

4.0 SAFETY CONCERNS

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

5.0 ACKNOWLEDGEMENTS

The protocols have been developed through collaboration between government and private sector companies. Many agencies have supported the development of the manual including: Ontario Ministry of Natural Resources, Department of Fisheries and Oceans, Conservation Authorities and Trout Unlimited Canada. In addition, contributions to sections of the manual include:

Section 2: Ontario Ministry of the Environment (Chris Jones and Keith Somers); Jacques Whitford Consulting (Bruce Kilgour).

Section 4: Parish Geomorphic (John Parish); Toronto Region Conservation Authority (Dave Bell currently with OMOE, and Scott Jarvie); Geological Survey of Canada (Marc Hinton); Trent University (Bruce Robertson and Jim Buttle).

The following individuals have assisted with the intellectual ideas within one or more modules: Mark Hinton, Chris Jones, Mike Jones, Bruce Kilgour, John Parish, Bruce Robertson, Mike Stoneman and Gord Wichert. Several individuals have contributed substantially through editorial changes: Jeff Andersen, Peter Ashmore, Derrick Beach, Stephen Casselman, Scott Finucan, Gareth Goodchild, Peter Hulsman, Bruce Kilgour, Brenda Koenig, Bob Newbury, Audie Skinner, Elizabeth Straszynski, Jennifer Thomas and Donna Wales.

Students of the Central Hastings Secondary School assisted with the testing of the repeatability and ease of application of several procedures.

Emily Joyce and Scott Gibson provided valuable criticisms of earlier drafts of the manual.

Sarah Hogg was instrumental in helping with the edits and updates to version 8 of the manual.

Appendix 1

Tips For Collecting High Quality Field Data

Clearly and legibly record all data with a sharp pencil.

Use capital letters for text records.

Make corrections neatly.

Once they are completed, data sheets should be checked by another person for legibility, accuracy and completeness.

Field forms can be photocopied onto waterproof paper for working in inclement weather.

Check all stream names, stream and site codes, and sample numbers to ensure they are correct on all forms.

Use an equipment checklist.

Record ‘-99’ (‘-999’ for depth) to indicate that a measurement could not be performed.

Only use codes that are specified in the protocol or on the data forms.

Additional information should be noted in the comments box.

Use only the measurement units on the field forms (i.e., mm, m etc).

DON'T leave a blank field on a data sheet. Always record a value for a numeric field or a dash for a presence/absence field if the object (i.e., a cover type) is absent.

DON'T ASSUME anything. Check the manual, or with your partners or your supervisor.

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SECTION 1

Site Identification and Documentation

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Module Code	Title	Type
S1.M1	Defining Site Boundaries and Key Identifiers	*mandatory*
S1.M2	Screening Level Site Documentation	*mandatory*
S1.M3	Assessment Procedures for Site Feature Documentation	Assessment Surveys
S1.M4	Diagnostic Procedures for Site Feature Documentation	Diagnostic Surveys
S1.M5	Site Features for Water Quality Surveys	Assessment Surveys

INTRODUCTION

This section describes a standard set of procedures for locating sites on streams, defining the boundaries of the sampling site and documenting landuses that may influence the biophysical conditions at a site.

To standardize data collection and reduce sampling error, site boundary definitions must be consistently defined. The first module provides methods for uniquely identifying a sample site. The other modules describe the screening, assessment and diagnostic techniques that should be used to document site location and adjacent landuses. Each module is described below.

The first two modules are mandatory and must be completed with every visit to a site. Modules 3 and 4 provide additional detail. Study objectives will determine which modules to use.

S1.M1: Defining Site Boundaries and Key Identifiers

This module defines a site as a geomorphic unit that begins and ends at a crossover (i.e., the location where the main concentration of flow is in the center of the channel when the stream is at bankfull flow) and is a minimum of 40 m long. Key identifiers that uniquely define a site are described (i.e., ‘Stream Name’, ‘Stream Code (Unique Code)’ and a ‘Site Code’).

S1.M2: Screening Level Site Documentation

This module describes the collection of geographic coordinates as the minimum information required to document a site location. Coordinates should be confirmed using a Geographic Information System (GIS).

S1.M3: Assessment Procedures for Site Feature Documentation

This module describes techniques for precise documentation of site boundaries (essential for tracking channel migration). Techniques for the collection of information on adjacent landuses are also described.

S1.M4: Diagnostic Procedures for Site Feature Documentation

This module provides methods for georeferencing the location and meander pattern of a site. Guidance for diagnosing the linkage between landuse and biophysical properties is also provided.

S1.M5: Site Features for Water Quality Surveys

This module provides methods for documenting a variety of factors that could influence the water quality at a site and help interpret benthic macroinvertebrate samples. This module is a mandatory component for participants in the Ontario Benthic Biomonitoring Network.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 1

Defining Site Boundaries and Key Identifiers[1]

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

The utility of data collected at a site is dependent on how well the site location, condition and surrounding environment are described. In this context, a site is a location on a stream where data from the application of a connected set of sampling protocols have been applied. Field studies for which data will be compared to a standard or among sites/years, require that site boundaries be consistent between sampling events. The specific location on a stream where data are collected vary with each module in OSAP from a single point location, to a transect or an extended riffle-pool sequence. Since a core objective of the Ontario Stream Assessment Protocol (OSAP) is to enable data collected with different modules to be spatially comparable, a standard definition of a sample site has been developed and is described in this module.

Historically, site lengths tended to be standardized within a study regardless of stream width (i.e., 50 m) and sites would start and finish often in different habitats. Alternatively, sampling areas were chosen based on time constraints or focused on specific habitat types (i.e., pool or riffle). A more objective approach is to base the sampling site on geomorphic criteria, such as the riffle-pool sequence. This is the basis of the site definition in this protocol. Defining sites by physical boundaries ensures that data will be comparable through space and time.

This module describes a consistent means of uniquely identifying each site, and documenting the site location. It must be conducted in conjunction with S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation to ensure that information about site location and length is accurately recorded. Note that with the development of a new Flowing Waters Information System (FWIS), greater emphasis will be given to the importance of documenting metadata associated with a study. As such, future datasets will require at minimum a “Project Code” and a “Project Lead Organization”. To ease the transition to the new system, the database managers will be ensuring that these presently optional attributes are populated for all new datasets (see the draft S0.M1, Study Design Metadata Module (available at www.trca.on.ca/osap) and S6.M1 Using the HabProgs Database).

2.0 PRE FIELD ACTIVITIES

This module takes 5 to 15 minutes to complete.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers:

  - check the HabProgs database to see if the site has been previously described and obtain the unique identifiers for the site
  - if it is a new site, **ensure that an appropriate stream name and code** is determined and is used on all data forms[2].
- Equipment check

The following equipment is required:

1. Tape measure or hip chain
2. Metre stick

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

3.1 Naming the Site

Each site should have three identifiers, (**'Stream Name', 'Stream Code'** and **'Site Code'**) that when combined, uniquely identify each site surveyed in the province.

The 'Stream Name', is the name recorded in the provincial gazetteer or the Ontario Stream Assessment Protocol database (HabProgs).

The 'Stream Code' allows differentiation between streams with similar names (i.e., Trout Creek). The 'Stream Code' may be recorded in HabProgs. Make sure that the correct Stream has been retrieved by checking the descriptive fields for the stream, otherwise data may end up attached to the wrong 'Trout Creek'. If the stream being surveyed is not in HabProgs, contact the database manager to obtain an appropriate 'Stream Name' and 'Stream Code'.

The 'Site Code' must be unique for each stream. The 'Site Code' cannot exceed eight digits and can be any combination of letters or numbers. It is best to choose abbreviations that describe the location of the site. For example, a site on Wilmot Creek, downstream of the 3rd concession, could be '3CDW'. Check the HabProgs database to avoid duplicating a 'Site Code'.

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[2] The province of Ontario is developing a master list of stream names and codes that will be stratified by the National Hydrographic Demarcation System for Watersheds. Once completed, this will be incorporated into HabProgs and will replace the existing stream name and stream code system of unique identifiers. This will not affect data that has already been collected, but will improve the future organization of data given the hierarchical nature of stream networks.

Avoid using O’s or 0’s; I’s or 1’s; dashes (“-“) or underscores (“_”) as these could create data entry problems.

To assist users in identifying the correct stream, it is recommended that the National Hydrographic Watershed Code also be recorded for each site sampled (i.e., 2HG02). This information is available in Ontario Ministry of Natural Resources (OMNR)’s Natural Resource Values Information System (NRVIS) and at OMNR District offices. It is also available from the Flowing Waters information System (FWIS) and this system can assign the codes to the database after the fact, assuming that the coordinates are accurately recorded.

Record these site identifiers on the Site Identification Form (see Appendix 2 in S1.M2, Screening Level Site Documentation). It is important that the ‘Stream Name’, ‘Stream Code’, and ‘Site Code’ are consistently recorded on all data sheets.

3.2 Identifying the Site Boundaries

A ‘Sampling Site’ should represent at least one riffle-pool sequence, be at least 40 m long, and begin and end at a crossover point (Figure 1). Measure the mid-channel length (Figure 1) by chaining the site from the bottom (i.e., the downstream end of the site) to the top. At some sites (channelized or highly unstable streams), it will be difficult to identify the crossover points. In these situations, an area with similar bank height on both sides and a relatively uniform depth profile across the channel should be chosen as the bottom of the site. Search for an area with similar conditions that is at least 40 m upstream and use this as the top of the site. For example, if crossover points occur at the 0, 29 and 52 m marks, the site would end at the 52 m mark. When study designs require sampling much longer units of stream, managers are encouraged to create back-to-back sites meeting the criteria above.

Crossover Point

A crossover is the location where the thalweg (main concentration of flow, normally the deepest part of the channel) is in the centre of the channel during bankfull discharge. This occurs when the flow "crosses over" from one side of the stream to the other. Crossovers are usually but not always associated with riffles and the banks on either side of the stream are very close to the same height. Crossover points will be separated by half-meander lengths (Figure 1) and therefore all sites will be multiples of half-meander lengths. The crossover point represents an area with a slower, uniform flow that occurs when the stream has its greatest erosive ability. These flows cause materials to be deposited across the stream (i.e., towards the middle of the channel), resulting in relatively uniform material sizes and depth at the crossover.

Procedures for Chaining Site Length

Site length is measured by chaining up the center of the stream (Figure 1). One person stands at the bottom of the site in the middle of the stream to mark the starting point. A second person proceeds upstream until the stream changes direction (or until the end of the tape). The second person marks the point, measures the distance, and waits for the first person to reach the mark before proceeding upstream to the next mark location (Figure 3). At the centre of each curve in the stream, the second person marks the location and calls for the first person to move up. Do not stretch the tape around corners.

This process is repeated until the total site length is measured. Unless the station boundaries have already been marked, crews will typically chain the length of the site and identify the upper boundary at the same time (i.e., at the first crossover after the 40 m mark is crossed).

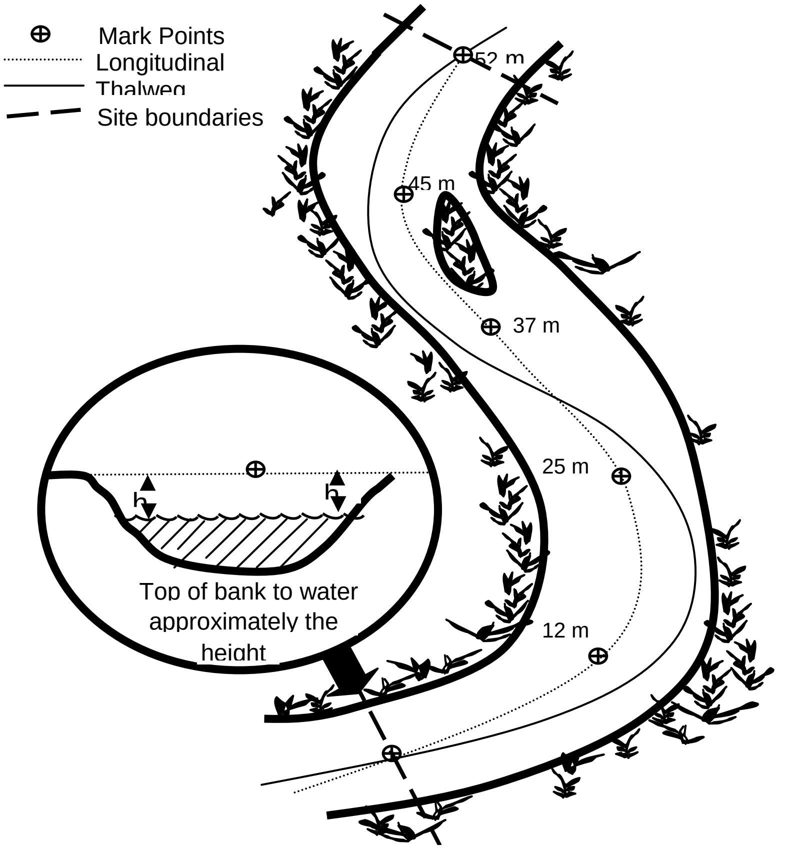

Figure 1: Site Boundaries and Length Determination.

The first crossover point (half-meander length) occurs at 27 m, therefore must continue to next crossover.

The spacing of crossovers is related to stream width. For many stable low gradient streams, crossover spacings are seven to ten times the bankfull stream width. For example, if the stream width at a crossover is 9 m, the next crossover should be between 63 and 90 m (longitudinal distance) upstream. In higher gradient, step-pool streams, this relationship decreases to five to seven times stream width. These patterns are not as reliable in developed areas.

Do not shorten the site length as this may bias the surveys because certain habitats may be under- or over-represented.

Appendix 1

Rationale for Site Boundary Definitions

1. Crossovers can be found in all flowing waters and even the most disturbed systems will begin re-establishing crossovers where velocities are the slowest (under high flow conditions).

2. Use of geomorphic boundaries standardizes definitions across disciplines and promotes multi-disciplinary studies of flowing waters.

3. The 40 m minimum length optimizes the balance of variance and effort for a variety of parameters (fish community, instream habitat, substrate).

4. This length of stream can be sampled in a single day using the methods described in this manual.

5. Sampling multiple sites within a longer stream segment provides a more rigorous evaluation than just sampling a larger section of stream. This enables local variances in the biophysical properties of the stream to be measured, whereas sampling one long stretch of stream homogenizes the results[3].

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[3] Some measures must be made over longer stream sections, for example, the longitudinal profile of riffle and pool sequences, or sinuosity. These should be measured using Geographical Information Systems or Global Positioning Systems.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 2

Screening Level Site Documentation[1]

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes how to record the minimum information required for site location documentation. This module should be used when no station markers are to be installed at a site. This module relies on accurate geocoordinates being obtained for a site and recommends that crews record as much additional information as necessary to ensure that future users of the data will have confidence that the coordinates recorded are an accurate description of the site location.

Recent advances in GIS provide tremendous opportunities for illustrating and analyzing spatial data. Trend analysis (in time or space) is feasible only if accurate descriptions of the location of the sites are available. Application of this module will enable future surveyors, with the aid of a GPS, to locate the approximate location of a sampling site. For more precise locations of site boundaries, it is recommended that the 'Assessment Procedures for Site Feature Documentation' (S1.M3) be used.

2.0 PRE-FIELD ACTIVITIES

This module should be performed in conjunction with S1.M1 ('Defining Site Boundaries and Key Identifiers') where applicable. Geographic coordinates can be obtained in several ways. With the following materials available, each technique typically takes less than five minutes.

1. Site Description form
2. GIS with water flow and roads layer
3. GPS unit (differentially corrected), and/or
4. Maps that are of sufficient scale to locate the site within 50 m

3.0 FIELD PROCEDURES

Both uncorrected (i.e. obtained in the field) and validated geocoordinates are mandatory for this module. Site description and access route information is also required, but the degree of detail[2] required will vary with study design. Study design will also dictate the degree to which each additional section is completed. For example, all fields are considered mandatory for partners of the Ontario Benthic Biomonitoring Network.

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[2] Degree of detail will vary depending on where the work is being done in the province. In some instances it will be sufficient to name a road crossing or proximity to a significant feature. Remember, the information is not being recorded for the crews needs, but for future users of the data.

3.1 Georeferencing the Site Location

Geographical coordinates (i.e., latitude and longitude or Universal Transverse Mercator (UTM)) are usually collected using a Global Positioning System (GPS) (see Appendix I). Some units provide uncorrected coordinates and considerable effort may be needed (up to 15 minutes per site) to correctly locate these sites. Correcting these coordinates is necessary before the data can be confidently used in Geographic Information Systems (GIS).

3.1.1 Using a GPS

Obtain and record coordinates for the bottom of the site. When sufficient satellites have been received, the GPS will provide the UTM coordinates. Please record the UTM zone and coordinates using the NAD 83 datum. If the site is in a heavily forested area, is isolated from beacons, or is in a steep valley, the GPS unit may be unable to read enough satellites to obtain a position. This is a good reason to bring a copy of the Ontario Base Map (OBM) as a backup.

3.1.2 Using a Map

Obtain a copy of the OBM that includes the location of the site. Locate the site on the map and using a straight edge, read the UTM coordinates for the bottom of the site (to the nearest metre, following the standard of two digits for the grid, six digits for the easting, and seven digits for the northing (see Appendix 1 for a discussion on UTM grid coordinates)). If an OBM is not available, obtain a 1:50 000 topographical map and record the latitude and longitude for the site in the appropriate boxes on the field sheet. Record these to the nearest decimal second (i.e., 48°24’.83”).

Note: be sure to record the observations in the correct format, for example, 50 seconds are recorded as 0.83.

3.1.3 Using a GIS

Many offices have access to a GIS and associated water flow and roads layers. Project managers will often identify the location of a site using a GIS and provide a map with the site location and coordinates to field crews. Crews must record new coordinates if the location differs from the coordinates provided. If no map or coordinates are provided, use a GIS to identify the site location when the crew returns from the field.

3.2 Validating the Site Location

The most reliable process for validating site locations is to compare coordinates recorded on the data sheet to the locations in a GIS or on an OBM. If either of these were used to initially locate the site, it is recommended that the alternate technique be used during the validation process.

This reduces reader error and the effects of drift. Drift refers to the error introduced into a GIS from overlaying maps of different resolution. The Flowing Waters Information System (FWIS) is operational for this purpose and correcting sites in this utility ensures the corrected locations are incorporated in the master database (see Section 6: Data Management) of the FWIS webpage (comap.ca\fwis) for further information.

3.3 Filling Out the Site Identification (without Site Markers) Form

Ensure that each box from the ‘Stream Name’ down to and including the ‘Site Description and Access Route’ is filled out. It is also beneficial to provide sketches of the study site and access route as well as information for any photos you may have taken. The ‘Crew Leader’ and ‘Date’ must also be filled out on all data sheets. Table 1 identifies **in bold** what must be recorded and in *italics* what should be recorded in each box and an example sheet is provided in Appendix 2.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store them in a place separate from the originals.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models and improve habitat management practices and policies.

Table 1: Guidelines for Filling Out the Site Identification Form

Data Required	Instructions
‘Organization’	Record the name of the organization collecting the data (e.g. Ministry of Natural Resources)
‘Stream Name’	Record as shown in the Master Stream Name Database (see S1.M1).
‘Stream Code (Unique Code)’	Enter appropriate three character code as per Master Stream Name Database (see S1.M1).
‘Site Code’	Assign appropriate code, descriptive of site location (see S1.M1).
‘Date’	Record as year/month/day
‘Sample’	A sample event is one completion of the protocol, regardless of how many days it takes to finish it. A second sample would be a repeat assessment or a sample conducted in a different year.
‘Uncorrected UTM Coordinates’	For uncorrected UTM coordinates, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven).
‘Latitude’ and ‘Longitude’	As an alternative to the UTM coordinates, record the latitude and longitude of the site to the nearest decimal second (at minimum)
‘Corrected UTM Coordinates’	Once corrected, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven) in the ‘Uncorrected UTM coordinates’ boxes. Note decimal places can be added for eastings and northings
‘Source of GIS Stream Layer’	The name of the GIS layer and its origin should be recorded to enable users to address drift issues during applications.
‘Source of Uncorrected UTM Coord’	Record which method was used to obtain the uncorrected geocoordinates (i.e., GPS unit, GIS, OBM or topographical map.
‘Source of Corrected UTM Coordinates’	Record the source of corrected UTM coordinates (i.e. FWIS[3], Ortho-photos, GIS). If a GIS layer was used, please provide the name of the layer used for the correction.
‘Site Description and Access Route’	Describe the route taken to the site, beginning at a major interchange or reference point. Include distances between turns in rural areas. Remember that the data will also be used to verify the location of the site on a GIS, so record distances, not just 911 addresses. Also , describe the walking route from the parking location to the site and provide a detailed description of landmarks for locating the site (see example in Appendix 2).
‘Photo No.’	Record the numbers of any photographs taken, use an ‘X’ if no photos are taken.
‘Photo Name’	Record the file name of the photo if it is downloaded from a digital camera.
‘Photograph Description’	Describe the photograph taken so it can be accurately labelled when downloaded/developed.
‘Crew Leader’	First initial and last name of the crew leader.
‘Crew’	Initials of crew members.
‘Recorder’	Initials of the person entering the information on the sheet.
‘Date’	Record as year/month/day – include the slashes.
‘Comments’	Record any other relevant information here, such as the landowner’s name and phone number, special requests (i.e., wants to be contacted with results, etc.).

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[3] See glossary for further details.

Appendix 1

Background on UTM Coordinates

The Universal Transverse Mercator (UTM) system was introduced to provide an accurate means of locating any position on the globe. The globe is divided into grids. Each grid square has a unique reference identifying its position on the globe. For example, Wilmot Creek is in grid square 10-17. Positions are identified relative to how far north or east they lie from established reference points.

UTM coordinates are often recorded to the nearest metre. However, maps such as the Ontario Base Maps (OBM) show the numbers in units of hundreds of metres. Most data is entered into the HabProgs database to the nearest metre (although more accurate datasets derived from GIS applications are easily merged in HabProgs). Users need to be aware of how obtaining data from different sources/scales affects the data quality. For example, a site located on the Ganaraska River was recorded from an OBM as having coordinates of 10-17-6548-48650, while a GPS recorded uncorrected UTM coordinates of 17-654608-4865735 (ignoring decimals). The reading from the OBM would require two zeros to be added to the easting and to the northing distances in order to make the distances comparable to the same units and to meet the standards for this module (i.e., 10-17-654800-4865000). Finally, correcting the site to the water flow layer may result in the following numbers (i.e., 10-17-654856.4592-4865126.87356). Each record has a different degree of accuracy and as such is stored in different locations within Habprogs. Clearly, less accurate coordinates emphasize the need for good quality descriptions and sketches.

Appendix 2

Example Site Identification Form

Site Identification:
without Site Markers

Organization: MIN NATURAL RESOURCES

Stream Name: WILMOT CREEK

Date (mm-dd): 2000-08-01

Stream Code: WM1

Site Code: 3CDW

Sample: 01

Site Length (m): 44.0

Record using NAD83 datum

	Zone	Easting	Northing
Uncorr. UTM	17	690485.0	4867500.0
Corr. UTM	17	690907.0	4868866.0

OR → Long. DD — MM — SS.sss .

Lat. — — .

Source of Uncorrected UTM Coord.
GPS/DGPS ☒
GIS ☐
OBM ☐
Other

Source of CorrectedUTM Coordinates
FWIS ☒
Ortho-photos ☐
GIS ☐
Other

Name of Layer Used for Correction: NRVIS 4

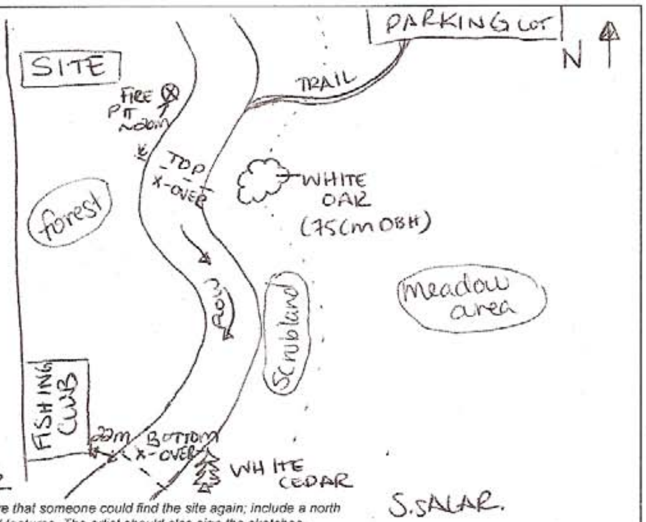
Site Description & Access Route

TAKE HWY 115/35 NORTH TO 4TH CONC. RD. TURN LEFT (WEST) ON 4TH CONC. YOU WILL PAST A BRIDGE AFTER LOCKHART RD - TURN LEFT (SOUTH) INTO PARKING LOT DIRECTLY AFTER BRIDGE (TURNE PARK (CONSERVATION AREA). WALK DOWN PATH TO STREAM. WALK 200 M DOWNSTREAM TO SITE. BOTTOM OF SITE IS 22M TO EAST OF WILMOT CREEK FISHING CLUB. FIRE PIT 20 M FROM TOP OF SITE.

Sketches

Site/Access Route Sketch

S.SALAR.



S.SALAR.

Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Photo No.	Photo Name	Photo Description
16	US_LOOKING_US	UPSTREAM CROSSOVER LOOKING UPSTREAM
17	US_LOOKING_DS	" " " DOWNSTREAM
18	DS_LOOKING_US	DOWNSTREAM " " UPSTREAM
19	DS_LOOKING_DS	" " " DOWNSTREAM

Comments

HIGH ALGAL GROWTH THROUGHOUT STREAM
BEATEN TRAILS AND DISCARDED FISHING LINE.

Crew Leader (init. & last name)	Crew	Recorder	Ent/Scanned	Verified	Corrected
J BEAL	S.S. A.C.	A.C	2000/10/11 A.C.	2000/11/10 J.B.	2000/11/11 S.S.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 3

Assessment Procedures for Site Feature Documentation[1]

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APPENDICES

Appendix 1. Background on UTM Grid Coordinates
Appendix 2. Example Site Identification Form
Appendix 3. Example Site Features Form

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

Monitoring initiatives require that sites be revisited, often by different surveyors. Unfortunately, field crews cannot always locate exact site boundaries due to insufficient or erroneous information. This limits the ability to evaluate trends through time at a particular site.

This module describes an approach for describing the site location such that field crews will be able to confidently return to the exact location on a stream where data have been collected and if desired track changes in the site boundaries over time. The information in this module can also be used to confirm site locations using Geographic Information Systems (GIS). In addition, methods for collecting information that might help to explain the biophysical condition of a site, such as surrounding land uses (current and historical) and unique features, are provided.

The information collected in this module reflects the effort by field crews and their diligence at researching historical information. Project managers must inform crew members how much effort should be applied to this portion of the survey. The procedures described in this module provide a qualitative description of the current and historical land uses that may influence a site. For studies designed to diagnose cause and effect, it is suggested that users consider the procedures described in S1.M4, Diagnostic Procedures for Site Feature Documentation in addition to those found in this module.

This module is applied in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers.

2.0 PRE-FIELD ACTIVITIES

This module takes 10 minutes to two hours to complete (depending on how much effort is used to document the landscape features). With a three-person crew, the most efficient procedure is to have one person fill out the forms while the other two measure and mark the site.

2.1 Equipment Checklist

The following equipment is required:

1. ‘Site Identification’ and ‘Site Features’ field forms (ideally copied onto waterproof paper)
2. HB Pencils
3. Tape measure or hip chain
4. Compass

Optional equipment includes a camera, site markers (see Section 3.5, Making a Site Sketch, for options), and flagging tape.

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

This module should be initiated during the first site visit. Boundary locations and distances from permanent site markers should be checked and recorded on each subsequent visit to the site.

3.1 Georeferencing the Site Location

3.1.1 Using a GPS

Obtain coordinates for the bottom of the site. When sufficient satellites have been received, the GPS will provide the UTM coordinates. Please record the UTM zone and coordinates using the NAD 83 datum. If the site is in a heavily forested area, is isolated from beacons, or is in a steep valley, the GPS unit may be unable to read enough satellites to obtain a position. This is a good reason to bring a copy of the Ontario Base Map (OBM) as a backup.

3.1.2 Using a Map

Obtain a copy of the OBM that includes the location of the site. Locate the site on the map and using a straight edge, read the UTM coordinates for the bottom of the site (to the nearest metre, following the standard of two digits for the grid, six digits for the easting, and seven digits for the northing (see Appendix 1 for a discussion on UTM grid coordinates). If an OBM is not available, obtain a 1:50 000 topographical map and record the latitude and longitude for the site in the appropriate boxes on the field sheet. Record these to the nearest decimal second (i.e., 48°24'.83").

Note: be sure to record the observations in the correct format, that is 50 seconds is recorded as 0.83.

3.1.3 Using a GIS

Many offices have access to a GIS and associated water flow and roads layers. Project managers will often identify the location of a site using a GIS and provide a map with the site location and coordinates to field crews. Crews must record new coordinates if the location differs from the coordinates provided. If no map or coordinates are provided, use a GIS to identify the site location when the crew returns from the field.

3.2 Validating the Site Location

The most reliable process for validating site locations is to compare coordinates recorded on the data sheet to the locations in a GIS or on an OBM. If either of these were used to initially locate the site, it is recommended that the alternate technique be used during the validation process. This reduces reader error and the effects of drift. Drift refers to the error introduced into a GIS from overlaying maps of different resolution. The Flowing Waters Information System (FWIS) is operational for this purpose and correcting sites in this utility ensures the corrected locations are incorporated in the master database (see Section 6: Data Management) for more details on this and or refer to theFWIS webpage (comap.ca\fwis).

3.3 Filling Out the Site Identification Form

Ensure that each box from the ‘Stream Name’ down to and including the ‘Site Description’ is filled out. Try to fill out the “Township/Municipality’, ‘MNR District’, ‘Watershed Code’ and ‘Lot’ and ‘Concession’ boxes. The ‘Crew Leader’ and ‘Date’ must also be filled out on all data sheets. Further detail regarding Site Markers is provided below. Table 1 identifies **in bold** what must be recorded and in *italics* what should be recorded in each box and an example sheet is provided in Appendix 2.

3.4 Site Markers

3.4.1 Marking the Site for Future Reference

Clearly document the site location so that it can easily be relocated. The best option for permanently marking a site is to use existing structures such as: fence lines, healthy “distinct” trees[2] or corners of buildings as reference points. Alternatives include:

- rebar placed well into the ground beside a tree or other objects
- spray-painted metal survey stakes that are driven into the ground
- coloured metal tree tags driven into a tree (ensure that enough space is left for the tree to grow) or
- spray paint on trees or large boulders (appropriate as short-term markers i.e., annual)

Flagging tape can also increase site visibility in the short term. It should be tied to a marker and the site name and date should be written on the flagging tape.

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[2] Select only trees that can be easily distinguished by field crews, i.e., a lone large maple tree in a pasture, the only hemlock tree in the riparian zone. Do not choose one white cedar in a cedar forest!

Important Terms for Describing the Site

When describing a site, make sure that the following terms are used consistently and correctly: top, bottom, left and right. The upstream end of a site is the top; the downstream end is the bottom. Left and right are defined when standing in the water and facing upstream.

Ask the landowner’s permission prior to putting in any permanent site markers. Some landowners would prefer that the markers be out of sight (i.e., at ground level or below). In these instances, the location should be clearly noted on the Site Identification form.

Markers should be placed at the top and bottom of every site (i.e., ‘Upstream Marker’ and ‘Downstream Marker’), above the high water mark on the bank associated with deposition (i.e., the convex bank). Measure the ‘Distance (m.)’ to the nearest 0.1 m from the marker to the edge of the water (for the closest bank that marks the bottom or top of the site). Record the side of the stream (left or right) and the compass bearing (‘Bearing (Degrees)’) from the marker to the bottom or top of the site (i.e., 10.2 m on a 272° bearing to the bottom right bank of the site).

Include the marker locations on the sketch of the site (see Section 3.2, ‘Making a Site Sketch’). Changing the location of the permanent site markers on subsequent visits should be avoided because these markers are used for monitoring channel movement. If a permanent marker must be moved, the location of the new marker (relative to the old one) should be recorded in the ‘Comments’ section of the field sheet and on the sketch.

Attach a labeled photograph (citing the site location and date of visit) to the Site Identification form. This photograph should be taken looking upstream from the bottom of the site. Additional photographs showing site features should also be taken (see Appendix 2, Example Site Identification Form). Record the photograph numbers on the form, and describe what they show[3]. The use of digital cameras or scanned pictures provides a permanent electronic image of the site.

3.4.2 Changing Site Markers at an Existing Site

Occasionally a site marker must be moved or is lost due to changes in the stream or surrounding environment (e.g. due to erosion or development).
If a site marker must be moved, complete a new Site Identification form and re-establish markers following the instructions provided above. Provide a distance measurement and compass bearing from the old location to the new marker and note the reason for relocation.

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[3] One option is to record the site code and orientation of the photo (i.e., bottom of site facing upstream) onto either a piece of paper or a chalk board and include this in the photo.

If a site marker is lost, locate the site to the best of your ability based on historical site identification information, remaining markers, and photographs (if available). Once the site is located re-establish markers following the instructions provided above. Note that the previous marker (or markers) has been lost in the comments field and whether the crew was able to "tie-in" the two stations or not.

3.5 Making a Site Sketch

On the upper half of the second page of the Site Identification form, draw a sketch of the site. The purpose of this sketch is to help future surveyors relocate the site and to show the location of adjacent features described on the Site Features field form (see Appendix 3).

This sketch must include the following information:

- 'Site Name'
- 'Stream Code'
- 'Site Code'
- 'Date (YYYY/MM/DD)' surveyed
- site boundaries
- location of site markers
- adjacent landscape features and land uses
- boundaries of vegetation types
- location of any buildings or fence lines
- route used to access the site
- a north arrow and relative scale

On the lower half of the second page of the form, photocopy a section of OBM or road map that includes the site. A map reference should also be included so future users can find the map. Mark the location of the site on the copied section of the map. Alternatively, draw a route map to the site from a major intersection.

Table 1: Guidelines for Filling out the Site Identification Form

Data Required	Instructions
'Organization'	Record the name of the organization collecting the data (e.g. Ministry of Natural Resources)
'Stream Name'	Record as shown in the Master Stream Name Database (see S1.M1).
'Stream Code (Unique Code)'	Enter appropriate three character code as per Master Stream Name Database (see S1.M1).
'Site Code'	Assign appropriate code, descriptive of site location (see S1.M1).
'Date'	Record as dd/mm/yyyy.
'Sample'	A sample event is one completion of the protocol, regardless of how many days it takes to finish it. A second sample would be a repeat assessment or a sample conducted in a different year.
'Uncorrected UTM Coordinates'	For uncorrected UTM coordinates, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven).
'Latitude' and 'Longitude'	As an alternative to the UTM coordinates, record the latitude and longitude of the site to the nearest decimal second (at minimum)
'Corrected UTM Coordinates'	Once corrected, record at least the following number of digits for the UTM coordinates: grid (two), easting (six), northing (seven) in the 'Uncorrected UTM coordinates' boxes. Note decimal places can be added for eastings and northings
'Source of GIS Stream Layer'	The name of the GIS layer and its origin should be recorded to enable users to address drift issues during applications.
'Source of Uncorrected UTM Coord'	Record which method was used to obtain the uncorrected geocoordinates (i.e., GPS unit, GIS, OBM or topographical map.
'Source of Corrected UTM Coordinates'	Record the source of corrected UTM coordinates (i.e. FWIS[4], Ortho-photos, GIS). If a GIS layer was used, please provide the name of the layer used for the correction.
'Township/ Municipality'	Identify the level of government responsible for planning (generally townships in rural areas and municipalities in urban areas).
'Lot' and 'Concession'	Enter the lot and concession in which the site is located.
'MNR District'	Enter the name of the district, not the area office.
'Watershed Code'	Five character code obtained from the provincial list/map. (i.e., 2HD-04)
'Access Route'	Describe the route taken to the site, beginning at a major interchange or reference point. Include distances between turns in rural areas. Remember that the data will also be used to verify the location of the site on a GIS, so record distances, not just 911 addresses.
'Site Description'	Describe the walking route from the parking location to the site and provide a detailed description of landmarks for locating the site (see example in Appendix 2).
'Site Marker Description'	Record the type(s) of markers used, locations, compass bearings, and distances (to the nearest 0.1 m) from the top and bottom of the site.
'Photo No.'	Record the number of any photographs taken.
'Photo Name'	Record the file name of the photo if it is downloaded from a digital camera.
'Photograph Description'	Describe the photograph taken so it can be accurately labelled when downloaded/developed.
'Crew Leader'	First initial and last name of the crew leader.
'Crew'	Record the initials of all crew members.
'Recorder'	Initials of the person entering the information on the sheet.
'Comments'	Record any other relevant information here, such as the landowner's name and phone number, special requests (i.e., wants to be contacted with results, etc.).
'Site Length'	Record (to the nearest metre) the longitudinal length of the site as measured down the centre of the stream. Not required for modules which are not applied on a geomorphic unit.

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[4] See glossary for further details.

3.6 Filling Out the ‘Site Features’ Form

3.6.1 Identifying the Site Features

For each site feature or landuse activity listed on the ‘Site Features’ form (Appendix 3), record <u>one</u> of the following options by marking an ‘X’ in the appropriate box:

‘Ongoing and Active’	there is evidence of the feature at the time of the site visit
‘Historical Evidence’	there are signs that the activity has occurred in the past
‘No Evidence but Reported’	it has been historically reported, but no obvious physical signs exist
‘No Evidence’	there is no current or historical evidence of this activity
‘Unknown’	the feature has not been sufficiently evaluated.

In the ‘Comments’ field, describe the features and landuses observed. Table 2 lists some indicators for each feature. If the activity is not present, mark the ’No Evidence’ box, otherwise it will be assumed that the site was not assessed for this activity. Other features observed near the site should be documented in the ‘Comments’ field at the bottom of the page.

Table 2: Definitions of Site Feature Attributes

Site feature	Diagnostic Indicators
‘Potential Point or Non-point Contaminant Sources’	Look for outlets from storm sewers, tile drains, or industrial discharge pipes. Note any obvious signs of discharge at the site (odour, staining, sheen, etc.).
‘Major Nutrient Sources Upstream’	Algal blooms or dense growth of aquatic macrophytes are indicators of upstream nutrient sources. If present, look for potential sources such as sewage treatment plants, processing plants, intensive agricultural operations (e.g., chicken ranches, livestock, feed lots) upstream of the site.
‘Channel Hardening or Straightening’	Hardening is indicated by rip-rap or gabion baskets. Straightened channels will often have dredged material piled adjacent to the stream, or will be atypically straight relative to the valley gradient.

Site feature	Diagnostic Indicators
‘Adjacent Landuses That Destabilize Banks’	This refers to unrestricted access (cattle, horses, humans, etc.) to banks, cutting or trampling of riparian vegetation.
‘Sediment Loading or Deprivation’	Evidence of sediment loading: mid channel bars; extended point bars around bends; pools filled with fines; sand dunes in shallow areas. Sediment deprivation can result in either hardening of the streambed (e.g., in high calcium areas), or boulders stacked like dominoes, (umbrication) where there are not enough cementing materials to hold larger particles in place.
‘Instream Habitat Modifications’	Debris or material removal, dam construction, habitat enhancement (lunker structures etc.).
‘Barriers and Dams in the Vicinity of the Site’	Often visible from roads or air photos; historical evidence includes elevated floodplains with an atypically flat gradient throughout the reach. There may also be evidence along the banks (e.g., elevated culverts, fallen timbers or old bridges that have been buried).
‘High Fishing Pressure’	Heavily packed trails, fishing debris, garbage, etc.
‘Log Jam Deflectors’	Fallen trees and woodpiles that are large enough to force water against the bank and cause lateral erosion. Record the number of occurrences within the site.
‘Springs or Seeps at the Site’	Abundant watercress in the stream; differences in stream temperature between sections (record temperatures in comments); a rust-coloured deposit on sediments surrounding the groundwater discharge zones in areas with high mineral content.
‘Impervious Substrate Limiting Burrowing Depth of Fish’	Exposed bedrock or hardpan (clay) within the site boundaries.
‘Fish Stocked Near Site’	Personal knowledge or anecdotal evidence such as the capture of fish with hatchery markings. Information is available from Ministry of Natural Resources.
‘Other Activities That Could Influence Biota or Habitat’	Any other features not already covered.

3.6.2 Documenting Information Sources

Record the information sources used to collect this data, by marking an 'X' in the appropriate box, as defined in Table 3 below. 'Visual Immediate' observations are mandatory when conducting a survey.

Table 3: Sources of Information

Information Source	Definition
'Visual Immediate'	Observed within 50 m of the site.
'Visual Extended'	Observed beyond 50 m of the site.
'Interview'	Discussion with someone familiar with the landuse history of the site (e.g., landowner).
'Maps/Photos'	Air photos or maps of the area (current and historical).

Record all pertinent information, including contact names and phone numbers and the source of maps and air photos used, in the 'Comments' field.

3.6.3 Recording the Riparian Vegetation Communities

Visually examine the vegetation communities occurring along each bank of the stream. Divide the bank into three zones based on distance from the water as follows: 1.5 to 10 m, 10 to 30 m, and 30 to 100 m. This can be done visually (where obvious) or by measuring the distance to zone boundaries. For each zone on each bank, record the dominant type of vegetation (Table 4) by marking an 'X' in the appropriate box. Record the right and left bank separately.

When the majority of a zone is covered by one vegetation community, this community type is dominant. If it is not obvious which type is dominant, use a measuring tape to sort out conflicts. Note that the classification is hierarchical, ensuring that all riparian zones meet one criterion, only.

Table 4: Types of Vegetative Communities

Vegetative Community	Description
‘None’	Over 75% of the soil has no vegetation.
‘Lawn’	Grasses that are not allowed to reach a mature state due to mowing.
‘Cropped Land’	Planted in agricultural crops in most years; plants typically arranged in rows (due to machine-planting); may be subject to periodic tillage.
‘Pasture’	Grasses and sedges that are not allowed to reach a mature state due to grazing by livestock.
‘Meadow’	< 25% tree/shrub cover; characterized by grasses and forbs
‘Scrubland’	> 25 and < 60% trees or shrubs interspersed with grasses and sedges (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height).
‘Forest’	> 60% of the canopy is covered by the crowns of trees.

3.7 Tips for Applying this Module

Site markers should be painted before going into the field.

Make up cue cards that include the site name and orientation of where the photo will be taken in relation to the site (i.e., bottom site 3CDW looking up). These can then be held or placed in each photo to prevent site misidentifications.

Be clear and consistent with the words used to describe locations; use the convention for top, bottom, left and right. Words like close, far, large, small, etc., are ambiguous and confusing.

Make sure that road crossings and access points are clearly and accurately labeled on the site location sketch.

Talk to landowners, anglers, and local conservation officers about the site for more information.

Look for evidence of historical activities (i.e., garbage piles, foundations, fence lines, dredging mounds, tree stumps of similar age). Presence or absence of vegetation types can provide indicators of past landuse (i.e., missing deciduous trees imply grazing, lack of wildflowers implies that rowcrops or hay have been planted).

Following completion of the survey, always check over field sheets for completeness, particularly for the UTM coordinates on the ‘Site Identification’ form. In addition, have someone else review the field forms and **critically** assess them for clarity and completeness.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

Appendix 1

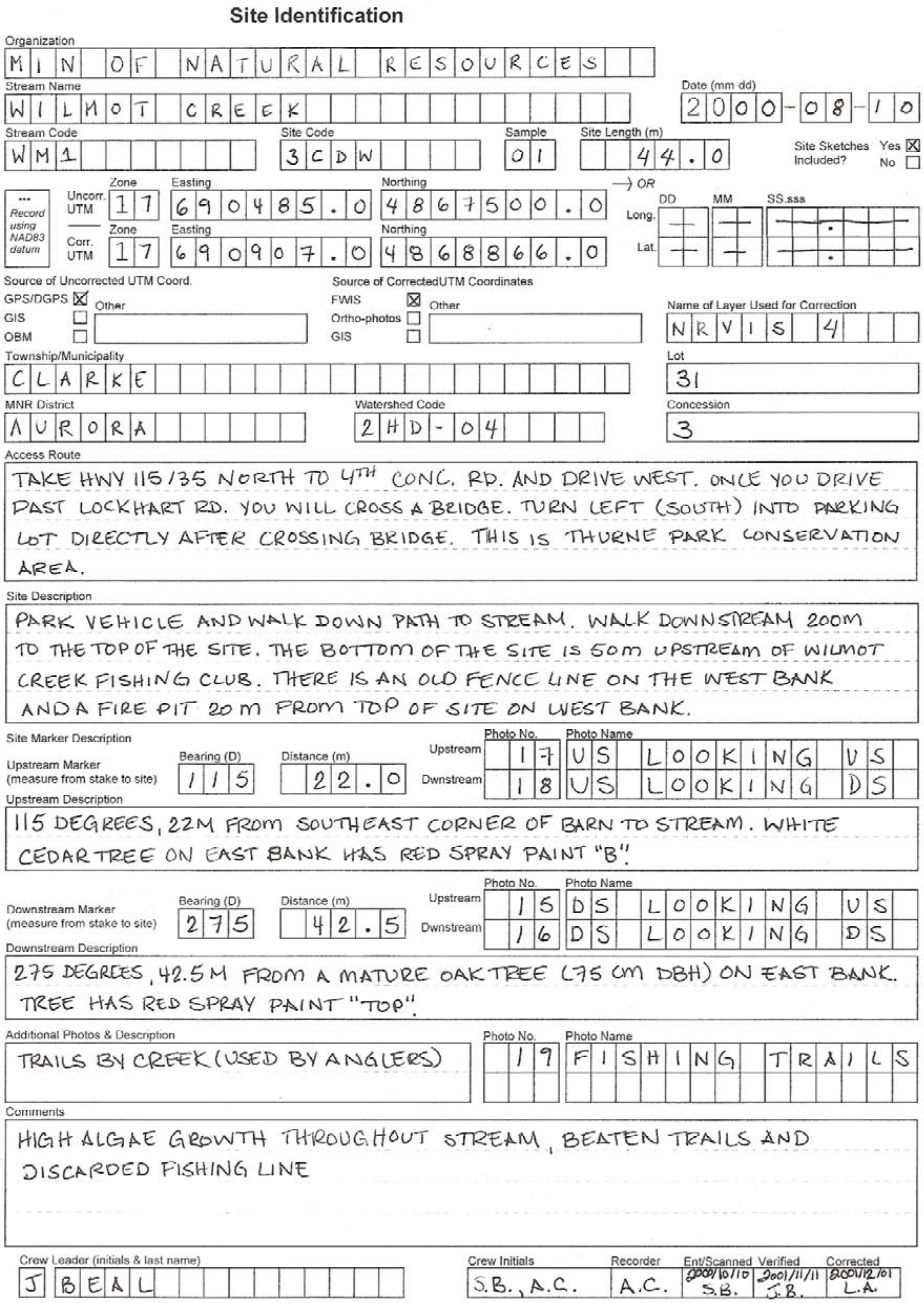
Background on UTM Coordinates

The Universal Transverse Mercator (UTM) system was introduced to provide an accurate means of locating any position on the globe. The globe is divided into grids. Each grid square has a unique reference identifying its position on the globe. For example, Wilmot Creek is in grid square 10-17. Positions are identified relative to how far north or east they lie from established reference points.

UTM coordinates are often recorded to the nearest metre. However, maps such as the Ontario Base Maps (OBM) show the numbers in units of hundreds of metres. Most data is entered into the HabProgs database to the nearest metre (although more accurate datasets derived from GIS applications are easily merged in HabProgs). Users need to be aware of how obtaining data from different sources/scales affects the data quality. For example, a site located on the Ganaraska River was recorded from an OBM as having coordinates of 10-17-6548-48650, while a GPS recorded uncorrected UTM coordinates of 17-654608-4865735 (ignoring decimals). The reading from the OBM would require two zeros to be added to the easting and to the northing distances in order to make the distances comparable to the same units and to meet the standards for this module (i.e., 10-17-654800-4865000). Finally, correcting the site to the water flow layer may result in the following numbers (i.e., 10-17-654856.4592-4865126.87356). Each record has a different degree of accuracy and as such is stored in different locations within Habprogs. Clearly, less accurate coordinates emphasize the need for good quality descriptions and sketches.

Appendix 2

Example Site Identification Form



Site Identification

Organization: MIN OF NATURAL RESOURCES

Stream Name: WILMOT CREEK

Date (mm dd): 2000-08-10

Stream Code: WM1

Site Code: 3CDW

Sample: 01

Site Length (m): 44.0

Site Sketches Included? Yes ☒ No ☐

Record using NAD83 datum

	Zone	Easting	Northing
Uncorr. UTM	17	690485.0	4867500.0
Corr. UTM	17	690907.0	4868866.0

→ *OR*

	DD	MM	SS.sss
Long.	—	—	—.—
Lat.	—	—	—.—

Source of Uncorrected UTM Coord.

- GPS/DGPS ☒
- GIS ☐
- OBM ☐
- Other:

Source of CorrectedUTM Coordinates

- FWIS ☒
- Ortho-photos ☐
- GIS ☐
- Other:

Name of Layer Used for Correction: NRVIS 4

Township/Municipality: CLARKE

Lot: 31

MNR District: AURORA

Watershed Code: 2HD-04

Concession: 3

Access Route

TAKE HWY 115/35 NORTH TO 4TH CONC. RD. AND DRIVE WEST. ONCE YOU DRIVE PAST LOCKHART RD. YOU WILL CROSS A BRIDGE. TURN LEFT (SOUTH) INTO PARKING LOT DIRECTLY AFTER CROSSING BRIDGE. THIS IS THURNE PARK CONSERVATION AREA.

Site Description

PARK VEHICLE AND WALK DOWN PATH TO STREAM. WALK DOWNSTREAM 200M TO THE TOP OF THE SITE. THE BOTTOM OF THE SITE IS 50m UPSTREAM OF WILMOT CREEK FISHING CLUB. THERE IS AN OLD FENCE LINE ON THE WEST BANK AND A FIRE PIT 20 m FROM TOP OF SITE ON WEST BANK.

Site Marker Description

Upstream Marker (measure from stake to site): Bearing (D) 115; Distance (m) 22.0

	Photo No.	Photo Name
Upstream	17	US LOOKING US
Dwnstream	18	US LOOKING DS

Upstream Description

115 DEGREES, 22M FROM SOUTHEAST CORNER OF BARN TO STREAM. WHITE CEDAR TREE ON EAST BANK HAS RED SPRAY PAINT "B".

Downstream Marker (measure from stake to site): Bearing (D) 275; Distance (m) 42.5

	Photo No.	Photo Name
Upstream	15	DS LOOKING US
Dwnstream	16	DS LOOKING DS

Downstream Description

275 DEGREES, 42.5 M FROM A MATURE OAK TREE (75 cm DBH) ON EAST BANK. TREE HAS RED SPRAY PAINT "TOP".

Additional Photos & Description

TRAILS BY CREEK (USED BY ANGLERS)

Photo No.	Photo Name
19	FISHING TRAILS

Comments

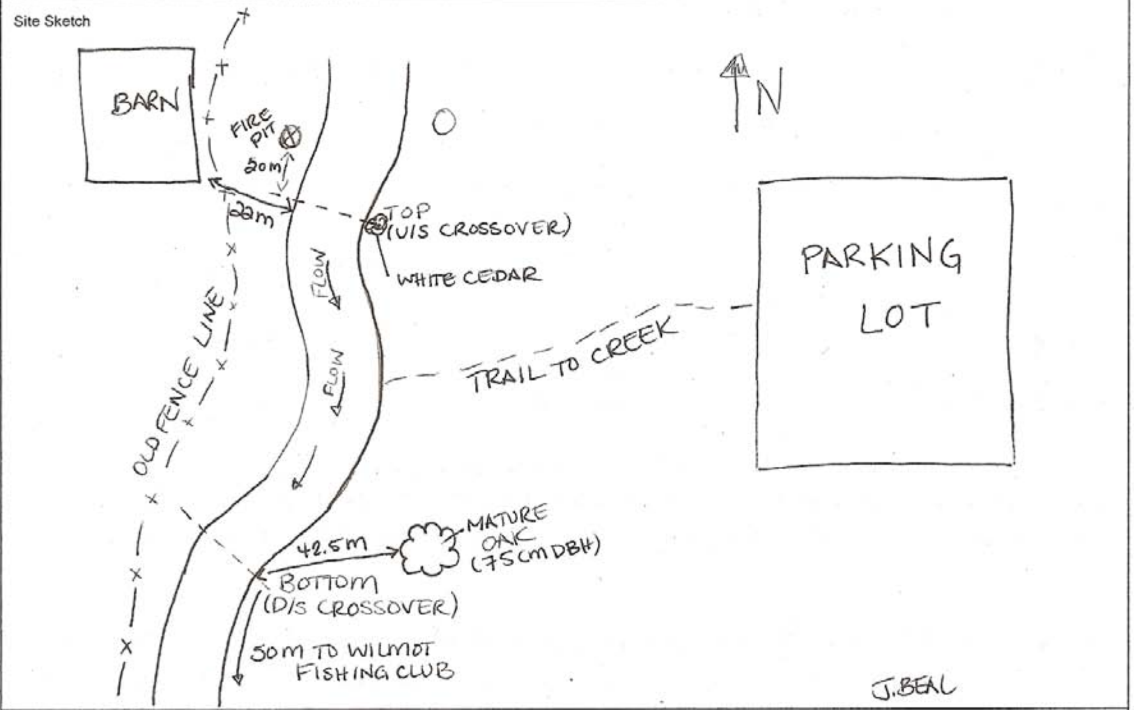
HIGH ALGAE GROWTH THROUGHOUT STREAM, BEATEN TRAILS AND DISCARDED FISHING LINE

Crew Leader (initials & last name): J BEAL

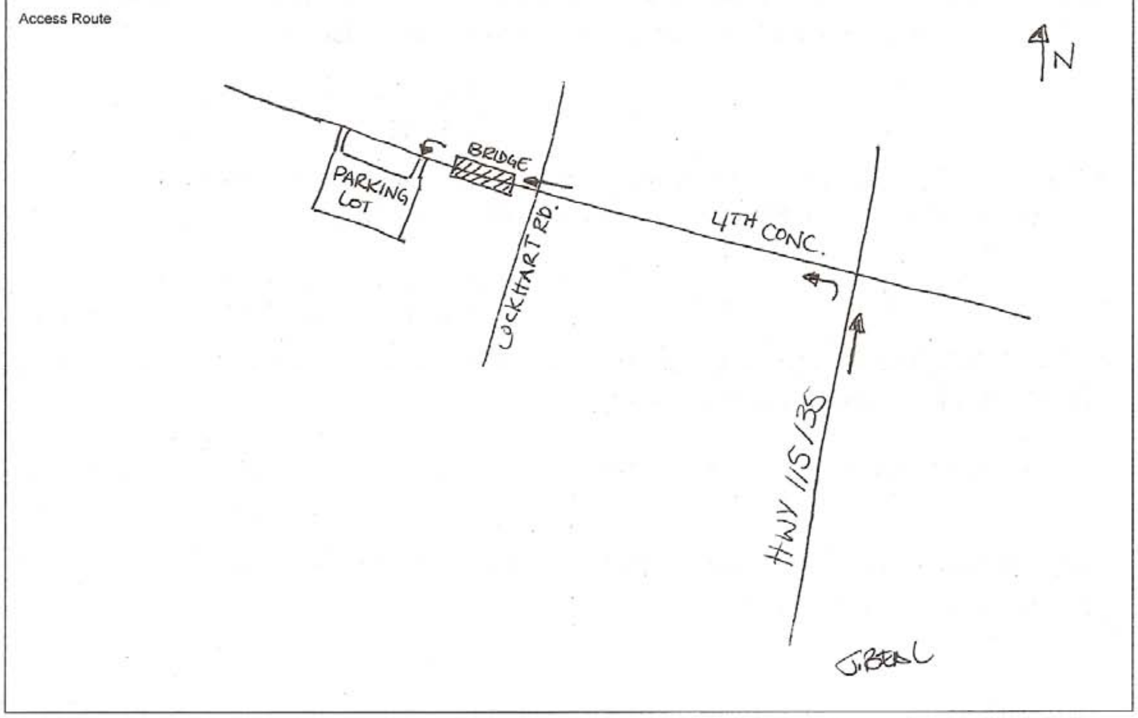
Crew Initials	Recorder	Ent/Scanned	Verified	Corrected
S.B., A.C.	A.C.	2001/10/10 S.B.	2001/11/11 J.B.	2001/12/01 L.A.

Site Identification:
Sketches

Site Sketch



Access Route

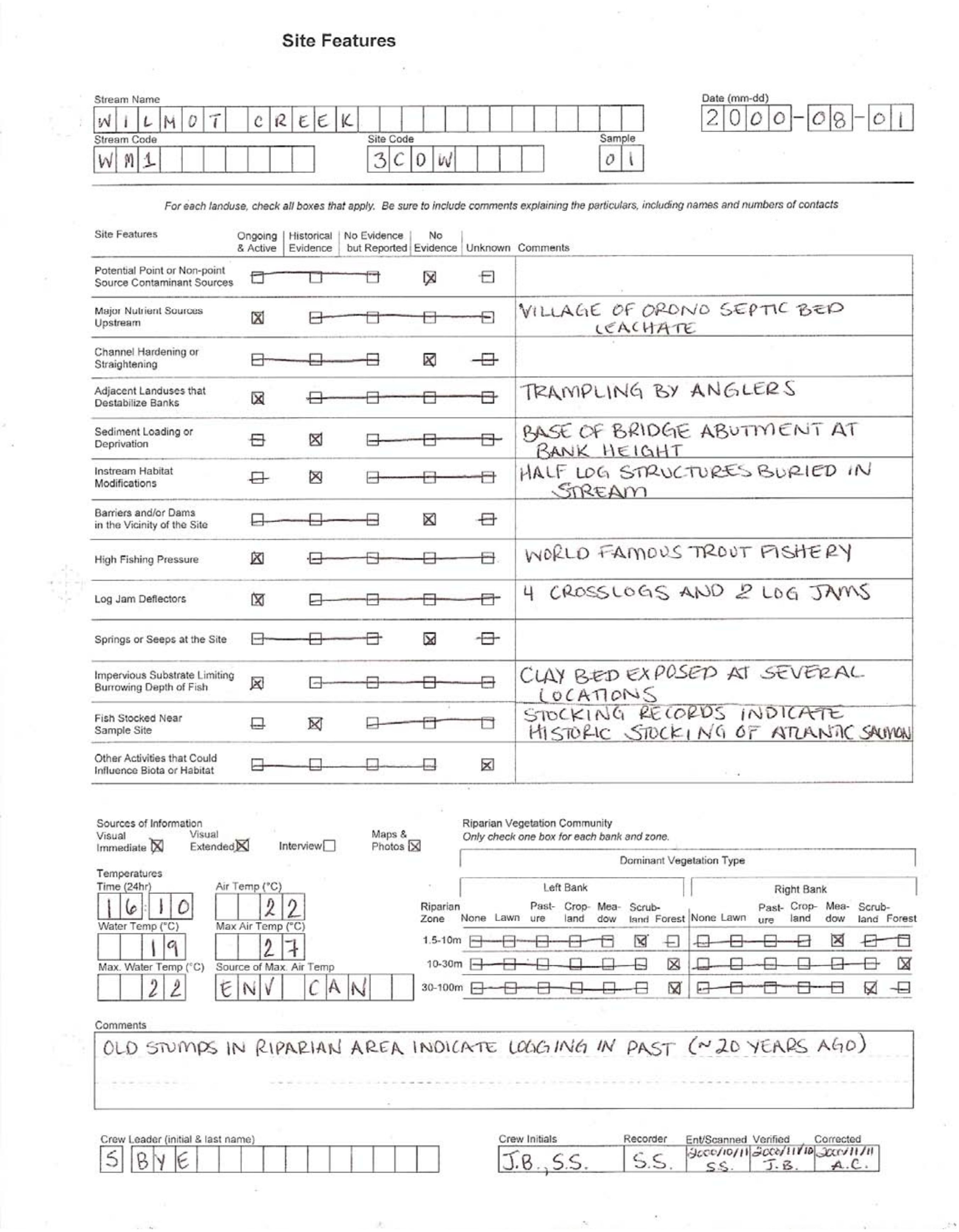


Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Appendix 3

Example Site Features Field Form

It should be noted that this form may also be used to record temperature data (see S5, Water Temperature Assessment) and sample data of this type have been included in this example.



Site Features

Stream Name: WILMOT CREEK
Date (mm-dd): 2000-08-01
Stream Code: WM1
Site Code: 3C0W
Sample: 01

For each landuse, check all boxes that apply. Be sure to include comments explaining the particulars, including names and numbers of contacts

Site Features	Ongoing & Active	Historical Evidence	No Evidence but Reported	No Evidence	Unknown	Comments
Potential Point or Non-point Source Contaminant Sources	☐	☐	☐	☒	☐	
Major Nutrient Sources Upstream	☒	☐	☐	☐	☐	VILLAGE OF ORONO SEPTIC BED LEACHATE
Channel Hardening or Straightening	☐	☐	☐	☒	☐	
Adjacent Landuses that Destabilize Banks	☒	☐	☐	☐	☐	TRAMPLING BY ANGLERS
Sediment Loading or Deprivation	☐	☒	☐	☐	☐	BASE OF BRIDGE ABUTMENT AT BANK HEIGHT
Instream Habitat Modifications	☐	☒	☐	☐	☐	HALF LOG STRUCTURES BURIED IN STREAM
Barriers and/or Dams in the Vicinity of the Site	☐	☐	☐	☒	☐	
High Fishing Pressure	☒	☐	☐	☐	☐	WORLD FAMOUS TROUT FISHERY
Log Jam Deflectors	☒	☐	☐	☐	☐	4 CROSSLOGS AND 2 LOG JAMS
Springs or Seeps at the Site	☐	☐	☐	☒	☐	
Impervious Substrate Limiting Burrowing Depth of Fish	☒	☐	☐	☐	☐	CLAY BED EXPOSED AT SEVERAL LOCATIONS
Fish Stocked Near Sample Site	☐	☒	☐	☐	☐	STOCKING RECORDS INDICATE HISTORIC STOCKING OF ATLANTIC SALMON
Other Activities that Could Influence Biota or Habitat	☐	☐	☐	☐	☒	

Sources of Information
Visual Immediate ☒ Visual Extended ☒ Interview ☐ Maps & Photos ☒

Temperatures
Time (24hr): 16:10
Air Temp (°C): 22
Water Temp (°C): 19
Max Air Temp (°C): 27
Max. Water Temp (°C): 22
Source of Max. Air Temp: ENV CAN

Riparian Vegetation Community
Only check one box for each bank and zone.

	Dominant Vegetation Type													
	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest
1.5-10m	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒
30-100m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐

Comments
OLD STUMPS IN RIPARIAN AREA INDICATE LOGGING IN PAST (~20 YEARS AGO)

Crew Leader (initial & last name): S BYE

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected
J.B., S.S.	S.S.	2000/10/11 S.S.	2000/11/10 J.B.	2000/11/11 A.C.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 4

Diagnostic Procedures for Site Feature Documentation[1]

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module provides an expanded process for evaluating the current and historical landuses and local features that potentially influence the biophysical properties at a site and should therefore be applied in conjunction with the other modules in this section (i.e., S1.M1, Defining Site Boundaries and Key Identifiers and S1.M3, Assessment Procedures for Site Feature Documentation). Users can adapt this approach to meet their specific needs.

The approach used in this module is an adaptation of the Watershed Report Card (2000). Local features that are critical to biota are identified. Techniques for evaluating past disturbances (i.e., presses such as landuse and pulses such as weather or fire events) that might affect site conditions are provided. Surveyors are directed to document mitigation techniques used by landowners. Finally, standard procedures (Newbury and Gaboury 1993) to monitor channel movement have been adapted for use in this module.

The objective of this module is to describe the common processes and features that influence streams and to identify characteristics that will provide information on the origin of the stressors.

2.0 PRE-FIELD ACTIVITIES

The time required to evaluate channel migration patterns is approximately 30 minutes. A challenge for users of diagnostic assessments is to balance sampling effort with the likelihood of drawing an inaccurate conclusion. Therefore, each project manager must decide on the level of detail (i.e., hours to weeks) that should be applied by field crews carrying out this module.

Pre-field preparation can vary considerably between projects and may include the following activities:

- an evaluation of landscape features influencing the biophysical conditions at the site
- reading historical accounts of landuse changes and disturbances in the watershed and how they might have influenced the stream
- reviewing historical maps, photos and art from the area
- interviewing long term residents and local authorities from the area

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

2.1 Evaluation of Landscape Conditions

Evaluation of landscape features such as the geology, topography, climate and zoogeography (specifically the post glacial dispersal patterns of biota) enables biologists to predict expected conditions at a site[2]. Procedures for conducting these analyses are described in two documents by Kilgour and Stanfield (2001) and Stanfield (2003).

2.2 Evaluating Press and Pulse Disturbances

Permanent landuse changes typically have long lasting (i.e. centuries rather than decades) effects on the biophysical features of a stream and are considered ‘presses’. In many situations, the streams adjust transport processes (water and sediment) in response to these historical perturbations. Current conditions reflect impacts from historical and more recent disturbances. For example, sites draining the Oak Ridges Moraine and Norfolk Sand Plains in southern Ontario were denuded of most vegetation and their channels altered by many obstructions by the turn of the century. These factors are still affecting the hydrology and sediment transport regime in these watersheds. Understanding the extent of historical and current landuses in the catchment can improve the ability to deduce stream limiting features.

In other situations, catastrophic changes may have occurred that act as a ‘pulse’ to change the stream processes. Pulse disturbances may include weather events such as hurricanes, tornadoes, extreme floods, fire etc.

Information on both of these types of disturbances is available from local history books, historical society notes and interviews.

2.3 Historical Maps, Photos and Paintings

Maps and aerial photographs can provide a record of historical conditions. These can be compared to present and reference state conditions to quantify the timing and degree of change.

Early photographs and landscape art also reflect historical conditions of the area. These are often available from long-term landowners, local papers or historical societies.

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[2] The Ontario Ministry of Natural Resources has recently developed a Geographic Information System (GIS) application to collect the landscape data for sites (and segments of streams) and has applied this to the Great Lakes basin. To obtain these data for a study area contact the Water Resources Information Project (WRIP) group in Peterborough or the GIS support staff at the district office.

2.4 Interviews

Long-term residents and resource managers are invaluable sources of information. Detailed notes should be made from interviews and should form part of the historical documentation. Reports should be provided to those interviewed to ensure accuracy.

3.0 FIELD PROCEDURES

After completion of S1.M3 (Assessment Procedures for Site Feature Documentation), expand the field assessment to include the surrounding landscape and additional variables outlined in this module.

3.1 Searching for Rare Features

Search the valleylands upstream and downstream of the site for any of the following features:

- groundwater upwellings (seeps, artesian wells)
- rare or indicator plant and animal species
- rare landform features (outcrops, eskers, terraces, sinks, etc.)
- historically or culturally significant features

Data on these features can be obtained through field surveys, satellite imagery analysis, air photo interpretation, or may also be found in old natural resource agency office records.

3.2 Historical and Current Landuse Stressors

Search the landscape for features indicating a major disturbance at the local level. Some of these features include:

- berms (from dredgings, pond walls, roads or railways)
- building foundations
- signs of clear cutting (tree stumps of similar age or uniformly aged tree stands)
- riparian vegetation dominated by a single species (implies extreme grazing pressure or planting efforts)
- mine tailings or garbage piles
- improper farming or land management practices such as destruction of riparian zones, livestock access, tile drainage within the flood plain etc.

3.3 Documenting Mitigation Techniques

There are many techniques that landowners and resource managers can use to mitigate the effects of poor land and water management. Document the presence and approximate installation year of techniques designed to address:

- sediment transport through the channel[3]
- overland transport of sediment and water
- riparian vegetation health
- bank stabilization
- woody material in the channel
- instream cover
- alterations to flow regime (particularly flood events)

3.4 Techniques for Tracking Channel Migration

To accurately track the movement of the channel over time, a base station and GPS should be used to accurately record the location of all important features (i.e., site boundaries, station markers, transect locations and channel edges). To create a longitudinal profile of the channel, track the depth and location of the mid-point of the channel through the entire length of the station (see Newbury and Gaboury 1993).

3.5 Recording the Data

In addition to filling out the Site Features form (S1.M3; Appendix 2), it is advised that the data be summarized in a report. The report should illustrate the location of the site on a georeferenced map, describe observations, and the data source. Provide an interpretation of the relative contribution of each feature influencing the biophysical properties of the study area.

Surveyors may wish to rate the extent (area affected by feature) and intensity (or magnitude[4]) of each feature as described in the Watershed Report Card (2000).

3.6 Tips for Applying this Module

Look for any features in the floodplain and channel that look ‘out of place’ and try to ascertain their origin and potential effects they historically or currently have on the system.

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[3] Record characteristics such as umbrication (stacking of larger substrate particles in ways that mimic fallen dominoes). This indicates a sediment transport imbalance.

[4] Examples of high versus low intensity features are feedlots compared to cattle ranges or full bank rip rap compared to rip rap placed on just one or two outside bends.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store them in a place separate from the originals.

The HabProgs database does not currently receive these data, however efforts continue to develop a standard storage program so all users can manage these data.

5.0 LITERATURE CITED

Kilgour, B.W. and L. W. Stanfield. 2001. Protocols for Delineating, Characterizing and Classifying Valley Segments. Report prepared by Jacques Whitford Environment Limited for the Regional Municipality of Ottawa-Carleton.

Newbury, R. W. and M. N. Gaboury. 1993. Stream analysis and fish habitat design: A Field Manual. Co-Published by Newbury Hydraulics Ltd., the Manitoba Habitat Heritage Corporation and Manitoba Natural Resources, Gibsons, British Columbia.

Stanfield, L. W. (Ed.). 2003. Guidelines for Designing and Interpreting Stream Surveys: A Compendium Manual to the Ontario Stream Assessment Protocol. Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton. Internal Publication.

Watershed Report Card. 2000. Watershed Report Card: Manuals for Community Involvement in Watershed Management. Watershed Report Card Inc., Port Elgin, ON.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 1, MODULE 5

Site Features for Water Quality Surveys[1]

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APPENDICES

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[1] Author: S. Hogg, L.W. Stanfield and C. Jones

1.0 INTRODUCTION

This module describes an approach for consistently documenting the features in and around a stream that might be influencing the benthos community and to capture the metadata associated with survey methodologies. The module evolved from and supports any collections made as part of the Ontario Benthos Biomonitoring Network (OBBN), but is also intended to support any other survey methods that sample benthos. This module is a mandatory component of a sample collected as part of an OBBN station. This module is also a good complement to any surveys in which benthos are used as indicators of water quality (Section 2) or for any study that includes elements of water quality in the objectives.

Site features data may be used in models that match reference-sites and test-sites in reference-condition-approach studies. In the event that atypical community composition is observed, site features data may also suggest hypotheses about potential causes of impairment (see Jones et al. 2007 for further detail). The habitat measures required in this module are hypothesized to influence the composition of benthic-invertebrate assemblages: this list may be updated as further information becomes available.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and can be completed, in combination with benthos collection, in about 30 minutes.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment is required:

1. Benthic Survey Sheet, on waterproof paper
2. Waders
3. Metre Stick (wooden)
4. Measuring Tape
5. Pencils

Optional equipment includes:

6. Device to measure canopy cover (e.g. densiometer)

7. Camera

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first-aid supplies and training, travel plan, minimum field crew size, and emergency equipment such as a mobile phone, etc.

3.0 FIELD PROCEDURES

This module should be performed in conjunction with S1.M1 (‘Defining Site Boundaries and Key Identifiers’), S1.M2, Screening Level Site Documentation and S2.M3, Transect Kick and Sweep for Macroinvertebrates.

3.1 Filling Out the Benthic Survey Sheet

Record the ‘Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample’, ‘Date’ and ‘Time’ on the Benthic Survey Sheet. If you are using a water quality probe, fill out the ‘Water Quality’ section of the form prior to entering/disturbing the stream in the sampling area.
Also record the ‘Crew Leader’, ‘Crew’ and ‘Recorder.

3.2 Collection Area Habitat

Document collection area habitat prior to collection of benthos, as their ollection will disturb substrate and dislodge macrophytes and algae present.

3.2.1 Substrate

For each collection area, record the dominant and second dominant substrate types in the ‘Substrate’ section. Dominant substrate types can be determined by visual estimation, the rapid assessment methodology (S4.M8), or the substrate portion of S4.M2. Substrate categories can be viewed in Table 1.

Table 1. Substrate Class Categories.

Class	Description
1	Clay
2	Silt (floury, <0.06 mm)
3	Sand (grainy, 0.06 – 2 mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 – 250 mm)
6	Boulder (>250mm)
7	Bedrock

3.2.2 Aquatic Macrophytes and Algae

For each collection area, record the types of aquatic macrophytes and algae present. Classify each as; 1 (Abundant), 2 (Present) or 3 (Absent). For definitions see Table 2.

Table 2. Aquatic Macrophytes and Algae

Aquatic Vegetation Type	Description
Macrophytes	aquatic plants with obvious stems, leaves and roots
‘Emergent’	rooted in substrate but part of plant extends above the water surface (e.g. cattails)
‘Rooted Floating’	rooted in the substrate with floating leaves (e.g. water lilies)
‘Submergent’	rooted in substrate and grow completely below surface of the water (e.g. milfoil)
‘Free Floating’	float on the water surface or in the water column and are not rooted to the substrate (e.g. duckweed)
Algae	aquatic organisms containing chlorophyll and distinguished from plants by the absence of true roots, stems, and leaves
‘Floating’	algae floating on the water surface or in the water column
‘Filamentous’	green algae having a hair-like growth form (cells arranged in long filaments); slimy to the touch
‘Attached’	algae attached to substrate (other than filamentous algae) (e.g. Chara); may form a slime or crust

3.3 Sampling Site Habitat

3.3.1 Measuring Bankfull Width

Record ‘Bankfull Width’ to the nearest tenth of a metre. Left and right banks are defined when facing upstream. If you are unfamiliar with bankfull indicators refer to S4.M3.

3.3.2 Riparian Vegetation Community

Observe the riparian vegetation community in zones 1.5-10 meters, 10-30 meters and 30-100 meters from the stream sampling reach. Indicate the dominant community in each zone for both the left and right banks in the ‘Riparian Vegetation Community’ section. Refer to Table 3 for community type descriptions.

3.3.3 Measuring Canopy Cover

Visually estimate the percent tree canopy shading the wetted area of the sampling reach (all three collection areas) or measure canopy cover using an appropriate instrument (e.g. densiometer). Record the ‘% Canopy Cover’ as; 0-24%, 25-49%, 50-74% or 75-100%.

3.3.4 River Characterization

Indicate whether the stream has permanent or intermittent flow. If the flow permanence is unknown, check '*Unknown*'. Identifying the flow status of a stream can be challenging and can be determined if the stream has been classified by the local Ministry of Natural Resources office or Conservation Authority. Another option is to apply the Stream Permanency Handbook for South-central Ontario (Bergman, Irwin and Boos 2005) in unclassified areas.

Table 3: Types of Vegetative Communities

Vegetative Community	Description
'None'	Over 75% of the ground surface is not vegetated.
'Lawn'	Grasses that are kept immature due to mowing.
'Cropped Land'	Planted in agricultural crops in most years; plants typically arranged in rows (machine-planted); may be tilled periodically.
'Pasture'	Grasses and sedges that are not allowed to reach a mature state due to grazing by livestock.
'Meadow'	< 25% tree/shrub cover; characterized by grasses and forbs allowed to reach a mature state
'Scrubland'	> 25% and < 60% trees or shrubs interspersed with grasses and sedges (a transitional area between meadow and forest, with trees generally less than 10 cm in diameter at breast height).
'Forest'	> 60% of the canopy is covered by the crowns of trees.

3.4 Reference Sites

Indicate whether the site is a candidate reference site (i.e. it reflects least disturbed conditions in the sample area ecoregion). If the site is a candidate reference site and the sampling is being conducted as part of the OBBN, collected invertebrate samples should be identified as precisely as possible (at least to the family level), preserve them and carry out appropriate quality assurance checks on the identifications and enumerations. Send the preserved sample to the OBBN Coordinator[2] for genus/species level identification.

4.0 DATA MANAGEMENT

Upon returning from the field;

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[2] Send samples to the attention of the OBBN Coordinator at: Ontario Ministry of the Environment, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON, P0A 1E0

1. Create paper copy backups (i.e., photocopy) of field forms, and store them in a place separate from originals.
2. Enter the data into a digital storage system, such as the OBBN benthos portal[3] or HabProgs, so that data can be shared.

5.0 LITERATURE CITED

Bergman, B., K. Irwin, and J. Boos. 2005. The Stream Permanency Handbook for South-central Ontario. Southern Region Planning Unit, Ontario Ministry of Natural Resources, Peterborough, Ontario.

Jones, C., K.M. Somers, B. Craig, and T. Reynoldson. 2007. Ontario Benthos Biomonitoring Network Protocol Manual, Version 1.0. Ontario Ministry of Environment, Dorset, Ontario.

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[3] The Ministry of Environment, Ontario Benthic Biomonitoring Network, has developed a portal and database for storing data collected as part of the Ontario Benthic Biomonitoring Network. Contact f.chris.jones@ontario.ca for more information and access to the system.

Appendix 1

Example Benthic Survey Sheet

Benthic Survey Sheet

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3CDW

Sample: 01

NOTE:
For all measurements, right and left banks defined facing upstream.

Date (mm-dd): 2010-08-21

Time (24hr): 13:12

Water Quality

Water Temp (°C): 19.6

Conductivity (uS/cm): 364

pH: 7.2

DO (mg/L): 9.4

Alkalinity (mg/L as CaCO3): 6.2

Substrate

Enter dominant substrate class and second dominant class for each sub-sample.

	Collect. Area 1	Collect. Area 2	Collect. Area 3
Dominant	4	3	4
2nd Dominant	2	2	3

Class	Description
1	Clay (hard pan)
2	Silt (floury, <0.06 mm particle diameter)
3	Sand (grainy, 0.06 - 2mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (>250 mm)
7	Bed Rock

Bankfull Width (m): 6.7

Gear Type
☐ Poled Seine ☐ Ponar
☒ D-Net ☐ Ekman
☐ Surber ☐ Other :

Collection Method
☐ Rapid Survey
☐ Stationary Kick Survey
☒ Transect Kick & Sweep
☐ Grab

MeshSize (microns)
☐ 250 ☐ 600
☒ 500 ☐ 1000
(Select the box that most closely represents the mesh size used.)

% Canopy Cover
☐ 0 - 24 ☒ 50 - 74
☐ 25 - 49 ☐ 75 - 100

If instrument used, record type:

River Characterization
☒ Perennial
☐ Intermittent
☐ Unknown

Candidate Reference Site? (ie. minimally impacted)
☐ Yes
☒ No

Comments
DATA TO BE PROVIDED TO OBBN

Crew Leader (initial & last name): A ROSS

Aquatic Macrophytes & Algae

Enter appropriate abundance class for each type and sub-sample.

Class	Description
0	Absent
1	Present
2	Abundant

Macrophytes	Collect. Area 1	Collect. Area 2	Collect. Area 3
Emergent	2	0	2
Rooted Floating	0	0	0
Submergent	0	0	1
Free Floating	0	0	0

Algae	Collect. Area 1	Collect. Area 2	Collect. Area 3
Floating Algae	0	0	0
Filamentous	1	1	1
Attached Algae	0	1	0

Riparian Vegetation Community

Only check one box for each bank and zone.

	Dominant Vegetation Type													
	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Pasture	Crop-land	Mea-dow	Scrub-land	Forest	None	Lawn	Pasture	Crop-land	Mea-dow	Scrub-land	Forest
1.5-10m	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐
10-30m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒
30-100m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒

	Pool or Riffle (P/R)	Sampling Dist.(m)	Sampling Time (min : sec)	Max. Depth (mm)	Hydraulic Head (mm)	Wetted Width (m)	Grabs/ Area
Collection Area 1:	R	3.5	3:01	37	15	3.5	1
Collection Area 2:	P	3.2	3:10	120	0	3.7	1
Collection Area 3:	R	3.7	2:56	43	10	3.4	2

Enter a P or an R to indicate whether the collection was a riffle or pool.

1, 2, or 3 grabs can be collected within each collection area.

Crew Names: J. BYE, A. CONE

Recorder Init.	Entered	Verified	Corrected
JB	07/21 AE	09/23 JB	09/23 JB

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2

Benthic Macroinvertebrate Assessment

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INTRODUCTION

This section describes three sampling methods for benthic macroinvertebrates[1] (benthos). Resulting samples characterize community composition, and can be used in bioassessments that evaluate water quality. Complementary methods for describing physical habitat conditions (depth, velocity and substrate) are also described because this information is often required for bioassessment.

The modules in this section can be applied in most wadeable streams with flowing water. Directions for splitting a sample of material collected in the field to reduce sample size for carrying back to a lab and a standard key for identifying benthos to the 28 groupings used for coarse level taxonomy surveys are also provided in this section as Appendix I and II).

S2M1: Rapid Macroinvertebrate Collection

This module describes a rapid sampling technique for determining if a site contains large-bodied benthic macroinvertebrates (benthos) that are known to be sensitive to most impacts (based on benthos tolerances to organic pollution[2]; e.g., Hilsenhoff 1987). Resulting data can be used in reconnaissance surveys as a coarse indicator of water quality conditions.

S2M2: Stationary Kick Survey for Macroinvertebrates

This module describes a stationary kick technique for evaluating the relative abundance of taxonomic groups of benthos from within riffle habitats. This approach can be used to provide a more comprehensive list of taxa than S2.M1, Rapid Macroinvertebrate Collections. If estimating relative abundance of taxa in the riffle and pool habitats of a site is critical to the study design, methods in S2.M3, Transect Travelling Kick and Sweep Survey for Macroinvertebrates, should be used.

S2M3: Transect Travelling Kick and Sweep Survey for Macroinvertebrates

Sampling techniques for determining relative abundance estimates for benthos in the riffle and pool habitats of a site are described. This approach can be used to estimate composition in a

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[1] Benthic macroinvertebrates are animals without backbones that live on the bottom of lakes, rivers, and streams and are visible with the naked eye. They are generally sedentary, exhibit variations in tolerances to ambient water and environmental quality, and are easy to collect.

[2] Low densities of pollution-sensitive taxa (e.g., mayflies, stoneflies and caddisflies) and an over-abundance of pollution tolerant taxa (e.g., midges, sow bugs and snails) imply a nutrient enriched site.

meander sequence by generating a composite sample of pools and riffles. This is the standard sampling procedure for the Ontario Benthos Biomonitoring Network.

LITERATURE CITED

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist. 20:31-39.

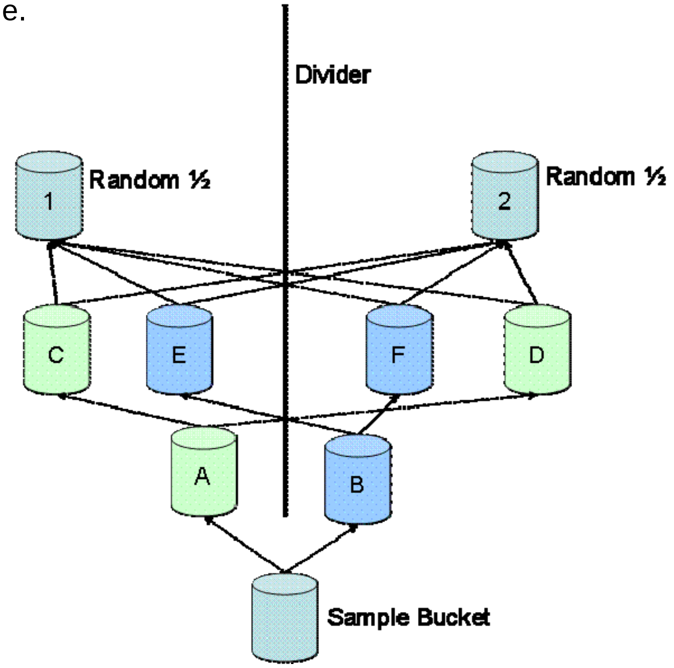
Appendix 1

Bucket Method for Splitting a Sample

Once sampling has been completed, if many more than the required number of animals have been collected, a random portion of the sample can be poured back into the stream to avoid removal of an unnecessarily high number of animals. A method for randomly splitting a sample is given below; for simplicity, the example illustrates how to split a sample into equal halves, but the technique can be modified to allow splitting into different proportions (e.g., quarters or thirds).

Bucket Method for randomly splitting a sample into two equal halves (refer to diagram below):

1. Randomize the sample in the bucket.
2. Place a divider in front of you.
3. Pour half of the randomized sample into bucket (now the sample is split into two buckets). Place one bucket on the left, and one bucket on the right side of the dividing line (positions A and B in diagram).
4. Randomize samples in buckets A and B and pour-off samples (as in step 3); this results in buckets at positions C and D, and E and F, respectively (each contains approximately 1/4th of the original sample).
5. Pour-off contents of buckets at positions C, E, F, and D, (as in step 3), into buckets at positions 1 and 2; this has the effect of splitting the sample down to eighths (4/8ths of the sample on each side of the divider), and then re-combining into one sample on each side of the divider. These final two samples are approximately random halves of the original sample.



Appendix 2

Identifying Macroinvertebrates

The following 'QuickGuide to Major Groups of Freshwater Invertebrates' has been reproduced with permission from '*A Guide to Common Freshwater Invertebrates of North America*' (R.J. Voshell, Jr., 2002, The McDonald and Woodward Publishing Company, Blacksburg, Virginia, xiv + 442 pp, ISBN 0-939923-87-4). Technicians and field crews that process benthos samples should be provided with copies of this excellent and reasonably-priced reference (approximately $30) as it contains additional information and colour plates that will be useful for identifying organisms.

Block 1: All Freshwater Invertebrates

Does it have 3 or more pairs of hard jointed legs?

Does it have a recognizable head, or at least some visible jaws or hooks for feeding?

If the answer to either of these questions is yes, go to **Block 2: Arthropods**

If the answer to both of these questions is no, go to **Chart A: Invertebrates That Are Not Arthropods**

Block 2: Arthropods

How many pairs of hard jointed legs does it have?

If 4 or more, go to **Chart B: Arthropods That Are Not Insects**
If 3 or none, go to **Chart C: Insects**

Chart A: Invertebrates That Are Not Arthropods

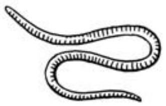
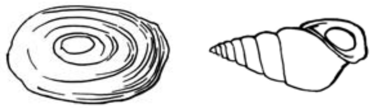
Body Texture; Shape	Body Arrangement	Suckers	Hard Shells Enclosing Bodies	Group
Soft; flat from top to bottom and elongate	All areas almost alike, no individual segments or specialized regions	None	None	**Flatworms** (Phylum Platyhelminthes, Class Turbellaria) 
Muscular; flat from top to bottom and elongate	Many similar segments arranged in a row, no specialized regions	2 on bottom, 1 at front and 1 at rear	None	**Leeches** (Phylum Annelida, Class Hirudinea) 
Soft; cylindrical and elongate	Many similar segments arranged in a row, no specialized regions	None	None	**Aquatic Earthworms** (Phylum Annelida, Class Oligochaeta) 
Soft; irregular but not usually visible	Several irregular regions but usually not visible	None	1, usually coiled but sometimes a short broad cone	**Snails** (Phylum Mollusca, Class Gastropoda) 
Soft; irregular but not usually visible	Several irregular regions but usually not visible	None	2, shaped like shallow bowls, opposite one another and connected by a hinge so that they seal tightly	**Mussels, Clams** (Phylum Mollusca, Class Bivalvia) 

Chart B: Arthropods That Are Not Insects

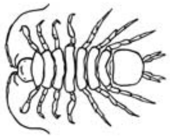
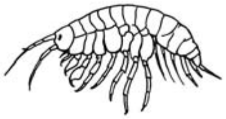
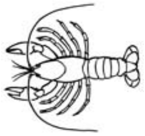
Hard Segmented Legs	Antennae	Body Size; Shape	Group
4 pairs	None	Very small, usually 3 mm or less, round, spherical, look like spiders	**Water Mites** (Order Hydracarina) 
7 pairs, first pair of legs with small claws	2 pairs, 1 pair much longer	Small, 5-20 mm, flattened from top to bottom	**Aquatic Sow Bugs** (Subphylum Crustacea, Order Isopoda) 
7 pairs, first 2 pairs of legs with small claws	2 pairs, about equal length	Small, 5-20 mm, flattened from side to side	**Scuds, Sideswimmers** (Subphylum Crustacea, Order Amphipoda) 
5 pairs, first 2 or 3 pairs of legs with claws, first pair of claws sometimes very large	2 pairs, 1 pair much longer	Large, usually 25-150 mm; mostly cylindrical	**Crayfishes, Shrimps** (Subphylum Crustacea, Order Decapoda) 

Chart C: Insects

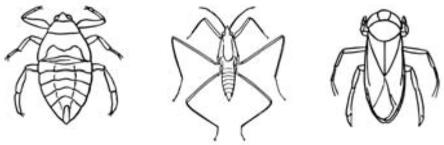
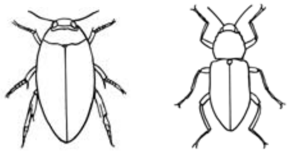
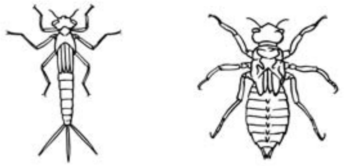
Mouthparts	Wings on Thorax	Hard Segmented Legs; Claws	Gills	Structures on End of Abdomen; Other Features	Group; Stage
1 sharp pointed beak or 1 blunt cone	Fully developed (capable of flying), reduced, developing in wing pads, or none	3 pairs; 2 claws	None	None or pair of elongate breathing straps or tubes	**True Bugs; Adults and Larvae** (Order Hemiptera) 
2 opposing jaws	Fully developed (capable of flying), front wings greatly modified into thick and protective covers	3 pairs; 2 claws	None	None	**Water Beetles; Adults** (Order Coleoptera) 
2 opposing jaws, also a large, elbowed lower lip with 2 hooks on end, lower lip folded under head at rest	Wing pads (developing wings) present but hard to distinguish on young larvae	3 pairs; 2 claws	Damselflies have 3 leaf-like gills on end of abdomen, dragonflies have none	Damselflies have 3 leaf-like gills, dragonflies have none	**Dragonflies, Damselflies; Larvae** (Order Odonata) 

Chart C: Insects (continued)

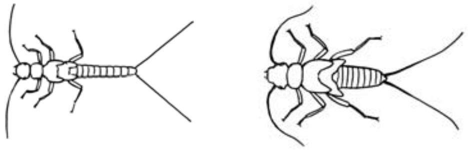
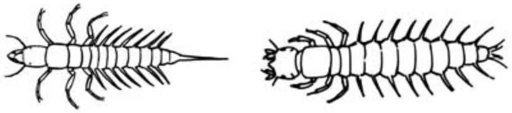
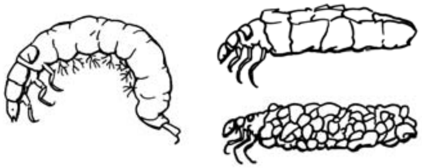
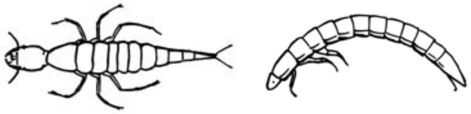
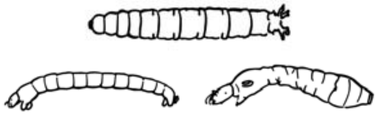
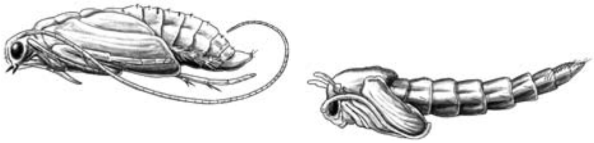
Mouthparts	Wings on Thorax	Hard Segmented Legs; Claws	Gills	Structures on End of Abdomen; Other Features	Group; Stage
2 opposing jaws	Wing pads (developing wings) present but hard to distinguish on young larvae	3 pairs; 2 claws	Single or branched filaments on bottom of thorax or none	All have 2 tails	**Stoneflies; Larvae** (Order Plecoptera) 
2 opposing jaws	Wing pads (developing wings) present but hard to distinguish on young larvae	3 pairs; 1 claw	Flat plates or filaments on at least some of abdomen segments	Most have 3 tails but a few have 2 tails	**Mayflies; Larvae** (Order Ephemeroptera) 
2 opposing jaws, protrude conspicuously in front of head	No wings or wing pads (developing wings)	3 pairs; 2 claws	Slender pointed gills on sides of abdomen, some also have tufts of filaments on bottom of abdomen	2 short fleshy projections with 2 claws on each or 1 long tapering tail	**Dobsonflies, Fishflies, Alderflies; Larvae** (Order Megaloptera) 
2 opposing jaws	No wings or wing pads (developing wings)	3 pairs; 1 claw	Finger-like on abdomen or none	2 short fleshy projections with 1 claw on each or just 2 claws; most kinds live in portable case or attached retreat (collecting destroys retreats)	**Caddisflies; Larvae** (Order Trichoptera) 

Chart C: Insects (continued)

Mouthparts	Wings on Thorax	Hard Segmented Legs; Claws	Gills	Structures on End of Abdomen; Other Features	Group; Stage
2 opposing jaws	No wings or wing pads (developing wings)	3 pairs; 1 or 2 claws	Most with none, some with small tufts of filaments on bottom or end of abdomen	Most with none; some with 2 tails	**Water Beetles; Larvae** (Order Coleoptera) 
2 opposing jaws or 2 vertical hooks (like snake fangs)	No wings or wing pads (developing wings)	None	A few finger-like gills on various parts of body, or none	Various lobes, finger-like projections, pointed filaments, or 1 very long breathing tube	**True Flies; Larvae** (Order Diptera) 
None or not visible if present	Wing pads (developing wings) present	3 pairs held very close to body; claws not visible	Finger-like on abdomen, filaments on thorax, paddles on end of abdomen, or none	Some with paddle-like gills or 2 short tails; some common kinds in 2 orders have aquatic pupae, difficult to distinguish, both resemble mummies	**Caddisflies, True Flies; Pupae** (Orders Trichoptera, Diptera) 

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2, MODULE 1

Rapid Macroinvertebrate Collections[1]

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APPENDICES

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[1] Author: L. W. Stanfield and C. Jones

1.0 INTRODUCTION

This module describes a rapid assessment technique for determining if a site contains sensitive large-bodied benthic macroinvertebrates (benthos). Results from these surveys can be used in reconnaissance surveys as a coarse indicator of water quality conditions, based on Hilsenhoff's (1987) invertebrate tolerances to organic pollution[2]. The procedures are comparable to those described in the Watershed Report Card (2000).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and data collection can be completed in 10 minutes.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment is required:

1. Benthic Macroinvertebrate Sample Forms (preferably on waterproof paper)
2. Pencils
3. Forceps
4. Sampling net (i.e., D-net, kick-net (see S2.M2, Stationary Kick Survey for Macroinvertebrates), large aquarium net, etc.)
5. Magnifying glass
6. White sorting tray and kitchen sieve
7. Metre Stick (wooden)
8. Waders

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

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[2] In most stony streams, low densities of pollution-sensitive taxa (e.g., mayflies, stoneflies and caddisflies) and an overabundance of pollution tolerant taxa (e.g., midges, sow bugs and snails) imply a nutrient enriched site.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. Additional information required depends on the objectives of the study and resources available. If the objective of the study is to assess differences among sites, surveys should be conducted over reasonably short periods of time and within similar physiographic and climatic zones. Benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards. Begin the survey at the downstream (bottom) end of the site and if additional sampling is required, select subsequent collection areas that are upstream.

3.1 Locating the Collection Area

At each site, samples will be collected from a riffle. In most stream types, riffles occur at crossovers and it is in these areas that sensitive taxa should be present. Under low flow conditions, riffles are areas of relatively fast, turbulent flow, where the water's surface is typically broken and has an obvious slope.

3.2 Documenting Collection Area Habitat Conditions

Record the 'Stream Name', 'Stream Code', 'Site Code', 'Sample #', 'Collection Area' (i.e., 1 or 2), 'Habitat Sampled', and 'Date' on the Benthic Macroinvertebrate Sample Form (see Appendix 1). Samples are consecutively numbered within a calendar year. Mark an 'X' in the box titled 'Rapid Survey'.

On the Benthic Macroinvertebrate Sample Form measure and record the following:

- Maximum water depth ('Water Depth' (mm)'); at the maximum depth within the collection area, place the ruler so that the thin side is facing into the current, ensuring that the ruler is straight and that it does not dig into the substrate. Measure the height of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler). Water depth measurements can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

- 'Hydraulic Head (mm)' is measured at the same location as the maximum water depth; place the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 1). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 1). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked 'Hydraulic Head (mm)' on the Benthic Macroinvertebrate Sample Form. It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the differences out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

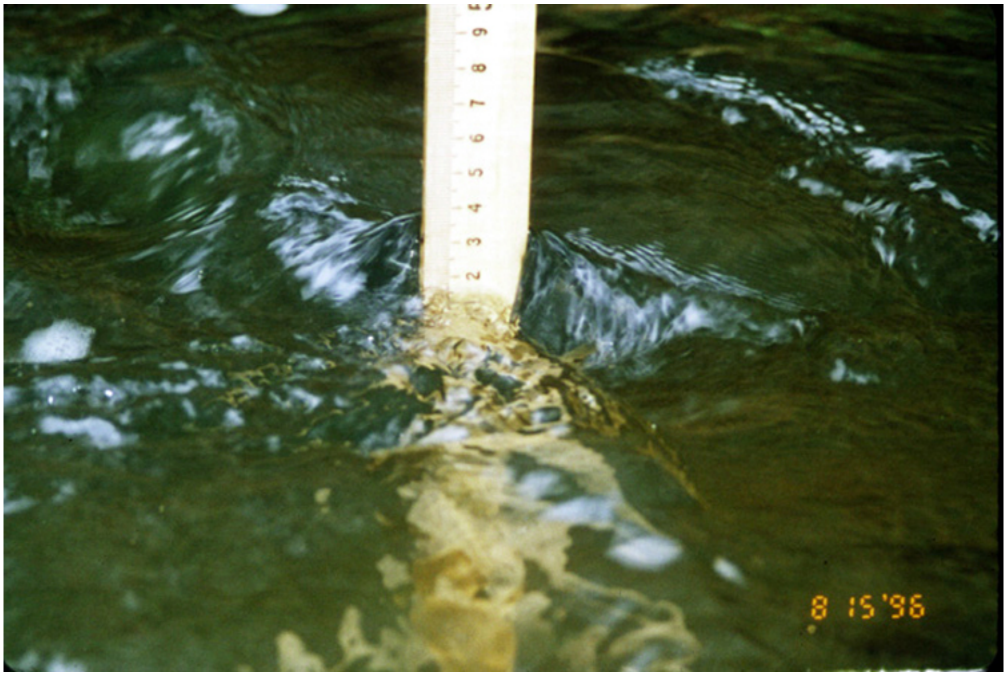


Figure 1: A Point Measurement of Hydraulic Head.
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

3.3 Evaluating Invertebrate Communities

To determine the sampling procedures, assess which bed type most appropriately describes the riffle:

- **cobble areas** have at least 10 particles with a median axis > 100 mm within the riffle
- **sand and gravel areas** have less than 10 particles with a median axis > 100 mm

3.3.1 Sampling Procedures for Cobble Areas

In the riffle area, randomly select a cobble particle (> 100 mm) and scan for benthos. Identify all animals using either the Benthic Macroinvertebrate Sample Form, S2.Appendix 2: Identifying Macroinvertebrates or Voshell (2002). Record the approximate number of organisms as per Section 3.3.3 Data Recording. Measure and record the median axis of the particle in the substrate box on the Benthic Macroinvertebrate Sample Form (Appendix 1). Repeat this across the entire riffle until 10 particles have been scanned for benthos and the particle size measured.

Measure and record 'Stream Width (m)' which is the wetted width of the stream (i.e., subtract the width of islands and include undercuts), to the nearest tenth of a metre.

3.3.2 Sampling Procedures for Sand and Gravel Areas

Place a kick-net or a D-net on the substrate and while standing upstream, kick the substrate over an area of approximately 1 m^2, for 20 seconds to dislodge invertebrates. If a smaller net is used (i.e., large aquarium net), kick the substrate for 20 seconds to dislodge invertebrates while sweeping the net in the water column to capture benthos and materials as they drift downstream. Pick up the net and transfer the contents into a flat white-bottomed tray for sorting. Identify all animals using either the Benthic Macroinvertebrate Sample Form, S2.Appendix 2: Identifying Macroinvertebrates or Voshell (2002). Record the number of organisms as per Section 3.3.3 Data Recording.

Identify the 'Net Type' used by circling the appropriate choice on the field form and also indicate the 'Mesh Size'.

After the identification of benthos is complete, randomly select 10 particles from within the area sampled. Record the size according to the classifications in Table 1, or if the median axis of the particle is between 2 mm and 1000 mm, record the actual measurement.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

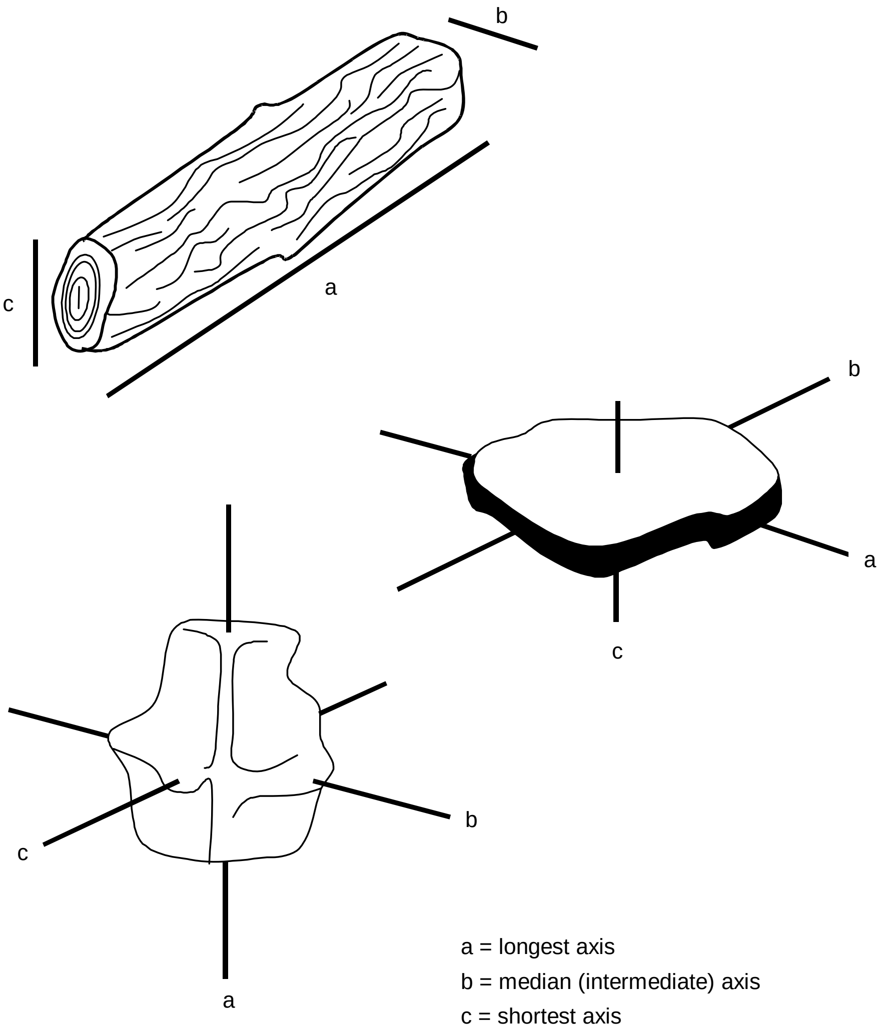


Figure 2: Measuring along the Median Axis of Objects.

Table 1: Substrate Descriptions and Size Categories

Material	**Description**	**Size to be Recorded**
‘Unconsolidated Clay’	Very hard packed when dry and sticky when wet	‘0.01’
‘Consolidated Clay’	Hard even when wet, slippery, grey in colour, often laminated	‘0.011’
‘Silt’	Feels soft like a powder or flour	‘0.05’
‘Sand’	Gritty, sizes >0.05 and < 2 mm	‘0.10’
‘Bedrock’	Exposed bedrock	‘1111’
Measured particles	Between 2 mm and 1000 mm.	Median axis

Material	Description	Size to be Recorded
‘Large Boulders’	> 1000 mm but not attached to bedrock	‘1001’

Note that large material (i.e., greater than 1000 mm wide) such as concrete slabs, etc., are classified as ‘Large Boulders’. To ensure accuracy of data entry, place a ‘0’ in front of all decimal points (i.e., ‘0.01’). **Be sure to measure all particles in your random sub-sample that are close to 2 mm in diameter to avoid misclassifying small particles.**

Measure and record ‘Stream Width (m)’ which is the wetted width of the stream (i.e., subtract the width of islands and include undercuts), to the nearest tenth of a metre.

3.3.3 Data Recording

Count the number of macroinvertebrates observed using the dot tally method on the Benthic Macroinvertebrate Sample Form. Estimate the numbers for taxa that are highly abundant and record all data on the Benthic Macroinvertebrate Sample Form. The objective is to classify the numbers of organisms into the three abundance classes: **Low** (< 10 %), **Medium** (10–40 %), or **High** (> 40 %) in order to obtain a coarse indication of water quality.

3.3.4 Criteria for Additional Sampling

If the samples from the first collection area indicate potentially impaired water quality (i.e., low numbers or absence of stoneflies, mayflies or caddisflies), move to another riffle in the site and continue sampling to confirm the results. Record the data from the second collection area on a new field form. Identify these as ‘Collection Area’ ‘1’ or ‘2’, as appropriate. Note that if sampling is repeated at the site throughout the year, record the ‘Sample #’ sequentially.

3.4 Tips for Applying this Module

Mayfly gills insert dorso-laterally on the abdomen; stoneflies have less obvious gills which are located on other parts of the body (e.g., thorax, underside of abdomen, underside of the head).

Check casings for the presence of caddisflies. Count only caddisflies, not empty cases.

Learn to characterize the organisms by their mode of movement: swimming, crawling or flexing, as this can help identify many of the taxa.

If a net is used to collect macroinvertebrates, there must be sufficient flow to enable dislodged animals to be carried into the net for capture. The net should be rinsed well between samples to prevent transfer of animals from one sample to another.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist. 20:31-39.

Voshell Jr., J.R. 2002. A Guide to Common Freshwater Invertebrates of North America. McDonald and Woodward Publishing Company, Blacksburg, Virginia. 442 pp.

Watershed Report Card. 2000. Watershed Report Card: Manuals for Community Involvement in Watershed Management. Watershed Report Card Inc., Port Elgin, ON.

Appendix 1

Example Benthic Macroinvertebrate Sample Form

Benthic Macroinvertebrate Sample Form

Survey Type: ☒ Rapid Survey ☐ Stationary Kick Survey

Stream Name: WILMOT CREEK

Date (YYYY/MM/DD): 2000/08/10

Identified in (circle): [✓ Field] Lab

Microscope Used? Yes [✓ No]

Sample Preserved? Yes [✓ No]

No. of Vials: 0

Mesh Size (microns): [✓ 251-500] 501-1000

Stream Code: WM1

Sample #: 1

Water Depth (mm.): 120

Stream width(m): 1.3

Habitat Sampled (circle): Riffle [✓ Pool]

Sorting Method (circle): [✓ Unsorted] Marchant Box Splitter

Site Code: 300W

Collection Area: 1

Hydraulic Head (mm.): 55

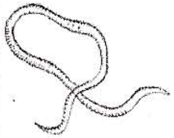
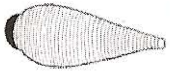
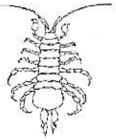
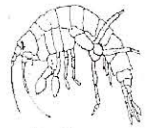
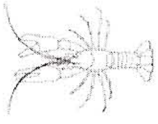
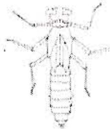
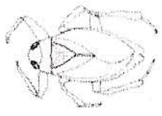
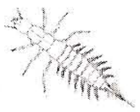
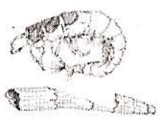
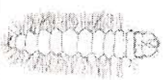
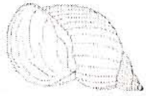
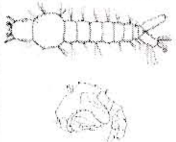
Sampling Time(sec): 20

Size of Kick Sample Collected (ml or gm) Total: — Portion not picked: —

Net Type(circle): Square Surber [✓ D-net]

Median sizes of 10 substrate particles randomly chosen from collection area (mm)

17	0.10
25	12
3	18
35	0.01
6	10

 2 – 5 mm Hydra (Coelenterates)	 2 – 10 mm Flatworms (Platyhelminthes)	 1 – 100 mm Nematoda (Roundworms)	 1 – 100 mm Oligochaeta (Aquatic Earthworms)	 5 – 100 mm Hirudinea (Leeches)	 5– 300 mm Isopoda (Aquatic Sowbugs)	 2 – 250 mm Pelecypoda (Clams)	 5 – 20 mm Amphipoda (Scuds)	 0 – 150 mm Decapoda (Crayfish)
• ①	—	—	—	—	• ①	•• ②	•• ②	—
 0.4 – 3.0 mm Acarina (Water Mites)	 3 – 28 mm Ephemeroptera (Mayflies)	 15 – 45 mm Anisoptera (Dragonflies)	 10 – 26 mm Zygoptera (Damselflies)	 5 – 50mm Plecoptera (Stoneflies)	 15 – 40 mm Hemiptera (True Bugs)	 25 – 90 mm Megaloptera (Helgrammites)	 2-50 mm Trichoptera ('Caddisflies)	 10 – 25 mm Lepidoptera (Aquatic Moths)
—	☒ ••• ⑬	• ①	•• ②	—	—	—	☒ ⑩	—
 2 - 40 mm Coleoptera (Beetles)	 2– 70 mm Gastropoda (Snails)	 2 – 20 mm Chironomidae (Blood Worms)	 15 – 40 mm Tabanidae (Horse and Deer Flies)	 2 – 50 mm Culicidae (Mosquitos)	 3 – 13 mm Ceratopogonidae (No-see-ums)	 10 – 45 mm Tipulidae (Crane Files)	 3 – 15 mm Simuliidae (Black Flies)	 Misc. Dipteras (Misc. True Flies)
—	• ①	☒ ☒ ⑳	—	—	—	—	—	—

Dot Tally, keep track of total number sampled

Crew Members: R.YAN, K.SALAR

Comments, check box if more on back: GRAVEL RIFFLE

	Ent.	Ver.	Corr.
Date	2000/11/10	2000/11/12	2000/11/13
Init.	R.Y.	K.S.	K.S.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2, MODULE 2

Stationary Kick Survey for Macroinvertebrates[1]

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APPENDICES

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[1] Authors: Stanfield, L. W. and B. Kilgour

1.0 INTRODUCTION

This module describes a stationary kick technique for estimating the relative abundance of benthic invertebrate (benthos) taxa from riffle habitats. Results from these surveys can be used in bioassessments or as indicators of water quality conditions. This sampling method is more quantitative than that of S2.M1, Rapid Macroinvertebrate Collections. If estimating relative abundance of taxa in the riffle and pool habitats of a site is critical to the study design, use S2.M3, Transect Travelling Kick and Sweep Survey for Macroinvertebrates.

Several options are provided for sample processing; sub-sampling procedures, processing location, detail of identification etc. These options allow practitioners to tailor their collection and processing methods to suit their expertise, resources and study design (Stanfield 2003, Jones et al. 2004).

This technique requires that there be sufficient flow to enable dislodged animals to be carried into the net for capture.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and data collection can be completed in 15 min. The time required for sample processing is quite variable.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment is required:

1. Benthic Macroinvertebrate Sample Forms (preferably on waterproof paper)
2. Pencils
3. Net – constructed out of 60 x 110 cm – 1000 µm window screening stapled to two pieces of wood (doweling or hockey stick) to make a 60 x 100 cm net
4. Metre stick (wooden)
5. Nalgene™ squirt bottle and soft brush
6. Fine tweezers (2 pairs)
7. Eye droppers (at least 2, a variety of sizes is preferable)
8. White sorting trays (2)
9. Plastic spoon (tea- or table-spoon, either size)
10. Pail or deep tray (2 L capacity)

11. Sample bottles (1 L)
12. Watch, with seconds indicator
13. Preservative solution for specimens (i.e. alcohol)
14. Labels or permanent marker
15. Weigh scale or measuring cup.
16. Waders
17. Buckets
18. Splitting devices (multiple buckets or containers with a wedge/plate insert)

Additional equipment for sample processing includes:

1. Microscope or magnifying glass
2. Marchant Box (optional)
3. Sorting trays or Petri dishes

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

Optional equipment includes a sample splitter, a device (e.g., a multi-probe) for measuring water quality variables (e.g., dissolved oxygen, pH, conductivity, and dissolved organic carbon) etc.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3 Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available. Benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards. Begin the survey at the downstream (bottom) end of the site and continue upstream.

3.1 Locating the Collection Areas

In most stream types, riffles occur at crossovers. Under low flow conditions, riffles are areas of relatively fast, turbulent flow, where the water's surface is typically broken and has an obvious slope.

Since most sites will contain multiple riffles, two riffle areas should be selected as follows:

- riffles at crossovers
- where depth, velocity and substrate permit easy sample collection

Once the riffles have been selected, the collection area is placed close to the center (both laterally and longitudinally) of each riffle, avoiding areas that contain large material, such as large logs or rocks, that would interfere with sample collection.

If there is no discernible riffle, collect the samples at the crossovers.

The following procedures (i.e., sections 3.2 to 3.6) must be repeated at each riffle collection area.

3.2 Documenting Collection Area Habitat Conditions

Record the ‘Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample #’, ‘Collection Area’ (i.e., 1 or 2), ‘Habitat Sampled’, and ‘Date’ on the Benthic Macroinvertebrate Sample Form (see Appendix 1). Samples are consecutively numbered within a calendar year. Mark an ‘X’ in the box titled ‘Stationary Kick and Sweep’, identify the ‘Net Type’ by circling ‘Square’, and the ‘Mesh Size’ by circling ‘501-1000 µm’ mesh size.

On the Benthic Macroinvertebrate Sample Form measure and record the following:

Maximum water depth (‘Water Depth’ (mm)); at the maximum depth within the collection area, place the ruler so that the thin side is facing into the current, ensuring that the ruler is straight and that it does not dig into the substrate. Measure the height of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler). Water depth measurements can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

‘Hydraulic Head (mm)’ is measured at the same location as the maximum water depth; at this location, place the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 1). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 1). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked ’Hydraulic Head (mm)’ on the Benthic Macroinvertebrate Sample Form. It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the differences out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

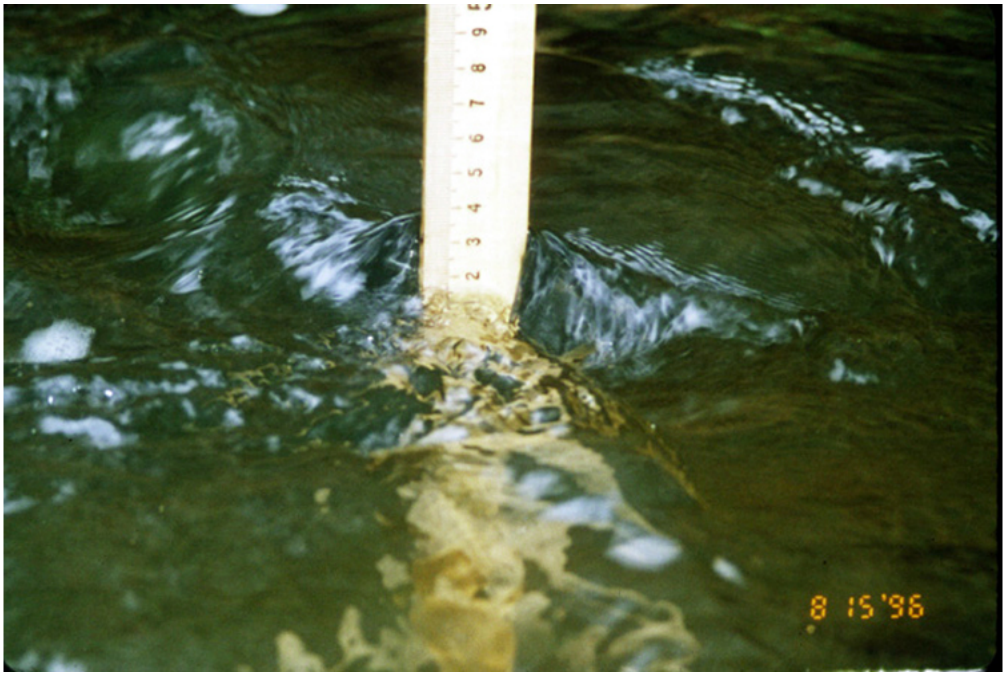

Figure 1: A Point Measurement of Hydraulic Head.
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

3.3 Obtaining the Invertebrate Sample

Place the sampling net on the stream bottom so that gaps are minimized and orient the net at a slight incline (i.e., approximately 70º from the stream bottom) (Figure 2). The second person kicks the substrate to a depth of ~5 cm for **one minute** over an area of approximately **1 m^2.** After kicking, pick up the largest particles in the collection area, hold them in front of the sampling net and rub them to dislodge any visible invertebrates (Figure 2). Do this for one minute.

Pick up the bottom of the net so that the current keeps the material on the sampling net. Bring the two poles together to form a cradle and carry the net to shore. Place a finger between the two poles and pinch the net at both ends. Splash the material on the net to the bottom of the cradle and empty the contents of the sampling net into a bucket. Use a soft brush or other device to remove the benthos. Ensure that no animals remain on the sampling net by rinsing it (Figure 3). Large organic debris (leaves, macrophytes, etc.) may be rinsed, inspected and discarded after removing any macroinvertebrates, adding these to the bucket.

8 30'95

Figure 2: Orientation of the Net and Collection of Benthos from Large Particles.

Figure 3: Sample Collection and Processing (in the field).

3.4 Preparing the Sample for Processing

Weigh or measure the total sample and record as ‘Total‘ under ‘Size of Kick Sample Collected (ml or gm)’. Since this measure is used to determine the relative portion of the sample that was identified, the water can be decanted or included in the weight/volume measurement depending on the option selected for processing the benthos sample (i.e., preserved or live). However, it is critical that the sample be measured in the same state (e.g., water decanted versus water not decanted), prior to and after processing.

After weighing or measuring the total sample, if clearly more than 500 animals were collected, randomly split the sample using the methods outlined in S2.Appendix 1: Bucket Method for Splitting a Sample. The volume or weight of the portion discarded should be noted on the back of the field form, so that the total ‘Portion Not Picked’ can be determined later.

3.5 Processing the Sample

There are a number of options available for processing the benthos sample. The study design will dictate which of the following options are selected:

- preserved or live
- laboratory or field picking
- Marchant box or spoon sub-sampling
- use of a microscope or no use of a microscope
- taxonomic level desired
- specimen archiving or discarding

3.5.1.1 Live or Preserved

If the sample is to be preserved, it should be transferred to a labelled container and enough preserving solution should be added to cover the animals. Seal the jar tightly and swirl gently to ensure all the sample gets mixed with the preserving solution. Each jar is labelled with a stream name, site code, the collection area number, the number of sample jars taken, the date, and the type of preserving solution used (usually alcohol). Place a label both on the lid of the jar and inside the jar (i.e., ideally on waterproof paper, with pencil). If the sample will be processed live, add water and keep the sample cool until it is processed. Live samples should be processed within 48 hours.

3.5.1.2 Picking the Sample

If a Marchant box (i.e., Marchant 1989) is being used and the sample has been preserved, rinse the sample with water and transfer to the box and see further directions in box below. Otherwise, gently stir the collected material and take a random sub-sample by collecting one spoonful of material. Put the sub-sample into a sorting tray. Add clean water to the tray.

Marchant Box Method

The standard sub-sampling box is a modified Marchant design consisting of an approximately 27 x 27 x 15 cm box that is divided into 100 cells and has a water tight lid. Wash the sample from the sieve into the Marchant Box and fill with water to a depth just below the height of the walls dividing the cells. Water depth is important. In the case of live samples, water deeper than the dividing walls will allow animals to swim between the cells once the contents have been randomized. Less water will make it difficult to distribute the sample among the 100 cells. Close and fasten the lid. Invert and gently mix the sample with side-to-side rocking motions. Right the box quickly and set on a level surface to let contents settle into cells. Using random numbers for the 10 columns and 10 rows, randomly select one or more cells and transfer contents to a suitable container or Petri dish using a pipette (or turkey baster), vacuum pump or aspirator and suction flask, or similar method.

The cell-extraction method used for Marchant sub-sampling strongly influences sample-processing time. Consider the costs of more sophisticated equipment such as aspirators, pumps, suction flasks, and tubing in relation to the improved efficiency resulting from their use. Using an aspirator and suction flask may be the best balance between minimal cost and extraction efficiency.

Pick out organisms one-at-a-time using either fine tweezers or an eyedropper. Identify each organism to the taxonomic level desired using either the Benthic Macroinvertebrate Sample Form, S2.Appendix 2: Identifying Macroinvertebrates, Voshell (2002), or other published keys. Record the abundance on the Benthic Macroinvertebrate Sample Form or a customized tally sheet[2].

If the sample will be processed live, add water and keep the sample cool until it is processed. Live samples should be processed within 48 hours. If samples are to be archived, place the identified organisms into one or more sample jars that contain 70% alcohol. The sub-sample is considered adequately ‘picked’ when no more animals are found in one to three minutes.

Animals that cannot be identified should not be included in the tally. They should be set aside and identified by an expert. To be counted, a specimen must have enough intact body parts to permit its identification and it must have a head. Larval husks and empty shells and cases are not counted.

Continue processing sub-samples until 100 animals have been picked or the whole sample has been searched. **Pick the entire sub-sample that contains the 100th animal;** this ensures that the samples are not biased towards larger animals.

Example: One spoonful of material provided 50 organisms. A second spoonful provided 62 organisms. The sampling can be terminated after the second spoonful has been processed because more than 100 organisms were found in the two complete sub-samples.

On the field form, circle ‘Field’ or ‘Lab’ depending on the location where benthos are identified. Convert the dot tally to a total number for each type of organism in the appropriate boxes on the data form. This ensures accurate conversion of the data and speeds data entry.

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[2] If identification below Order level is desired, a customized tally sheet will need to be developed.

3.6 Determining the Percent of Sample Processed

Once sorting is completed, measure (weight or volume) the remains of the kick sample and record this measurement in the 'Portion Not Picked:' box if the sample was not split. If the sample was split, the 'Portion Not Picked' will be the total of the weight or volume of the remaining kick sample in addition to the weight or volume of the portion that was discarded (i.e., recorded on the back of the field form).

Example: 1000 ml of kick sample (and water) was measured. More than 500 organisms were observed, so the sample was split and 500 ml of kick sample (and water) was discarded in the stream. After 112 organisms were identified, 100 ml of sample (and water) remains. The 'Portion Not Picked' equals 600 ml (500 ml +100 ml).

This information is used to estimate invertebrate abundance in the sampling area[3].

3.7 Recording Substrate Size and Stream Width

After the identification of benthos is complete, randomly select 10 particles from within the area sampled. Record the size according to the classifications in Table 1, or if the median axis of the particle is between 2 mm and 1000 mm, record the actual measurement.

Note that large material (i.e., greater than 1000 mm wide) such as concrete slabs, etc., are classified as 'Large Boulders'. To ensure accuracy of data entry, place a '0' in front of all decimal points (i.e., '0.01'). **Be sure to measure all particles that are close to 2 mm in diameter to avoid misclassifying small particles.**Measure and record 'Stream Width (m)' which is the wetted width of the stream (i.e., subtract the width of islands and include undercuts), to the nearest tenth of a metre.

Table 1: Substrate Descriptions and Size Categories

Material	**Description**	**Size to be Recorded**
'Unconsolidated Clay'	Very hard packed when dry and sticky when wet	'0.01'
'Consolidated Clay'	Hard even when wet, slippery, gray in colour, often laminated	'0.011'
'Silt'	Feels soft like a powder or flour	'0.05'
'Sand'	Gritty, sizes >0.05 and < 2 mm	'0.10'
'Bedrock'	Exposed bedrock	'1111'
Measured particles	Between 2 mm and 1000 mm.	Median axis
'Large Boulders'	> 1000 mm but not attached to bedrock	'1001'

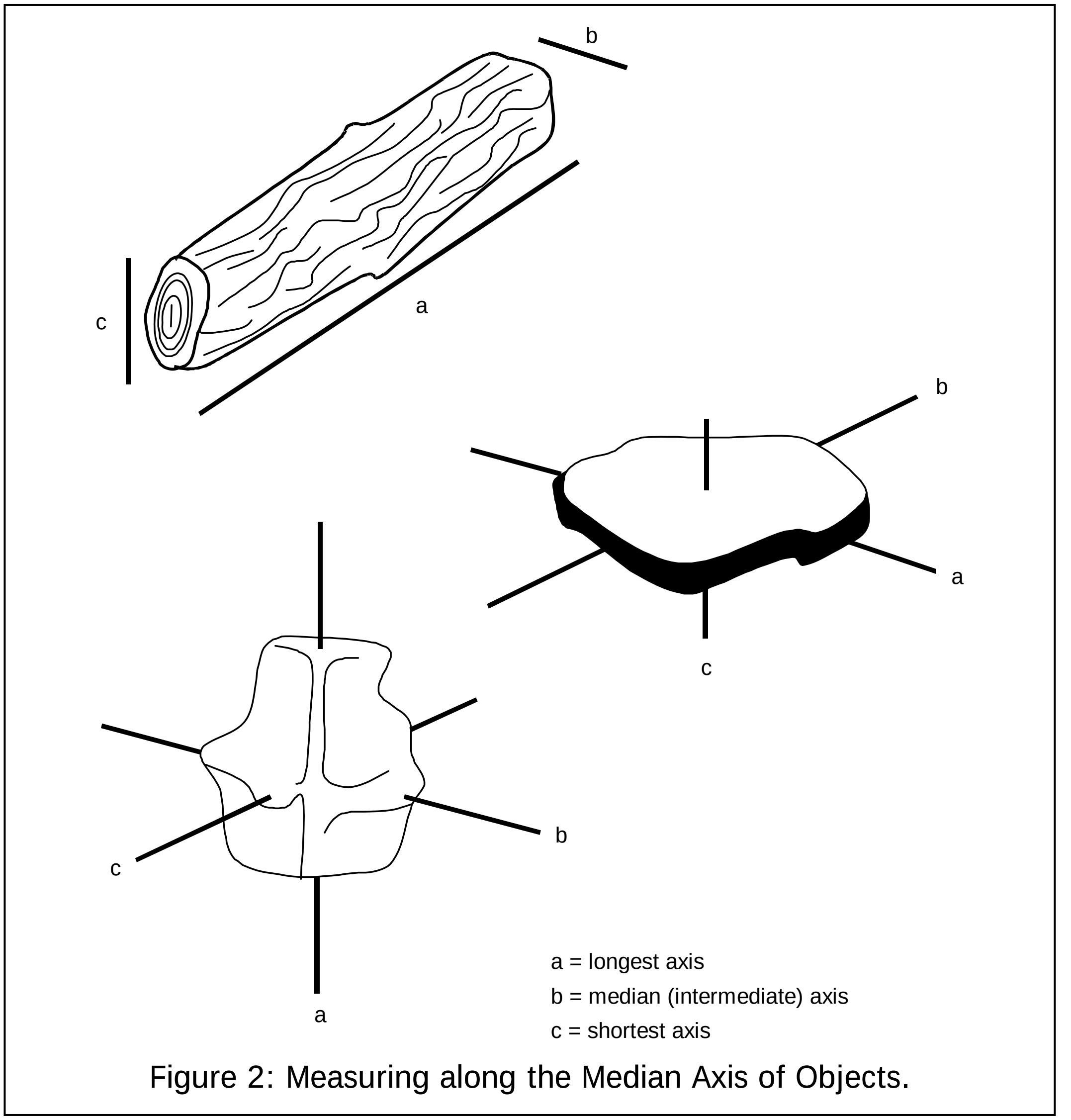
---

[3] # macroinvertebrates/m^2= # organisms counted *100/ %sample processed

Measure and record the wetted width of the stream (i.e., subtract the width of islands and include undercut(s), to the nearest tenth of a metre under ‘Stream Width’ (m)

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 4). Rocks will often lie with the median axis at right angles to the flow.



a = longest axis
b = median (intermediate) axis
c = shortest axis

Figure 2: Measuring along the Median Axis of Objects.

3.8 Tips for Applying this Module

Mayfly gills insert dorso-laterally on the abdomen; stoneflies have less obvious gills which are located on other parts of the body (e.g., thorax, underside of abdomen, underside of the head).

Check casings for the presence of caddisflies. Count only caddisflies, not empty cases.

Learn to characterize the organisms by their mode of movement: swimming, crawling or flexing, as this can help identify many of the taxa.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Jones, C., K.M. Somers, B. Craig, and T. Reynoldson. 2004. Ontario Benthos Biomonitoring Network Protocol Manual, Version 1.0. Ontario Ministry of Environment, Dorset, Ontario.

Marchant, R. 1989. A subsampler for samples of benthic invertebrates. Bulletin of the Australian Society of Limnology 12: 49-52.

Voshell Jr., J.R. 2002. A Guide to Common Freshwater Invertebrates of North America. McDonald and Woodward Publishing Company, Blacksburg, Virginia. 442 pp.

Stanfield, L. W. (Ed.). 2003. Guidelines for Designing and Interpreting Stream Surveys: A Compendium Manual to the Ontario Stream Assessment Protocol. Version 1.1 Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton.

Appendix 1

Example Benthic Macroinvertebrate Sample Form

Benthic Macroinvertebrate Sample Form

Survey Type: ☐ Rapid Survey ☒ Stationary Kick Survey

Stream Name WILMOT CREEK

Date (YYYY/MM/DD): 2000/08/10

Identified in (circle): [✓ Field] Lab

Microscope Used? Yes [✓ No]

Sample Preserved? [✓ Yes] No

No. of Vials: 1

Mesh Size (microns): [✓ 251-500] 501-1000

Median sizes of 10 substrate particles randomly chosen from collection area (mm)

17	0.10
25	12
5	18
35	0.01
4	10

Stream Code: WMI

Sample #: 1

Water Depth (mm.) 120

Stream Width (m): 4.3

Habitat Sampled (circle): [✓ Riffle] Pool

Sorting Method (circle): [✓ Unsorted] Marchant Box Splitter

Site Code: 3CDW

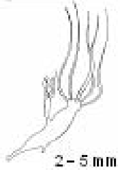
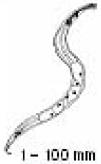
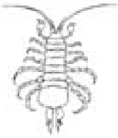
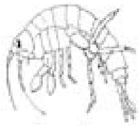
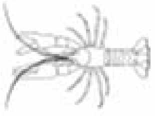
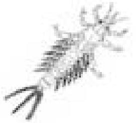
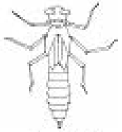
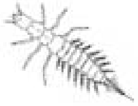
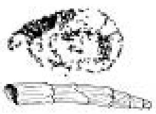
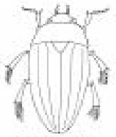
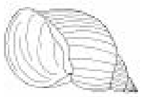
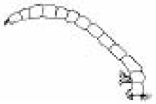
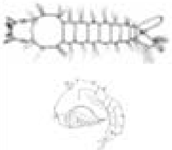
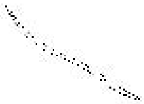
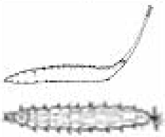
Collection Area: 1

Hydraulic Head (mm.) 55

Sampling Time (sec): 120

Size of Kick Sample Collected (ml or [✓ gm]): Total: 240 Portion not picked: 180

Net Type (circle): Square Surber [✓ D-net]

								
2 – 5 mm	2 – 10 mm	1 – 100 mm	1 – 100 mm	5 – 100 mm	5 – 300 mm	2 – 250 mm	5 – 20 mm	0 – 150 mm
Hydra (Coelenterates)	Flatworms (Platyhelminthes)	Nematoda (Roundworms)	Oligochaeta (Aquatic Earthworms)	Hirudinea (Leeches)	Isopoda (Aquatic Sowbugs)	Pelecypoda (Clams)	Amphipoda (Scuds)	Decapoda (Crayfish)
• 1	☒☒• 21	—	—	—	• 1	•• 2	•• 2	—
								
0.4 – 3.0 mm	3 – 28 mm	15 – 45 mm	10 – 26 mm	5 – 50mm	15 – 40 mm	25 – 90 mm	2-50 mm	10 – 25 mm
Acarina (Water Mites)	Ephemeroptera (Mayflies)	Anisoptera (Dragonflies)	Zygoptera (Damselflies)	Plecoptera (Stoneflies)	Hemiptera (True Bugs)	Megaloptera (Hellgrammites)	Trichoptera (Caddisflies)	Lepidoptera (Aquatic Moths)
—	☒ ••• 13	••• 3	•• 2	—	—	—	☒☒☒ 29	—
								
2 – 40 mm	2– 70 mm	2 – 20 mm	15 – 40 mm	2 – 50 mm	3 – 13 mm	10 – 45 mm	3 – 15 mm	
Coleoptera (Beetles)	Gastropoda (Snails)	Chironomidae (Blood Worms)	Tabanidae (Horse and Deer Flies)	Culicidae (Mosquitos)	Ceratopogonidae (No-see-ums)	Tipulidae (Crane Flies)	Simuliidae (Black Flies)	Misc. Dipteras (Misc. True Flies)
—	••	☒☒☒ 30	—	—	—	—	—	—

Dot Tally, keep track of total number sampled

☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒ ☒

••

Crew Members: R. YAN, K. SALAR

Comments, check box if more on back: ☐

GRAVEL RIFFLE

	Ent.	Ver.	Corr.
Date	i.s.	i.s.	i.s.
Init.	i.s.	i.s.	i.s.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 2, MODULE 3

Transect Travelling Kick and Sweep Survey for Macroinvertebrates[1]

TABLE OF CONTENTS

APPENDICES

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[1] Authors: C. Jones and L.W. Stanfield

1.0 INTRODUCTION

This module describes techniques for sampling benthic macroinvertebrates (benthos) in the riffle and pool habitats of a site. Results from these surveys can be used in bioassessments or as indicators of water quality conditions.

This methodology is designed to be used on any wadeable habitat within a stream, but to standardize approaches we suggest it be applied on either riffles or pools. These two habitats provide good contrast in flow and sediment composition that result in different benthic communities and are hypothesized to respond differently to stressors.

Several options are provided for sample processing; sub-sampling procedures, processing location, detail of identification etc. These options allow practitioners to tailor their collection and processing methods to suit their expertise, resources and study design (Stanfield 2003, Jones et al. 2004).

This module is consistent with the Travelling- Kick-and-Sweep-Transect method of the Ontario Benthos Biomonitoring Network (Jones et al. 2007).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people and sample collection can be completed in 30 minutes. The time required for sample processing will vary with the study design for sample identification.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment is required:

1. Benthic Macroinvertebrate Sample Forms, on waterproof paper
2. Stopwatch
3. Waders
4. Metre Stick (wooden)
5. Measuring tape
6. Pencils
7. D-Net (500 µm mesh, 25-40 cm net opening width)

8. Squirt bottle and a fine brush
9. Sample bottles (1 L)
10. Labels or permanent marker
11. Buckets
12. Preservative solution for specimens

Equipment for processing the sample includes:

13. Sorting trays or Petri dishes
14. Fine tweezers (2 pairs)
15. Plastic spoon (teaspoon or tablespoon)
16. Equipment for splitting samples (e.g., multiple buckets or Marchant Box)
17. Specimen bottles or vials
18. Microscope
19. Sieve (500 µm)

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. Additional information required depends on the objectives of the study and resources available. Benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards. Begin the survey at the downstream (bottom) end of the site and proceed upstream.

If this module is being used as part of the Ontario Benthos Biomonitoring Network, in addition to the above requirements, crews must also complete module S1.M5, Site Features for Water Quality Surveys.

Be sure to fill out the form headers with the ‘Stream Name’, ‘Stream Code’, ‘Site Code’ and ‘Sample’ Number as per S1.M2.

3.1 Locating the Collection Areas

To collect data to the OBBN standard (Jones et al. 2007) select three collection areas; two in riffles and one in a pool. In most stream types, riffles occur at crossovers. Under low flow conditions, riffles are areas of relatively fast, turbulent flow, where the water’s surface is typically broken and has an obvious slope. Under low flow conditions, pools are areas of relatively slow flow and have no obvious slope in the water's surface.

Since most sites will contain multiple pools and riffles, collection areas should be selected as follows:

- riffles that are located at crossovers
- where depth, velocity and substrate permit safe sample collection

In atypical streams, where riffles and pools either cannot be easily distinguished, or do not occur at normal locations in the meander sequence, select 'pool' and 'riffle' sampling locations that are relatively slow and deep and relatively fast and shallow, respectively.

3.2 Recording the Maximum Depth, Hydraulic Head and Wetted Width

Before kicking and sweeping in each collection area, measure and record the maximum water depth, hydraulic head, and wetted width.

3.2.1 Measuring Maximum Water Depth

At the maximum depth in the collection area, place the ruler so that the thin side is facing into the current, ensuring that the ruler is straight and that it does not dig into the substrate. Measure the depth of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler). Water depth measurements can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretation.

3.2.2 Measuring Hydraulic Head

'Hydraulic Head (mm)' is measured at the same location as the maximum water depth; at this location, place the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 1). The ruler will create a barrier to flow causing the water to climb the upstream side of the ruler. Avoid standing in front or too close behind the ruler as this can obstruct the flow. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 1). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked 'Hydraulic Head (mm)' on the Benthic Survey Sheet. It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the differences out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

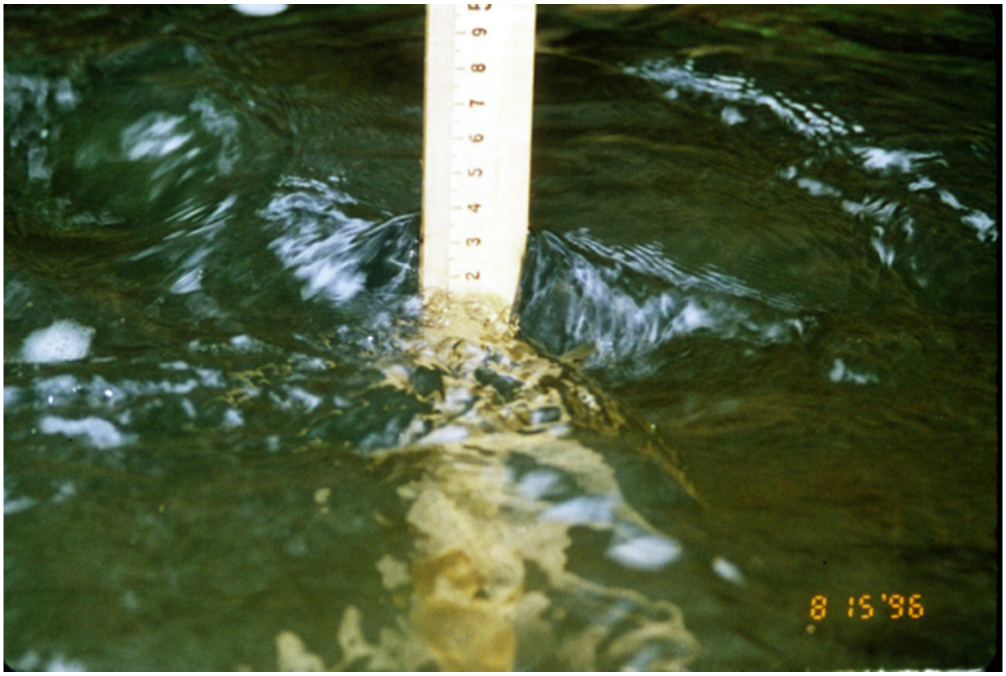

Figure 1: Measuring Hydraulic Head.
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

3.2.3 Measuring Wetted Width

Measure and the wetted width at each collection area (subtract the width of islands and include undercuts). Record wetted width to the nearest tenth of a metre.

3.3 Collecting the Invertebrate Sample

Invertebrate densities vary depending on habitat and food availability. The intention of this module is to:

- sample enough habitat to obtain at least 100 organisms
- to minimize disturbances to the stream
- minimize effort/cost
- and ensure catch per unit effort of sampling is comparable

To accommodate these objectives a tiered approach is offered. In areas where abundance of benthos is unknown or known to be low, sample a minimum of 10 linear metres of stream in approximately 3 minutes along each collection area (transect). This will generally provide 100 animals or more. If stream width at the collection area is less than 10 m, multiple transects should be sampled such that the total distance sampled is at least 10 m (i.e., a distance greater than 10 m may be attained as transects must be sampled in their entirety).

In areas where benthos are known to be abundant and the stream width is between 4 and 10 m wide, sampling a single transect is likely to be sufficient. If the stream width greater than 15 m and benthos are known to be abundant, sampling along the transect can be adjusted such that about 10 m is covered, sampling all habitats with equal effort. If this approach is applied, record the actual width of stream sampled in the comments field of the Benthic Survey form. Note that regardless of which approach is applied the entire width of the stream should be sampled (except where safety is a concern) to ensure all habitats are sampled equally. Transects are established perpendicular to the main concentration of flow (i.e., thalweg).

Begin sampling at the farthest downstream collection area (transect). Prior to sampling, place a bucket at the water's edge. Start the timer and begin at the water's edge, vigorously kicking the substrate to disturb it to a depth of ~5 cm. Continue this process along the transect to the opposite bank. Use the timer to guide sampling to ensure that approximately 3 minutes of effort is applied proportionately to all habitats and record the actual time spent sampling. Sweep the D-net both vertically and horizontally through the water column, keeping the net downstream and close to the area being disturbed so that dislodged invertebrates will be carried into the net. A good sweeping motion is particularly important in areas of slow current to ensure animals are collected in the net. If only one person is sampling, the net is held downstream as the sampler progresses along the transect kicking the substrate (sampler typically moves sideways along the transect facing downstream).

If the sampling net fills (i.e., when material begins to bypass the net), stop sampling (also stop the stopwatch), mark the location, sieve the sample in the net, empty the net contents into a bucket and return to continue sampling the transect (restart stopwatch). Transfer all collected material to a labelled container, ensuring that all invertebrates are removed from the D-net (use a water bottle to wash down the sides and if necessary remove any remaining animals by hand). Add water if the collection is to be live processed, and keep the sample cool.

Repeat this process for subsequent upstream collection areas.

3.4 Documenting Sampling Effort

Record the ‘Sampling Time’ (i.e., the cumulative time spent kicking and sweeping only) and the ‘Sampling Distance’ (i.e., the total distance sampled while kicking and sweeping) on the Benthic Survey Sheet.

3.5 Sample Sorting and Preserving

3.5.1 Preparing the Sample for Processing

Rinse off and discard wood, rocks, leaves and other large materials; release any non-benthos animals (e.g. fish) that were caught in the net. Sieve collected materials through 500 µm mesh to remove fine particulate matter (which clouds sorting trays and makes sorting much more difficult). If clearly more than 500 animals were collected, the sample can be randomly split using the methods outlined in S2.Appendix 1: Bucket Method for Splitting a Sample. The volume or weight of the portion discarded should be noted in the ‘Comments’ on the field form so that the portion of the sample picked can be estimated.

3.5.2 Processing the Sample

There are a number of options available for processing the benthos sample. The study design will dictate which of the following options are selected. Preferred options for the OBBN are identified with a “P”

- preserved or live
- laboratory (P) or field picking
- Marchant box (P) or bucket sub-sampling
- use of a microscope (P) or no use of a microscope
- taxonomic precision: detailed (species/lowest taxonomic level achievable) (P); family level; 27 group level as shown on tally sheet
- specimen archiving (P) or discarding

3.5.2.1 Live or Preserved

If the sieved sample is to be preserved, it should be transferred to a labelled container and preserving solution should be added as per the type of solution used. Seal the jar tightly and swirl gently to ensure all the sample gets mixed with the preserving solution. Each jar is labelled with the stream name, site code, sample number, collection area, the number of sample jars taken, the date, and the type of preserving solution used (usually alcohol). Place a label both on the lid of the jar and inside the jar (i.e., ideally on waterproof paper, with pencil). If the sample will be processed live, add water and keep the sample cool until it is processed. Live samples should be processed within 48 hours.

3.5.2.2 Picking the Sample

If a subsampling device similar to that designed by Marchant (i.e., Marchant 1989) is to be used, rinse the sample with water and transfer to the "box". Otherwise, gently stir the collected material and take a random portion of material. Use a device that enables collection of material from the bottom of the container. Put this sub-sample into a sorting tray or into a Petri dish if a microscope is being used. Add clean water to the tray.

Preserving a Sample

With advances in genetic technology and information, it is now possible to identify many benthic species based on genetics (DNA barcoding). The following process is recommended to both preserve the sample should DNA analysis be undertaken in future and to reduce the shrinking of the organism to enable identification based on morphology. The sample should be as clean as possible to minimize false DNA information being attached to organisms.

To fix the organism and its DNA, the initial preservation should be into 95% ethanol. The sample should be stored in either hard plastic or glass for approximately one week. Make sure that the total volume of the combined tissues does not exceed 10% of the liquid volume. To minimize shrinking of organisms from dehydration, samples can be transferred to 80% alcohol after several days or one week.

Make sure that the bottle is labelled with all the pertinent key identifiers for each vial, including: Stream Code, Site Code, Sample, Date, and Collection area. If you must place a label inside the container, do not use plastic paper or "Rite in the Rain", as these contain chemicals that interfere with DNA storage and extraction. Store the sample bottle at room temperature.

Under a microscope or from an open pan, pick out organisms using either fine tweezers or an eyedropper. Identify each organism to the taxonomic level desired using diagnostic characteristics (see Appendix 2: Identifying Macroinvertebrates) or published keys (e.g., Voshell 2002). Record the abundance on the Benthic Tally Sheet or a customized tally sheet[2]. If samples are to be archived, place the identified organisms into one or more sample jars containing preservative (generally 70% alcohol). Search each sub-sample thoroughly. To gain confidence in knowing "when to stop" have a colleague check the sample . They should not be able to find an organism within a minute of searching.

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[2] A customized tally sheet will reflect the level of precision employed in the study and the expected taxa that will be found in a sample. Leave space to add new taxa.

Marchant Box Method

The preferred sub-sampling device is a modified Marchant design consisting of a tight sealing box that is divided into 100 cells. A size of approximately 27 x 27 x 15 cm works well. Wash the sample from the sieve into the Marchant Box and fill with water to a depth just below the height of the walls dividing the cells. Water depth is important. In the case of live samples, water deeper than the dividing walls will allow animals to swim between the cells once the contents have been randomized. Less water will make it difficult to distribute the sample among the 100 cells. Close and fasten the lid. Invert and gently mix the sample with side-to-side rocking motions. Right the box quickly and set on a level surface to let contents settle into cells. Using random numbers for the 10 columns and 10 rows, randomly select one or more cells and transfer contents to a suitable container for sorting/identification using a pipette (or turkey baster), vacuum pump or aspirator and suction flask, or similar method.

The cell-extraction method used for Marchant sub-sampling strongly influences sample-processing time. Consider the costs of more sophisticated equipment such as aspirators, pumps, suction flasks, and tubing in relation to the improved efficiency resulting from their use. Using an aspirator and suction flask may be the best balance between minimal cost and extraction efficiency.

Animals that cannot be identified should not be included in the tally. They should be set aside and identified by an expert. To be counted, a specimen must have enough intact body parts to permit its identification and it must have a head. In biomonitoring surveys, larval husks and empty shells and cases are not counted.

Continue processing sub-samples until 100 animals have been picked or the whole sample has been picked. **Pick the entire sub-sample that contains the 100th animal**. This ensures that the samples are not biased toward larger animals.

Example: One spoonful of material provided 50 organisms. A second spoonful provided 62 organisms. The sampling can be terminated after the second spoonful has been processed because greater than 100 organisms was obtained in the two complete sub-samples.

If identification is carried out on preserved samples, the taxonomist will record the organisms present on a tally sheet to the level of taxonomy specified by the project objectives. Record the number of each type of organism in the appropriate boxes on the data form.

3.6 Determining the Percent of Sample Processed

Weigh or measure the total sample and record as ‘Total Vol/Wt‘ under ‘Sample Size’, also indicate the units used for sample size (e.g. ml or gm). Since this measure is used to determine the relative portion of the sample that was identified, the water can be decanted or included in the weight/volume measurement depending on the option selected for processing the benthos sample (i.e., preserved or live). However, it is critical that the sample be measured in the same state (e.g., water decanted versus water not decanted), prior to and after processing.

Once sorting is completed, measure (weight or volume) the remaining sample and record this measurement in the 'Vol/Wt Not Picked' box if the sample was not split. If the sample was split, the 'Portion Not Picked' will be the total of the weight or volume of the remaining kick sample in addition to the weight or volume of the portion that was discarded (i.e., recorded on the Benthic Survey Sheet field form).

Example: 1000 ml of kick sample (and water) was measured. More than 500 organisms were observed, so the sample was split and 500 ml of kick sample (and water) was discarded in the stream. After 112 organisms were identified, 100 ml of sample (and water) remains. The 'Portion Not Picked' equals 600 ml (500 ml +100 ml).

This information is used to estimate invertebrate abundance in the sampling area[3].

On the benthic tally sheet, circle 'Field' or 'Lab' depending on the location where benthos are identified, and indicate whether a microscope was used to aid in identification. Also indicate whether the sample was preserved and the number of vials the sample was archived in.

3.7 Tips for Applying this Module

Check snail, clam and caddisfly casings for the presence of animals. Count only animals, not empty cases.

Learn to characterize the organisms by their mode of movement:(swimming, crawling or flexing) and the morphological characteristics of each taxa that are diagnostic of the taxonomic membership.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

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[3] # macroinvertebrates/m-minute= # organisms counted *100/ %sample processed

2. Enter the data into a digital storage system, such as HabProgs or on the OBBN portal (http://www.moegisportal.ca/welcome/) and save backup copies in a separate location from the master copy. Participants in the OBBN should contact f.chris.jones@ontario.ca for more details.

By storing the data digitally in a corporate repository, the data can be shared with a large number of users province-wide. Data sharing will facilitate a better understanding of the factors that influence benthos in Ontario streams.

5.0 LITERATURE CITED

Jones, C., K.M. Somers, B. Craig, and T. Reynoldson. 2004. Ontario Benthos Biomonitoring Network Protocol Manual, Version 1.0. Ontario Ministry of Environment, Dorset, Ontario.

Marchant, R. 1989. A subsampler for samples of benthic invertebrates. Bulletin of the Australian Society of Limnology 12: 49-52.

Voshell Jr., J.R. 2002. A Guide to Common Freshwater Invertebrates of North America. McDonald and Woodward Publiushing Company, Blacksburg, Virginia. 442 pp.

Stanfield, L. W. (Ed.). 2003. Guidelines for Designing and Interpreting Stream Surveys: A Compendium Manual to the Ontario Stream Assessment Protocol. Version 1.1 Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton.

Appendix 1

Example Benthic Survey Sheet

Benthic Survey Sheet

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3CDW

Sample: 01

NOTE:
For all measurements, right and left banks defined facing upstream.

Date (mm-dd): 2010-08-21

Time (24hr): 13:12

Water Quality

Water Temp (°C): 19.6

Conductivity (uS/cm): 364

pH: 7.2

DO (mg/L): 9.4

Alkalinity (mg/L as CaCO3): 6.2

Substrate

Enter dominant substrate class and second dominant class for each sub-sample.

	Collect. Area 1	Collect. Area 2	Collect. Area 3
Dominant	4	3	4
2nd Dominant	2	2	3

Class	Description
1	Clay (hard pan)
2	Silt (floury, <0.06 mm particle diameter)
3	Sand (grainy, 0.06 - 2mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (>250 mm)
7	Bed Rock

Bankfull Width (m): 6.7

Gear Type
- ☐ Poled Seine
- ☐ Ponar
- ☒ D-Net
- ☐ Ekman
- ☐ Surber
- ☐ Other :

Collection Method
- ☐ Rapid Survey
- ☐ Stationary Kick Survey
- ☒ Transect Kick & Sweep
- ☐ Grab

MeshSize (microns)
- ☐ 250
- ☐ 600
- ☒ 500
- ☐ 1000

(Select the box that most closely represents the mesh size used.)

% Canopy Cover
- ☐ 0 - 24
- ☒ 50 - 74
- ☐ 25 - 49
- ☐ 75 - 100

If instrument used, record type:

River Characterization
- ☒ Perennial
- ☐ Intermittent
- ☐ Unknown

Candidate Reference Site? (ie. minimally impacted)
- ☐ Yes
- ☒ No

Comments

DATA TO BE PROVIDED TO OBBN

Crew Leader (initial & last name): A ROSS

Aquatic Macrophytes & Algae

Enter appropriate abundance class for each type and sub-sample.

Class	Description
0	Absent
1	Present
2	Abundant

Macrophytes	Collect. Area 1	Collect. Area 2	Collect. Area 3
Emergent	2	0	2
Rooted Floating	0	0	0
Submergent	0	0	1
Free Floating	0	0	0

Algae	Collect. Area 1	Collect. Area 2	Collect. Area 3
Floating Algae	0	0	0
Filamentous	1	1	1
Attached Algae	0	1	0

Riparian Vegetation Community

Only check one box for each bank and zone.

	Dominant Vegetation Type													
	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Pasture	Crop-land	Mea-dow	Scrub-land	Forest	None	Lawn	Pasture	Crop-land	Mea-dow	Scrub-land	Forest
1.5-10m	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒	☐
10-30m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒
30-100m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒

	Pool or Riffle (P/R)	Sampling Dist.(m)	Sampling Time (min : sec)	Max. Depth (mm)	Hydraulic Head (mm)	Wetted Width (m)	Grabs/ Area
Collection Area 1:	R	3.5	3:01	37	15	3.5	1
Collection Area 2:	P	3.2	3:10	120	0	3.7	1
Collection Area 3:	R	3.7	2:56	43	10	3.4	2

Enter a P or an R to indicate whether the collection was a riffle or pool.

1, 2, or 3 grabs can be collected within each collection area.

Crew Names: J. BYE, A. CONE

Recorder Init.	Entered	Verified	Corrected
JB	07/21 AE	09/23 JB	09/23 JB

Appendix 2

Example Benthic Tally Sheet

Benthic Tally Sheet

Date (mm-dd): 2000-07-18

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3CDW

Sample: 01

Collection Area: 01

Sorting Method: ☒ Unsorted ☐ Marchant Box ☐ Splitter

Sample Size: ☐ mL ☒ g

Total Vol/Wt: 1050

Vol/Wt not Picked: 400

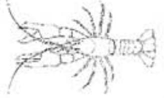
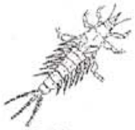
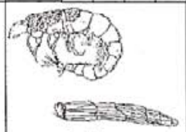
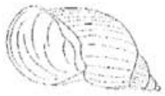
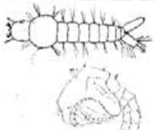
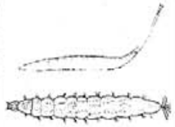
Sample Preserved? ☒ Yes ☐ No

No. of Vials: 01

Identification: ☐ in Field ☒ in Lab ☒ Microscope ☐ no Microscope

Unknown Species:

Comments:
SAMPLE TO BE IDENTIFIED TO GENUS IN LAB LATER IN YEAR
SAMPLE PICKED LIVE

 2 - 5 mm **Coelenterates** (Hydra) —	 2 - 10 mm **Platyhelminthes** (Flatworms) —	 1 - 100 mm **Nematoda** (Roundworms) 1	 1 - 100 mm **Oligochaeta** (Aquatic Earthworms) —	 5 - 10 mm **Hirudinea** (Leeches) —	 5 - 300 mm **Isopoda** (Aquatic Sowbugs) 4	 2 - 250 mm **Pelecypoda** (Clams) 3	 5 - 20 mm **Amphipoda** (Scuds) 4	 10 - 150 mm **Decapoda** (Crayfish) —
 0.4 - 3 mm **Acarina** (Water Mites) 3	 3 - 28 mm **Ephemeroptera** (Mayflies) ☒☒ 25	 15 - 45 mm **Anisoptera** (Dragonflies) 2	 10 - 26 mm **Zygoptera** (Damselflies) —	 5 - 50 mm **Plecoptera** (Stoneflies) ☒☒ 22	 15 - 40 mm **Hemiptera** (True Bugs) 2	 25 - 90 mm **Megaloptera** (Helgrammites) 4	 2 - 50 mm **Trichoptera** (Caddisflies) ☒☒☒ 30	 10 - 25 mm **Lepidoptera** (Aquatic Moths) —
 2 - 40 mm **Coleoptera** (Beetles) ☒ 13	 2 - 70 mm **Gastropoda** (Snails) —	 2 - 20 mm **Chironomidae** (Blood Worms) ☒☒ 19	 15 - 40 mm **Tabanidae** (Horse & Deer Flies) 4	 2 - 50 mm **Culicidae** (Mosquitos) —	 3 - 13 mm **Ceratopogonidae** (No-see-ums) 5	 10 - 45 mm **Tipulidae** (Crane Flies) 2	 3 - 15 mm **Simuliidae** (Black Flies) —	 **Misc. Diptera** (Misc. True Flies) 4

Dot Tally (track total no. sampled):

Crew Leader (initial & last name): R YAN

Crew Init.: K.SALAR

Recorder Init.: K.S.

Entered: 2000/08/10 K.S.

Verified: 2000/08/03 R.Y.

Corrected: 2000/08/10 K.S.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 3: MODULE 1

Fish Community Sampling Using Screening, Standard and Multiple Pass Electrofishing Techniques[1]

TABLE OF CONTENTS

APPENDICES

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[1] Author: L. W. Stanfield

1.0 INTRODUCTION

This module describes how to conduct electrofishing surveys. Electrofishing is a common technique used to collect information on stream fish communities or populations. It is popular because it is non-lethal, can be performed relatively quickly, can be applied in a standardized way, and most fish are vulnerable to the gear.

In this module, three standard approaches are described that vary in the amount of sampling effort required. Since the approaches are very similar, they are described in one module. A brief overview of the three approaches is provided to assist in the selection of the appropriate method. Procedural differences are outlined in Section 3.1, Differences in Sampling Approaches.

The standard approaches are recommended for use in wadeable, hard-bottomed streams. Each approach requires that all habitats within the site boundaries are sampled. Water levels should be near baseflow conditions for maximum efficiency. Winter sampling poses additional problems such as ice build-up on equipment.

The completion of S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation, are mandatory when using this module.

This module complements the Ontario Ministry of Natural Resources (OMNR) Backpack (Class II) electrofishing course and the provincial electrofishing policy (Electrofishing Equipment and Operating Guidelines and Procedures, OMNR Official Procedure Manual FI.3.01.01). Surveyors must meet all of the guidelines and safety requirements applicable to their office when conducting electrofishing surveys.

Screening Survey:

This approach is used to generate a list of the common fish species at a site. This approach characterizes fish communities at the site provided all habitats are sampled. It also provides a qualitative assessment of species abundance at a site.

This approach does not provide quantitative estimates of population abundance and should not be used when a comprehensive species list is required. In light of the low sampling effort, there is a high probability that rare species will not be captured. The screening survey methodology is not recommended for ‘trend through time’ surveys.

Standard Single Pass Survey:

This approach can be used to produce a comprehensive fish species list for a site. It will characterize the fish community and provide a qualitative assessment of species abundance at the site.

In some situations, this approach can also be used to determine salmonine biomass and/or population size. The biomass/population size must be previously calibrated, using the Multiple Pass Survey. Sixty percent of the population must be captured in the Standard Single Pass Survey. This approach has been shown to be effective in determining salmonine biomass in waters with high conductivity using well trained crews (Jones and Stockwell 1995). If these conditions cannot be met, the multiple pass survey is recommended for determination of salmonine biomass/populations.

Multiple Pass Survey:

Standard three-pass removal surveys (e.g., Zippen 1958) are used to estimate population size of individual fish species at a site. These surveys produce lower variances in catches than single pass surveys. This provides the ability to detect differences in catches over time or between sites. Assumptions of this approach and ways to address them are:

1. Emigration from and immigration to the site must be negligible. Block(barrier)nets placed at the top and bottom of the site will ensure this condition is met.

2. The probability of capture during a pass is the same for each fish. Applying appropriate sampling effort (see Section 3.2, Electrofishing Survey Methods) and sampling all habitats within a site will help. Attempt to capture all fish observed with equal intensity, regardless of species or size.

3. The probability of capture remains constant between passes. Using the same effort (measured as shocker seconds) and crew on each pass will ensure that this condition is met.

This approach maximizes the probability of obtaining declining catches with each pass. Population estimates can then be calculated for all species and age groups. This approach also offers the greatest probability of capturing all species within a site. When catches do not decline (because of lower catchability rates for some species, Mahon 1980), catch per unit effort can be derived.

Use of Block (Barrier) Nets

Blocknets must be used during Multiple Pass Surveys and may be used for Single Pass Surveys. To install blocknets, pound T-bars or poles into the stream bottom at the top and bottom of the site. Place the net on the upstream side of the poles and tie it well above the water level. The net should be anchored to the stream bottom with materials heavy enough to prevent it from being lifted as debris collects in the net (and increases the drag). Surveyors should ensure that there are no escape routes. Minimize disturbance by not walking into the sample site except where necessary. Do not take any boulders for anchoring the net from within the site.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two to five people. The number varies depending on the technique used, the size of the stream and the abundance of fish that will be sampled.

Pre-field activities should include:

- Obtaining a “Licence to Collect Fish for Scientific Purposes” from OMNR
- Obtain any other authorizations that may be required (e.g. *Endangered Species Act, 2007* (ESA) and/or *Species at Risk Act*).
- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment is required[2]:

1. Fish Sampling form(s) on waterproof paper (if possible)
2. Pencils
3. Backpack electrofisher
4. Charged batteries or gasoline, as appropriate
5. Anode pole
6. Electrofishing nets (2 or 3)
7. Chest waders for all crew members
8. Polarized glasses and hats for all crew members
9. Electrofishing gloves for all crew members

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[2] It is recommended that crews take backup equipment as this type of survey often results in frequent breakdowns, especially with batteries, electrofishers, nets, and weighing scales.

10. Aquarium dip nets (2-4)
11. Buckets for holding fish (6-10)
12. Bowl of sufficient size for weighing fish
13. Weighing scales (different capacities)
14. Measuring board
15. Sampling box with Whirl-Pak® bags
16. Collection labels
17. Preserving solution for specimens
18. Fish identification keys
19. Tape measure

Additional equipment for multiple pass surveys includes:

20. Seine or small mesh gill nets
21. Sufficient number of poles (T-bars) to span the stream with approximately 1 m spacing between poles
22. Pole driver or sledge hammer
23. Materials to anchor the bottom of the net to the stream bottom to prevent fish escape[3]

Optional items include cellular/satellite phone, spare anode ring and/or pole, tool kit with wrench and screw drivers, spare gloves and chest waders, wader repair kit, two to three buckets with screened sides for flow-through circulation or portable power source with water pump and hoses to circulate water and fish immobilizing agents.

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

Define and document the site boundaries and location following the procedures described in S1M1, Site Identification and Documentation.

3.1 Differences in Sampling Approaches

The main differences in the three sampling approaches are summarized in Table 1. Effort expended by field crews during a sampling pass greatly influences the outcome of the survey. Table 1 provides the basic sampling intensity guidelines for the three different protocols.

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[3] Boulders from outside the site or from the floodplain are the easiest to use for this task, but crews need to have alternatives for streams where these materials are not available.

Table 1. Sampling Techniques for Screening, Single Pass and Multiple Pass Electrofishing Surveys.

Approach	Intensity	Effort	Blocknets	Survey Technique	Release of Fish
Screening	Single pass Low (2-5 sec/m^2)	20 to 30 min	Not used	Emphasis on coverage of all habitats	into site
Single Pass	Single pass High (7-15 sec/m^2)	45 min to 2 hrs	Optional	*Attempt to capture all fish observed and 60-70 % of entire population	into site
Multiple Pass	Multiple pass Moderate (5-10 sec/m^2)	3 to 8 hrs	Top and bottom	Attempt to capture 50-60 % of fish each pass	outside site

* In waters with low conductivity, it is unknown if this level of intensity/effort is sufficient to meet this criteria.

3.2 Electrofishing Survey Methods

Prior to starting the survey, enter the water 5 to 10 m downstream of the bottom of the site, adjust the settings on the electrofisher and test the electrofisher to ensure that it is working properly. Move to the bottom of the site. Zero the timer on the electrofisher, record the start time, shocker setting and begin sampling.

The anode operator usually carries the bucket with the fish while the netter(s) position themselves in escape routes, usually on either side of the anode. The amount of time spent in each habitat should be adjusted to optimize catches, however surveyors should ensure that shallower, less complex habitats are also sampled (see Figure 1).

Extra time should be spent sampling areas of instream cover (i.e., undercut banks, macrophyte beds, unembedded large rocks, woody material) as these areas likely harbour fish.

Use only enough current to immobilize the fish. All fish should be netted and retained. Minimize the disturbance to instream habitat while electrofishing.

If a species protected under the ESA[4] is caught incidentally, it should immediately be returned to the waters from which it was caught and released in a manner that causes the least harm to the fish (unless otherwise authorized through a permit issued under the ESA or acting in accordance with conditions on a Licence to Collect Fish for Scientific Purposes). Incidental catches of all species at risk, including those listed as special concern, should be reported to the Natural Heritage Information Centre (NHIC)[5].

The following techniques are useful when sampling different habitat types.

Technique 1: In very fast water (i.e., chutes), place the nets at obvious escape routes, making sure they touch the stream bottom. Then, place the anode approximately 1 to 1.5 m upstream of the nets. Turn the power on and draw the anode to the nets. Check the nets for fish. Repeat this process across the fast water.

Technique 2: In deep pools and log jams, experiment with different techniques to pull the fish towards the netter(s) (i.e., place anode ring on bottom of stream and pull up and towards the netter(s), or place the anode as far forward as safely possible and draw back).

Technique 3: In areas that have relatively uniform depth and substrate (i.e., shallow riffles and flats), and sufficient flow to draw the fish to the nets, begin sampling at one side and move across the stream at right angles to the flow. Move the anode in a regular pattern to cover all of the stream bottom within 1 m of the sampler (i.e. ).

Technique 4: To capture lamprey in silty backwater habitats, try pulsing the electrofisher (i.e., turning power on and off in rapid succession).

For multiple pass surveys, release all processed fish downstream of the site after they have been processed. Leave sufficient time between passes for the stream to stabilize (approximately one hour). The interval between passes can be used to enumerate and identify captured fish.

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[4] Species listed as extirpated, endangered or threatened on the Species at Risk in Ontario List (SARO List) are protected under the ESA. Refer to Ontario Regulation 230/08 for the SARO List.

[5] Report a SAR occurrence by calling (705) 755-2159 or visiting the NHIC website (http://nhic.mnr.gov.on.ca/).

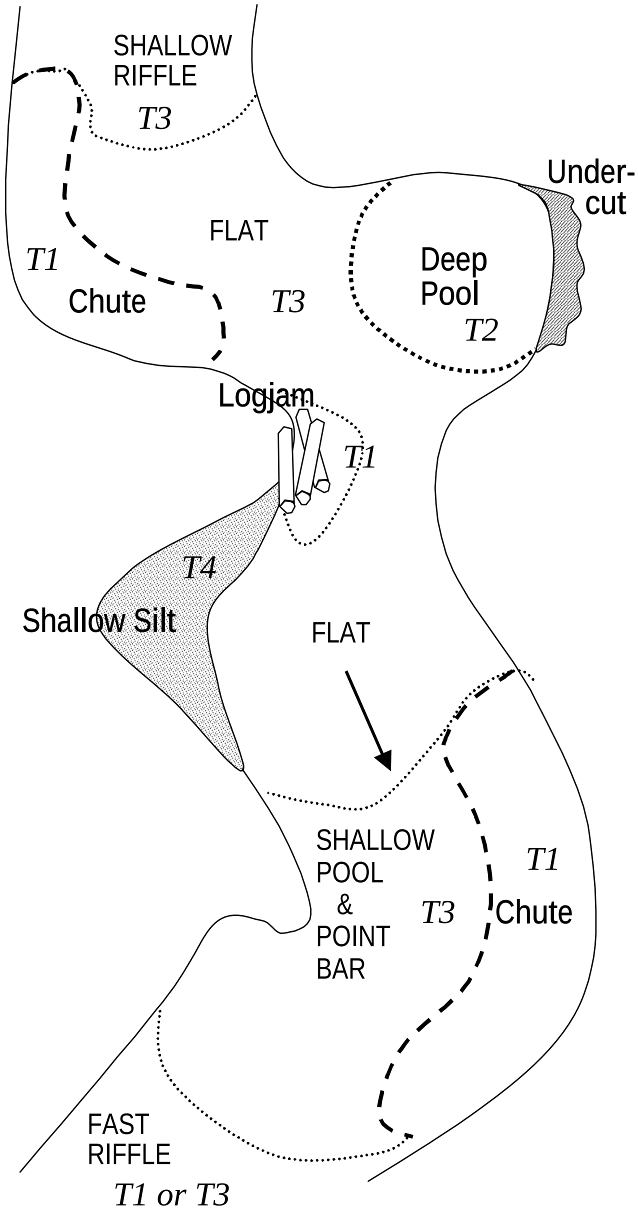

Figure 1: Suggested Electrofishing Techniques for Various Habitats. The letter 'T' and following number refers to the techniques described in Section 3.2, Electrofishing Survey Methods.

3.3 Processing Fish

To maintain temperature and oxygen levels, all fish should be kept in a flow-through holding tank downstream of the site. The catch should be periodically emptied into this holding tank.

Alternatively, the fish could be held in a container placed in a shaded area and the water changed regularly until the pass is complete.

When species identification is obvious, sort all fish into bins according to species (otherwise sort to the lowest taxonomic level possible[6]). It may be prudent to divide the catches of species into size groupings (e.g. young-of-year, yearlings, etc.)[7].

Process the fish according to the objectives of the project, recording data to the lowest level of taxonomic resolution feasible given the crews training and expertise. Note that biomass estimates are generated for all fish with associated weight data. Density estimates are generated using all fish from the individual records that do not have the “bulk” box marked off and all bulk fish. In effect, marking the bulk logical field indicates that this fish should not be counted twice in any summary queries. Therefore it is important to make sure this box is marked when a fish is included in both the individual and bulk sides of the field sheet. Three options are described below:

1. At minimum, count and record the number of fish in each grouping/species, and take a bulk weight (nearest gm) to provide information on fish biomass. Measure the length of the largest and smallest fish of each game fish species and any other species that is being targeted in the survey. Record this information in the individual fish data section, making sure to mark off the box titled “bulk” if the weight of the fish is included in the bulk weight measurement. The size range provides information on the life stages of fishes inhabiting a site (see example Appendix I).

2. Where a survey focuses on particular target species or life stages, and time does not allow for measuring length and weight of all individuals, randomly select a sample of each species (typically up to 20 specimens) and measure individual length and weight of each fish. Where only a length frequency histogram is desired or target fish are too small to be weighed, record the individual total length only along with an x in the “bulk” box. These fish will be counted and bulk weighed. All remaining fish should be counted and weighed in bulk by group/species (see Appendix II).

3. For detailed fish population assessments, count and record the number of each grouping/species, and take individual length and weight measurements from all fish. Where time is limiting or weigh scales are not available, individual length measurements

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[6] In Ontario, the Ministry of Natural Resources (OMNR), Department of Fisheries and Oceans and the Royal Ontario Museum (ROM) have developed an OSAP fish identification certification program. The program certifies individuals in fish identification at different levels of expertise. The ROM also offers fish identification workshops.

[7] ‘Group number’ codes are user defined and may be assigned as dictated by study design.

are often sufficient. Good relationships between length and weight for most sport fish species are available, so where lengths are available, weights can be derived.

For all fish that cannot be positively identified to species, preserve a subsample for laboratory verification. Voucher specimens of known or suspected aquatic invasive species should also be retained, preserved and reported to the Ministry of Natural Resources Invading Species Awareness Program[8].

3.4 Preserving Sampled Fish

Where species identification is uncertain or study design dictates that preservation or validation of species identification is necessary, there are several options for preserving specimens. The approach used will be dictated by whether the fish are to be: retained for identification based on morphological characteristics (Option 1); retained for potential future research using DNA bar-coding (Option 2); or live released (Option 3).

DNA bar-coding is a rapidly evolving technique that offers the potential to be able to identify organisms based on DNA sequences. Using an approach that offers the potential for DNA bar-coding does not guarantee resources will be available to conduct immediate analysis, but allows for the archiving of specimens for potential future analyses and research projects.

If a decision is made to retain specimens for preservation, fish should be euthanized as per organizational guidelines. Storage of all preserved specimens must be arranged by the organization that collected the sample (or requested it be retained) as no central repository is currently in place.

Regardless of the procedure followed, preserve the organisms in groups according to the lowest taxonomic resolution possible and follow the guidelines below for labelling the sample. Never preserve more fish than are necessary for the study purpose.

*Option 1**:** Preservation for Morphological Identification (no DNA analysis)*
Where no requirement for genetic validation is expected and surveyors wish to minimize shrinking of fish to make morphological examinations easier, each family group sample should be fixed in 10% buffered formalin to prevent tissue decomposition. These fish can be placed in separate Whirl-Pak® bags, jars or resealable bags (doubled). Specimens should be fully immersed in the fixative for a minimum of three days (optimum fixation times are 1-2 weeks for fish less than 6 inches, and 2-4 weeks for fish larger than 6 inches). After fixation, specimens

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[8] Contact the Invading Species Hotline (1-800-563-7711) or website (www.invadingspecies.com) to report an occurrence. To request a copy of the *Ontario Field Guide to Aquatic Invasive Species (3rd ed.)* call 705-755-1960.

should be thoroughly rinsed with water and transferred to 40% ethyl alcohol for preservation prior to identification and/or storage. Note that specimens fixed in formalin may not be suitable for future DNA analysis.

Option 2: Preservation for Future DNA bar-coding and Morphological Identification
Where a desire to both preserve the sample for potential DNA bar-coding and identify the specimen based on morphological characteristics exists, specimens should be preserved in ethanol. This method will reduce the shrinking of the organism to enable identification based on morphology. The sample should be as clean as possible to minimize false DNA information being attached to organisms.

To fix the organism and its DNA the initial preservation should be into 95% ethanol. The sample should be stored in either hard plastic or glass for approximately one week. Make sure that the total volume of the combined tissues does not exceed 10% of the liquid volume. Transfer the sample to 80% alcohol to minimize shrinking.

Another option is to remove a small piece of fin that can be stored in a glass or hard plastic vile as a means of validating the specimen using DNA bar-coding. The fin can either be stored in 95% ethanol or it can be allowed to "dry". If samples are to be preserved dry, pat the fin dry before putting it in the vile to remove liquids that promote decay. It is not recommended that fins from more than one fish be placed in a single jar if the "dry" fin approach is used as the fins tend to stick to each other and/or break into pieces.

Option 3: Live Release
Depending on the study and the conditions associated with a collection permit, all fish may need to be live released. In these instances high quality photographs of fish for which identification is uncertain should be taken. Photos should document the key morphological features that allow one species to be distinguished from another. Note, if a fish is believed to represent a range expansion for that species, or is of other special interest, the surveyor should consider taking a fin sample as described above for potential DNA bar-coding.

3.4.1 Labelling

For each container of preserved fish, record the following onto a label that is either placed inside the jar, for non-DNA samples, or is attached to the outside of the jar for all others[9]:

1. Site identification information (i.e., 'Stream Name', 'Stream Code', 'Site Code')
2. 'Date'

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[9] Placing labels inside jars is appropriate if the material is guaranteed not to leach (e.g. do not use "write in the rain" or plastic labels) or if the samples are never to be analyzed for DNA.

3. ‘Bag No’ (number consecutively, i.e., ‘1’ of ‘5’)
4. ‘Batch #’ (the individual identification number used for this record on the fish sampling form)
5. ‘Type of Sample’ (i.e., whether it represents a random or specific sample)
6. ‘No Org’ (number of organisms in each container)
7. ‘Suspected Contents’ (the family or species code used to identify the fish catch (common name is fine)).
8. ‘Collector’ (the person who identified the sample).

Use waterproof paper and an HB pencil for labels. The information recorded should correspond to the information recorded in the Fish Sampling Form.

Example Fish Sample Label

Stream Name: WILMOT CREEK Stream Code: WM1 Site Code: 3CDW
Date: 97/08/10 Sample: 1 Bag No: 1 of 5 Batch #: 1 of 4
Type of Sample: RANDOM No Org: 5
Suspected Contents: MOTTLED SCULPIN Collector: K. RYAN

3.5 Recording Data

Record the ‘Stream Name’, ‘Stream Code’, ‘Site Code’ and ‘Sample’ number on the Fish Sampling Form (see Appendix 1). Samples are consecutively numbered within a calendar year. Record the ‘Run’ number as applicable (e.g., Run 1 of 1). Record the ‘Licence to Collect Fish for Scientific Purposes' number under which the fish were collected in the ‘Science Collect. No.’ box.

Record all data pertaining to the sampling methods used and all survey results on the Fish Sampling Forms. The intent of the survey methods data is to document the factors in each survey that might influence catch. Record the type of electrofisher used and the settings (voltage, frequency and pulse width). Record any deviations from the recommended techniques in the appropriate boxes.

- ‘Inexperienced Sampler’ indicates that at least one of the crew members did not meet Class 2 certification according to the OMNR electrofishing policy
- ‘Imprecise Weigh Scale Used’ indicates that the unit used did not have a least 0.5 g accuracy
- ‘All Habitats Not Sampled’ indicates that some habitat could not be sampled
- ‘Upstream Blocknet Used’ indicates that a net was used in a single pass survey to reduce escapement from the site.

Record the time that the crew began electrofishing (‘Start Time’) and the time that they finished (‘Stop Time’) using the 24-hour clock. Calculate the duration in minutes and record this under ‘Elapsed Time’. Also record the electrofishing seconds (‘Shocker Sec’) from the electrofishing unit, the names of the ‘Shocker’ and ‘Netters’, and the number of pages (‘Page __ of __’) associated with the sample. If more than one page is required, record the site identification data and the date on each page.

Data for individual fish (‘Individual fish data’) and bulk samples (‘Bulk fish data’) are recorded as follows:

Individual fish data:

- ‘Id #’, a unique number that is consecutively recorded (beginning at 1) for each fish[10]
- ‘Species’, a unique number that refers to each species or family of fish (a list of Ontario fish species codes is provided in Appendix 2)

The first time that the species code is used, record the common name or an acceptable acronym[11] (as listed in Appendix 2) in the ‘Remarks’ column. This will provide a backup in case the wrong number was recorded or the number is illegible. There are also columns to record whether the individual fish weight was included in a bulk sample (‘B’), whether scales (‘S’) or otoliths (‘O’) were taken and if the sample was preserved (‘P’). Record any other information on the fish including diseases or malformities in the ‘Remarks’ column.

Bulk fish data:

- ’Batch #’, sequentially identify each bulk sample
- ‘Species or Family’, code for unidentifiable groups
- ‘Number of fish’, number of individuals counted
- ‘Bulk Weight (gm.)’, bulk weight to the nearest gram
- ‘# Pres.’, number preserved
- ‘Bag #’, allows more than one bag to be recorded per batch (i.e., bags 4 and 5)

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[10] If desired, fish from different portions of the site may be separated by recording individual numbers 100, 101, etc. for fish captured in the first portion and 200, 201, etc. for the next portion.

[11] For common species, surveyors often use short forms that include distinct letters from the species name, e.g., rainbow trout RBT, mottled sculpin MSC etc. (see Appendix 2). Acronyms should be defined on the field form to prevent misunderstandings.

Finally, record the name of the person who identified the fish in the filed ‘Field Id. Name’. If several people were involved, record the person who was responsible for quality control.

Bulk Weights

Bulk weights are obtained by sorting fish into similar species or groups and weighing them as a group. Count the number of fish in the bulk sample. Net all of the fish and allow the water to drain. Place all of the fish into a tared weighing bin and record the bulk weight of the sample to the nearest gram. The weighing bin should contain enough water to cover the fish, this will reduce handling stress.

3.6 Recording the Area Sampled

Site area must be measured so effort and catch can be estimated per unit area (m^2). If Point Transect Sampling for Channel Structure, Substrate and Bank Conditions (S4.M2) is being conducted at this site in the same year, then site length and widths will be available and new measurements are not necessary (place an ’X’ in the box titled ‘Channel Morphology Data Available’).

If this data is not available, an estimate of sample area is required. Chain the length of the site midstream. Measure 10 wetted stream widths (i.e. subtract the width of islands and include undercuts) at approximately even distances along the length of the site. Record the results of these measurements under ‘Site Length (m.)’ and Stream Width (‘Widths (m.)’) on the Fish Sampling Form.

3.7 Fish Species Confirmation

Preserved fish need to be identified by a knowledgeable/certified individual. Contact the ROM or OMNR Fisheries Policy Section for a list of certified taxonomists. Provide a photocopy of the original Fish Sampling Form so the contents can be recorded on the form, either under the bulk fish data or on the back of the form (see example in Appendix 1). Record the name of the taxonomist and their level of certification (if applicable) on the form under ‘Lab Identification’.

The following protocol is suggested for correcting bulk sample identifications:

1. If a bag contains a mixture of two or more species of the same genus, rerecord the data for that sample to the genus level (e.g., if the bag contains longnose and western blacknose dace, record as *Rhinichthys* - code ‘226’).

2. If a bag contains several species of different genera, rerecord the data to the lowest taxonomic level that appropriately describes the sample (e.g., northern redbelly dace, creek chub and bluntnose minnow would be recorded as minnow family – code ‘180’).

3. Record a weight and count for the appropriate code. For Lab Identification Results, add the new species and counts, but leave the weight box empty.

The weight and count data should be accurate to the level of identification. Crews should staple a copy of the sheet used for lab identification to the original field sheet, changing codes on the field sheets as necessary. In Examples C and D in Appendix I, the Species or Family number for the Bulk Sample 1 (Bag # 1) would be changed from 380 (sculpins) to 381 (mottled sculpin) to reflect the lab identification results.

3.8 Tips for Applying this Module

Avoid overcrowding fish in buckets to reduce mortality from stress and lack of oxygen.

Routinely change the water in all buckets.

Allow sufficient time for anaesthetized fish to recover before releasing them.

Expect to find unfamiliar species at a site. Although mortality should be minimized, preserve representative fish so that identifications can be confirmed.

Laminate and tape the species codes to the back of the clipboard.

While electrofishing, it is important to maintain a high level of interest and alertness among crew members to ensure that effort remains constant. This is usually accomplished by constant verbal communication amongst crew members.

Use Mandrak and Crossman (1992) as a guide to species distribution within the study area and preserve new species that are caught as voucher specimens.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies. To meet the requirements of the "Licence to Collect Fish for Scientific Purposes", the mandatory collection report must be sent to OMNR.

5.0 LITERATURE CITED

Jones, M.L. and J.D. Stockwell. 1995. A rapid assessment procedure for enumeration of Salmonine populations in streams. North American Journal of Fisheries Management 15:551-562.

Mahon, R. 1980. Accuracy of catch-effort methods for estimating fish density and biomass in streams. Environmental Biology of Fishes. 5:343-360.

Mandrak, E. and E. J. Crossman. 1992. A checklist of Ontario freshwater fishes. Royal Ontario Museum, Toronto, Canada 176 pp.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.

Appendix 1

Example Fish Sampling Forms

Example A:

Note that the field identification was carried out by a Certificate Level 2, therefore each of these taxa could be identified to species. No new taxa were identified for this watershed, therefore no fish were preserved. One netter was inexperienced (was not certified with the appropriate number of hours of experience). No channel morphology data was collected in the same year, therefore site length and width data was collected.

Fish Sampling

Page No. 01 of 01

Stream Name: WILMOT CREEK

Date (mm-dd): 2000-07-21

Stream Code: WM1

Sample: 01

Run No. 01 of 01

Start Time (24hr): 10:30

Elapsed Min. 75

Shocker Sec. 2755

Site Code: 3CDW

Science Collect. No. 96789903

Stop Time (24hr): 11:45

Model No. 12-B

Anod. Voltage: 1300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☐ Yes ☒ No

If no, measure the station length and 10 widths.

Length (m): 45.5

Widths (m)

1	5.6	6	5.0
2	5.8	7	5.4
3	6.0	8	5.7
4	4.8	9	6.7
5	4.5	10	8.0

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B P O S	Sp Name/Remarks
1	076	120	15		RBT
2	076	96	9		"
3	078	53	5		BROWN TROUT
4	078	102	10		"
5	210	22	8		BLACKNOSE DACE
6	210	28	9		"
7	212	56	7		CREEK CHUB
8	212	62	8		"
9	163	126	45		WHITE SUCKER
10	163	158	50		"
11	209	22	4		FATHEAD MINNOW
12	209	34	7		"
13	198	12	3		COMMON SHINER
14	198	18	7		"
15					
16					
17					
18					
19					
20					

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Deviations *(Check all that apply)*

☒ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	0	20	24	0	—	RBT
2	078	0	2	4	0	—	BROWN TROUT
3	210	0	7	20	0	—	BLACKNOSE DACE
4	212	0	4	30	0	—	CREEK CHUB
5	163	0	3	150	0	—	WHITE SUCKER
6	209	0	2	12	0	—	FATHEAD MINNOW
7	198	0	2	9	0	—	COMMON SHINER
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (initial & last name): S TRUTTA

Crew Initials: E.LUCIUS, C. BAIRD

Recorder: E.L.

Field ID (initial & last name): S TRVTTA

Cert. Level: 2

Lab ID (initial & last name): ~~ ~~

Cert. Level:

Entered/Scanned: E.L. 2000/10/10

Verified: C.B. 2000/10/20

Corrected: S.T. 2000/10/22

Comments: FIRST TIME NETTING FOR C. BAIRD - LEARNED QUICKLY

Example B:

Note that the field identification was carried out by a Certificate Level 1, and the taxa captured were identifiable to species at this level. No new taxa were identified for this watershed, therefore no fish were preserved. Channel morphology data was collected in the same year, therefore no site length or width data was collected.

Fish Sampling

Page No. 01 of 01

Stream Name: WILMOT CREEK

Date (mm-dd): 2000-06-21

Stream Code: WM1

Sample: 01

Run No. 01 of 01

Start Time (24hr): 10:30

Elapsed Min. 75

Shocker Sec. 2755

Site Code: 3CDW

Science Collect. No. 9678903

Stop Time (24hr): 11:45

Model No. 12-B

Anod. Voltage: 1 300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☒ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): .

Widths (m)

1	.	6	.
2	.	7	.
3	.	8	.
4	.	9	.
5	.	10	.

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B/O	P/S	Sp Name/Remarks
1	076	115	40	☐☐	☐☐	RBT
2	076	78	7	☐☐	☐☐	"
3	076	75	6	☐☐	☐☐	"
4	076	253	475	☐☐	☐☐	"
5	076	215	376	☐☐	☐☐	"
6	076	130	85	☐☐	☐☐	"
7	076	70	6	☐☐	☐☐	"
8	076	68	3	☐☐	☐☐	"
9	076	60	2	☐☐	☐☐	"
10	078	210	301	☐☐	☐☐	BROWN TROUT
11	078	195	270	☐☐	☐☐	"
12	078	65	3	☐☐	☐☐	"
13	078	95	17	☐☐	☐☐	"
14	163	150	42	☐☐	☐☐	WHITE SUCKER
15	163	122	31	☐☐	☐☐	"
16	163	201	77	☐☐	☐☐	"
17				☐☐	☐☐	
18				☐☐	☐☐	
19				☐☐	☐☐	
20				☐☐	☐☐	

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (initial & last name): S TRUTTA

Crew Initials: E.LUCIUS, C. BAIRD

Recorder: C.B.

Field ID (initial & last name): S TRUTTA

Cert. Level: 1

Lab ID (initial & last name):

Cert. Level:

Entered/ Scanned: 2000/11/11 E.B.

Verified: 2000/11/12 C.B.

Corrected: 2000/11/14 S.T.

Example C:

This field record shows a combination of individual and bulk data. Note that the field identification was carried out by a Certificate Level 1, therefore cyprinidae and sculpins were preserved. The crew separated *Rhynichthys sp.*, as they were confident that this group was either long- or western blacknose dace. Total lengths of young of year (< 100 mm) rainbow and brown trout were bulk weighed and recorded as Group 1. Scale samples were taken from representative fish in the sample.

Fish Sampling

Page No. 01 of 01

Date (mm-dd) 2000-07-06

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3C0W

Sample: 01

Run No. 01 of 01

Science Collect. No. 9678903

Start Time (24hr) 10:30

Stop Time (24hr) 11:45

Elapsed Min. 75

Shocker Sec. 2755

Model No. 12-B

Anod. Voltage 1300

Frequency 060

Pulse 04

Channel Morphology Available? ☒ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m) .

Widths (m)

1	.	6	.
2	.	7	.
3	.	8	.
4	.	9	.
5	.	10	.

Individual Fish ☒ Total Length ☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B	P	O	S	Sp Name/Remarks
1	076	115	40	☐	☐	☐	☒	RBT
2	076	78	7	☐	☐	☐	☒	" "
3	076	75	6	☐	☐	☐	☒	" "
4	076	253	475	☐	☐	☐	☒	" "
5	076	130	376	☐	☐	☐	☒	" "
6	076	70	85	☐	☐	☐	☒	" "
7	076	210	406	☐	☐	☐	☒	" "
8	078	212	301	☐	☐	☐	☒	BROWN TROUT
9	078	195	270	☐	☐	☐	☒	" "
10	078	65	—	☒	☐	☐	☐	" "
11	077	130	35	☐	☐	☐	☒	NO CLIPS ATS
12	077	120	30	☐	☐	☐	☒	NO CLIPS ATS
13	076	65	—	☒	☐	☐	☒	RBT
14	076	63	—	☒	☐	☐	☒	" "
15	380	25	3	☐	☐	☐	☐	SCULPIN
16	380	31	4	☐	☐	☐	☐	SCULPIN
17	226	62	5	☐	☐	☐	☐	RHYNICTHYS
18	226	48	3	☐	☐	☐	☐	RHYNICTHYS
19	180	78	5	☐	☐	☐	☐	CYPRINIDAE
20	180	62	3	☐	☐	☐	☐	CYPRINIDAE

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	1	10	24	0	—	RBT
2	078	1	2	4	0	—	BROWN TROUT
3	380	0	30	102	6	1	SCULPIN
4	226	0	9	32	9	2	RYNICTHYS
5	180	0	8	41	8	3	CYPRINIDAE
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (initial & last name): S TRUTTA

Crew Initials: C.BAIRD, E.WCNS

Recorder: E.L.

Field ID (initial & last name): S TRUTTA

Cert. Level: 1

Lab ID (initial & last name):

Cert. Level:

Entered/Scanned: 2000/08/02 E.L.

Verified: 2000/09/01 C.B.

Corrected: 2000/09/03 C.B

Example D:

Lab identification results are recorded on this field sheet. Note that the bag number must be recorded to enable summary reports to accurately record results to the most accurate level of identification. The summary report will be able to report that the bulk catch of sculpins were of one species i.e., mottled sculpin, as long as the bag number and number of fish are recorded.

Fish Sampling

Page No. 01 of 01

Date (mm-dd) 2000-07-06

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3C0W

Sample: 01

Run No. 01 of 01

Science Collect. No. 9678903

Start Time (24hr): 10:30

Stop Time (24hr): 11:45

Elapsed Min. 75

Shocker Sec. 2755

Model No. 12-B

Anod. Voltage: 1 300

Frequency: 060

Pulse: 04

Channel Morphology Available? ☒ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): .

Widths (m)

1	.	6	.
2	.	7	.
3	.	8	.
4	.	9	.
5	.	10	.

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Individual Fish

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B	P	O	S	Sp Name/Remarks
1	076	115	40	☐	☐	☐	☒	RBT
2	076	78	7	☐	☐	☐	☒	" "
3	076	75	6	☐	☐	☐	☒	" "
4	076	253	475	☐	☐	☐	☒	" "
5	076	130	376	☐	☐	☐	☒	" "
6	076	70	85	☐	☐	☐	☒	" "
7	076	210	406	☐	☐	☐	☒	" "
8	078	212	301	☐	☐	☐	☒	BROWN TROUT
9	078	195	270	☐	☐	☐	☒	" "
10	078	65	—	☒	☐	☐	☐	" "
11	077	130	35	☐	☐	☐	☒	NO CLIPS ATS
12	077	120	30	☐	☐	☐	☒	NO CLIPS ATS
13	076	65	—	☒	☐	☐	☒	RBT
14	076	63	—	☒	☐	☐	☒	" "
15	380	25	3	☐	☐	☐	☐	SCULPIN
16	380	31	4	☐	☐	☐	☐	SCULPIN
17	226	62	5	☐	☐	☐	☐	RHYNICTHYS
18	226	48	3	☐	☐	☐	☐	RHYNICTHYS
19	180	78	5	☐	☐	☐	☐	CYPRINIDAE
20	180	62	3	☐	☐	☐	☐	CYPRINIDAE

Comments

ALL LAB ID RESULTS ENTERED IN DATABASE.

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1	076	1	10	24	0	—	RBT
2	078	1	2	4	0	—	BROWN TROUT
3	380	0	30	102	6	1	SCULPIN
4	226	0	9	32	9	2	RYNICTHYS
5	180	0	8	41	8	3	CYPRINIDAE
6	—	LAB IDENTIFICATION					RESULTS —
7	381	-	6	—	—	1	MOTTLED SCULPIN
8	210	-	7	—	—	2	BLACKNOSE DACE
9	211	-	2	—	—	2	LONGNOSE DACE
10	212	-	4	—	—	3	CREEK CHUB
11	198	-	2	—	—	3	COMMON SHINER
12	209	-	2	—	—	3	FATHEAD MINNOW
13							
14							
15							

Crew Leader (initial & last name): S TRUTTA

Crew Initials: C.BAIRD, E.WCNS

Recorder: E.L.

Field ID (initial & last name): S TRUTTA

Cert. Level: 1

Lab ID (initial & last name): S GIBBS

Cert. Level: 2

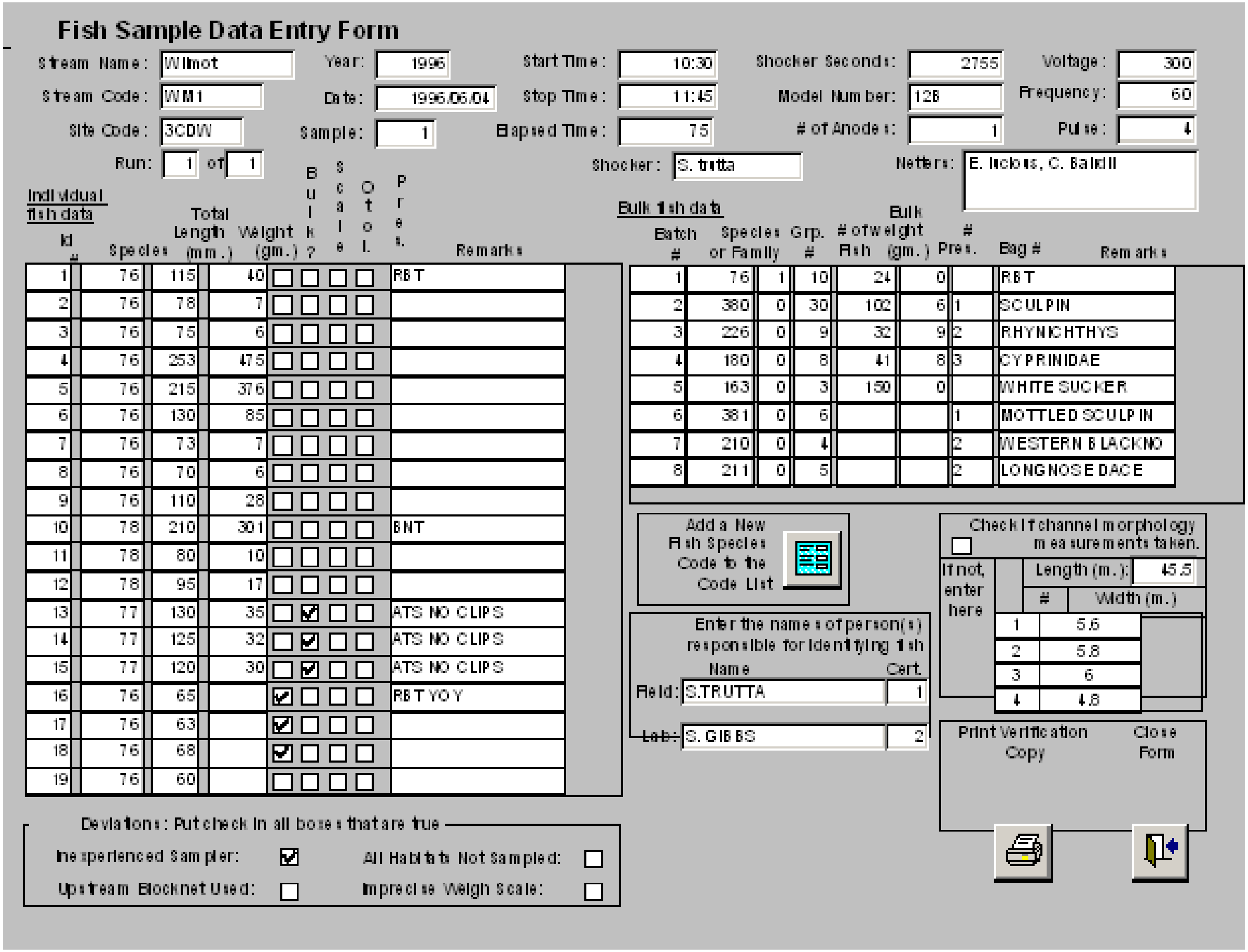
Entered/Scanned: 2000/08/02 E.L.

Verified: 2000/09/01 C.B.

Corrected: 2000/09/03 C.B

Example E:

Partial printout of a data entry screen illustrating how to enter laboratory identified specimens. Note data with a bag number and no weight data indicate they are laboratory identified fish. This information is essential for accurate summary statistics.



Fish Sample Data Entry Form

Stream Name: Wilmot
Stream Code: WM1
Site Code: 3CDW
Run: 1 of 1
Year: 1996
Date: 1996.06.04
Sample: 1
Start Time: 10:30
Stop Time: 11:45
Elapsed Time: 75
Shocker: S. trutta
Shocker Seconds: 2755
Model Number: 12B
# of Anodes: 1
Netters: E. Iiclois, C. Baldil
Voltage: 300
Frequency: 60
Pulse: 4

Individual fish data

Id #	Species	Total Length (mm.)	Weight (gm.)	Bulk?	Scale	Otol.	Pres.	Remarks
1	76	115	40	☐	☐	☐	☐	RBT
2	76	78	7	☐	☐	☐	☐	
3	76	75	6	☐	☐	☐	☐	
4	76	253	475	☐	☐	☐	☐	
5	76	215	376	☐	☐	☐	☐	
6	76	130	85	☐	☐	☐	☐	
7	76	73	7	☐	☐	☐	☐	
8	76	70	6	☐	☐	☐	☐	
9	76	110	28	☐	☐	☐	☐	
10	78	210	301	☐	☐	☐	☐	BNT
11	78	80	10	☐	☐	☐	☐	
12	78	95	17	☐	☐	☐	☐	
13	77	130	35	☐	☑	☐	☐	ATS NO CLIPS
14	77	125	32	☐	☑	☐	☐	ATS NO CLIPS
15	77	120	30	☐	☑	☐	☐	ATS NO CLIPS
16	76	65		☑	☐	☐	☐	RBT YOY
17	76	63		☑	☐	☐	☐	
18	76	68		☑	☐	☐	☐	
19	76	60		☐	☐	☐	☐	

Bulk fish data

Batch #	Species or Family	Grp. #	# of Fish	Bulk weight (gm.)	# Pres.	Bag #	Remarks
1	76	1	10	24	0		RBT
2	380	0	30	102	6	1	SCULPIN
3	226	0	9	32	9	2	RHYNICHTHYS
4	180	0	8	41	8	3	CYPRINIDAE
5	163	0	3	150	0		WHITE SUCKER
6	381	0	6			1	MOTTLED SCULPIN
7	210	0	4			2	WESTERN BLACKNO
8	211	0	5			2	LONGNOSE DACE

Add a New Fish Species Code to the Code List

Enter the names of person(s) responsible for identifying fish

	Name	Cert.
Field:	S.TRUTTA	1
Lab:	S. GIBBS	2

☐ Check if channel morphology measurements taken.

If not, enter here

Length (m.): 45.5

#	Width (m.)
1	5.6
2	5.8
3	6
4	4.8

Print Verification Copy

Close Form

Deviations: Put check in all boxes that are true

Inexperienced Sampler: ☑
Upstream Blocknet Used: ☐
All Habitats Not Sampled: ☐
Imprecise Weigh Scale: ☐

Appendix 2

Fish Identification Codes

ONTARIO MINISTRY OF NATURAL RESOURCES FISH SPECIES CODES & COMMON NAMES[1]

PETROMYZONTIDAE - Lampreys - 010
016. chestnut lamprey ... *Ichthyomyzon castaneus*
012. northern brook lamprey ... *Ichthyomyzon fossor*
013. silver lamprey ... *Ichthyomyzon unicuspis*
011. American brook lamprey ... *Lampetra appendix*
014. sea lamprey ... *Petromyzon marinus*
015. ... *Ichthyomyzon* sp.

POLYODONTIDAE - Paddlefishes - 020
021. paddlefish ... *Polyodon spathula*

ACIPENSERIDAE - Sturgeons - 030
031. lake sturgeon ... *Acipenser fulvescens*

AMIIDAE - Bowfins - 050
051. bowfin ... *Amia calva*

LEPISOSTEIDAE - Gars - 040
042. spotted gar ... *Lepisosteus oculatus*
041. longnose gar ... *Lepisosteus osseus*
. Florida gar ... *Lepisosteus platyrhinchus*
043. ... *Lepisosteus* sp.

ANGUILLIDAE - Freshwater Eels - 250
251. American eel ... *Anguilla rostrata*

CLUPEIDAE - Herrings - 060
061. alewife ... *Alosa pseudoharengus*
062. American shad ... *Alosa sapidissima*
063. gizzard shad ... *Dorosoma cepedianum*
064. ... *Alosa* sp.

HIODONTIDAE - Mooneyes - 150
151. goldeye ... *Hiodon alosoides*
152. mooneye ... *Hiodon tergisus*

SALMONIDAE ....salmon, trout, whitefishes, grayling
400. ... hybrids

SALMONINAE - Salmon, Trout subfamily - 070
071. pink salmon ... *Oncorhynchus gorbuscha*
072. chum salmon ... *Oncorhynchus keta*
073. coho salmon (coho) ... *Oncorhynchus kisutch*
076. rainbow trout (RBT) ... *Oncorhynchus mykiss*
074. sockeye salmon ... *Oncorhynchus nerka*
075. Chinook salmon (CHIN ..) *Oncorhynchus tshawytscha*
077. Atlantic salmon (ATS) ... *Salmo salar*
078. brown trout (BRN) ... *Salmo trutta*
079. Arctic char ... *Salvelinus alpinus*
080. brook trout (BKT) ... *Salvelinus fontinalis*
083. Aurora trout ... *S. fontinalis timagamiensis*
081. lake trout(LT)……………… *Salvelinus namaycush*
082. splake ... *S. fontinalis x S. namaycush*
087. tiger trout ... *Salmo trutta* X *Salvelineus fontinalis*
084. ... *Oncorhynchus* sp.
085. ... *Salmo* sp.
086. ... *Salvelinus* sp.
420. hybrids

COREGONINAE - Whitefish subfamily - 090
092. longjaw cisco ... *Coregonus alpenae*
093. cisco (lake herring) ... *Coregonus artedi*
091. lake whitefish ... *Coregonus clupeaformis*
094. bloater ... *Coregonus hoyi*
095. deepwater cisco ... *Coregonus johannae*
096. kiyi ... *Coregonus kiyi*
097. blackfin cisco ... *Coregonus nigripinnis*
098. Nipigon cisco * ... *Coregonus nipigon*
099. shortnose cisco ... *Coregonus reighardi*
100. shortjaw cisco ... *Coregonus zenithicus*
101. pygmy whitefish ... *Prosopium coulterii*
102. round whitefish ... *Prosopium cylindraceum*
103. chub ... *Coregonus* sp.
(Cisco species other than *C. artedi*)
106. *Coregonus sp.*
107. ... *Prosopium* sp.
450. hybrids

* This species is a synonym of *C. artedi* (Scott & Crossman 1973)

THYMALLINAE - Grayling subfamily - 110
111. Arctic grayling ... *Thymallus arcticus*

OSMERIDAE - Smelts - 120
121. rainbow smelt ... *Osmerus mordax*

ESOCIDAE - Pikes - 130
133. grass pickerel ... *Esox americanus vermiculatus*
131. northern pike ... *Esox lucius*
132. muskellunge ... *Esox masquinongy*
135. chain pickerel ... *Esox niger*
134. ... *Esox* sp.
500. hybrids
501. ... *Esox lucius x Esox americanus vermiculatus*
502. norlunge ... *Esox lucius x Esox masquinongy*

UMBRIDAE - Mudminnows - 140
141. central mudminnow ... *Umbra limi*

CYPRINIDAE - Carps and Minnows - 180
216. central stoneroller ... *Campostoma anomalum*
181. goldfish ... *Carassius auratus*
184. redside dace ... *Clinostomus elongatus*
185. lake chub ... *Couesius plumbeus*
219. grass carp ... *Ctenopharyngodon idella*
203. spotfin shiner ... *Cyprinella spiloptera*
186. common carp ... *Cyprinus carpio*
187. gravel chub ... *Erimystax x-punctatus*
188. cutlip minnow ... *Exoglossum maxillingua*
189. brassy minnow ... *Hybognathus hankinsoni*
190. eastern silvery minnow ... *Hybognathus regius*
217. striped shiner ... *Luxilus chrysocephalus*
198. common shiner ... *Luxilus cornutus*
205. redfin shiner ... *Lythrurus umbratilis*
191. silver chub ... *Macrhybopsis storeriana*
214. pearl dace ... *Margariscus margarita*
192. hornyhead chub ... *Nocomis biguttatus*
193. river chub ... *Nocomis micropogon*
194. golden shiner ... *Notemigonus crysoleucas*
195. pugnose shiner ... *Notropis anogenus*
196. emerald shiner ... *Notropis atherinoides*
197. bridle shiner ... *Notropis bifrenatus*
218. ghost shiner ... *Notropis buchanani*
199. blackchin shiner ... *Notropis heterodon*
200. blacknose shiner ... *Notropis heterolepis*
201. spottail shiner ... *Notropis hudsonius*
215. silver shiner ... *Notropis photogenis*
202. rosyface shiner ... *Notropis rubellus*
204. sand shiner ... *Notropis stramineus*
206. mimic shiner ... *Notropis volucellus*
207. pugnose minnow ... *Opsopoeodus emiliae*
182. northern redbelly dace ... *Phoxinus eos*
183. finescale dace ... *Phoxinus neogaeus*
208. bluntnose minnow ... *Pimephales notatus*
209. fathead minnow ... *Pimephales promelas*
210. western blacknose dace (BND) .. *Rhinichthys obtusus*
211. longnose dace (LND) ... *Rhinichthys cataractae*
220. rudd ... *Scardinius erythrophthalmus*
212. creek chub (CCHUB) ... *Semotilus atromaculatus*
213. fallfish ... *Semotilus corporalis*
222. ... *Hybognathus* sp.
228. ... *Hybopsis* sp.
229. ... *Luxilus* sp.
223. ... *Nocomis* sp.
224. ... *Notropis* sp.
221. ... *Phoxinus* sp.
225. ... *Pimephales* sp.
226. ... *Rhinichthys* sp.
227. ... *Semotilus* sp.
600. ... hybrids
601. ... *Carassius auratus x Cyprinus carpio*
602. ... *Phoxinus* hybrids
603. ... *Phoxinus eos x Phoxinus neogaeus*
604. ... *Phoxinus eos x Margariscus margarita*
605. ... *Phoxinus neogaeus x Margariscus margarita*
610. ... *Notropis* hybrids
611. ... *Luxilus cornutus x Notropis rubellus*
612. ... *Luxilus cornutus x Semotilus atromaculatus*
620. ... *Pimephales promelas x Pimephales notatus*

CATOSTOMIDAE - Suckers - 160
162. longnose sucker ... *Catostomus catostomus*
163. white sucker ... *Catostomus commersonii*
161. quillback ... *Carpiodes cyprinus*
164. lake chubsucker ... *Erimyzon sucetta*
165. northern hog sucker ... *Hypentelium nigricans*
166. bigmouth buffalo ... *Ictiobus cyprinellus*
174. black buffalo ... *Ictiobus niger*
167. spotted sucker ... *Minytrema melanops*
168. silver redhorse ... *Moxostoma anisurum*
173. river redhorse ... *Moxostoma carinatum*
169. black redhorse ... *Moxostoma duquesnei*
170. golden redhorse ... *Moxostoma erythrurum*
171. shorthead redhorse ... *Moxostoma macrolepidotum*
172. greater redhorse ... *Moxostoma valenciennesi*
176. ... *Catostomus* sp.
177. ... *Moxostoma* sp.
178. ... *Ictiobus* sp.
550. hybrids
551. ... *Ictiobus* hybrids

ICTALURIDAE - Bullhead Catfishes - 230
231. black bullhead ... *Ameiurus melas*
232. yellow bullhead ... *Ameiurus natalis*
233. brown bullhead ... *Ameiurus nebulosus*
234. channel catfish ... *Ictalurus punctatus*
235. stonecat ... *Noturus flavus*
236. tadpole madtom ... *Noturus gyrinus*
237. brindled madtom ... *Noturus miurus*
238. margined madtom ... *Noturus insignis*
244. northern madtom ... *Noturus stigmosus*
239. flathead catfish ... *Pylodictis olivaris*
241. ... *Ictalurus* sp.
242. ... *Noturus* sp.
243. ... *Ameiurus* sp.
650. hybrids
651. ... *Ameiurus melas x Ameiurus nebulosus*

PERCOPSIDAE - Trout-perches - 290
291. trout-perch ... *Percopsis omiscomaycus*

GADIDAE - Cods - 270
271. burbot ... *Lota lota*

FUNDULIDAE - Killifishes - 260
261. banded killifish ... *Fundulus diaphanus*
262. blackstripe topminnow ... *Fundulus notatus*

ATHERINIDAE - Silversides - 360
361. brook silverside ... *Labidesthes sicculus*

GASTEROSTEIDAE - Sticklebacks - 280
284. fourspine stickleback ... *Apeltes quadracus*
281. brook stickleback ... *Culaea inconstans*
282. threespine stickleback ... *Gasterosteus aculeatus*
283. ninespine stickleback ... *Pungitius pungitius*

COTTIDAE - Sculpins - 380
381. mottled sculpin (MSC) ... *Cottus bairdii*
382. slimy sculpin (SSC) ... *Cottus cognatus*
383. spoonhead sculpin ... *Cottus ricei*
384. deepwater sculpin ... *Myoxocephalus thompsonii*
387. fourhorn sculpin ... *Myoxocephalus quadricornis*
385. ... *Cottus* sp.
386. ... *Myoxocephalus* sp.
800. hybrids
801. ... *Cottus bairdi x Cottus cognatus*

CYCLOPTERIDAE - Lumpfishes - 390
391. lumpfish ... *Cyclopterus lumpus*

MORONIDAE - Temperate Basses - 300
301. white perch ... *Morone americana*
302. white bass ... *Morone chrysops*
303. ... *Morone* sp.

CENTRARCHIDAE - Sunfishes - 310
311. rock bass (RBASS) ... *Ambloplites rupestris*
312. green sunfish ... *Lepomis cyanellus*
313. pumpkinseed (PUMP) ... *Lepomis gibbosus*
323. warmouth ... *Lepomis gulosus*
324. orangespotted sunfish ... *Lepomis humilis*
314. bluegill ... *Lepomis macrochirus*
315. longear sunfish ... *Lepomis megalotis*
316. smallmouth bass (SMB) ... *Micropterus dolomieu*
317. largemouth bass (LMB) ... *Micropterus salmoides*
318. white crappie ... *Pomoxis annularis*
319. black crappie ... *Pomoxis nigromaculatus*
320. ... *Lepomis* sp.
321. ... *Micropterus* sp.
322. ... *Pomoxis* sp.
700. hybrids
701. ... *Lepomis* hybrids
702. ... *Lepomis gibbosus x Lepomis macrochirus*
703. ... *Lepomis cyanellus x Lepomis gibbosus*
704. ... *Lepomis cyanellus x Lepomis megalotis*
705. ... *Lepomis cyanellus x Lepomis macrochirus*
706. ... *Pomoxis annularis x Pomoxis nigromaculatus*

PERCIDAE - Perches - 330
335. eastern sand darter ... *Ammocrypta pellucida*
336. greenside darter ... *Etheostoma blennioides*
337. rainbow darter (RBDART) ... *Etheostoma caeruleum*
338. Iowa darter ... *Etheostoma exile*
339. fantail darter ... *Etheostoma flabellare*
340. least darter ... *Etheostoma microperca*
341. johnny darter ... *Etheostoma nigrum*
346. tessellated darter ... *Etheostoma olmstedi*
350. ruffe ... *Gymnocephalus cernuus*
331. yellow perch (YPERCH) ... *Perca flavescens*
342. logperch ... *Percina caprodes*
343. channel darter ... *Percina copelandi*
344. blackside darter ... *Percina maculata*
345. river darter ... *Percina shumardi*
332. sauger ... *Sander canadensis*
333. blue pike ... *Sander vitreus glaucus*
334. walleye (yellow pickerel) ... *Sander vitreus*
347. ... *Stizostedion* sp.
348. ... *Etheostoma* sp.
349. ... *Percina* sp.
750. ... hybrids
751. ... *Stizostedion canadense x Stizostedion vitreum*

SCIAENIDAE - Drums - 370
371. freshwater drum ... *Aplodinotus grunniens*

GOBIIDAE - Gobies -
366. round goby ... *Neogobius melanostomus*
367. tubenose goby ... *Proterorhinus marmoratus*

PLEURONECTIDAE - Righteye Flounders -
396. European flounder ... *Platichthys flesus*

ONTFISH.DOC, 4 March 4, 2002

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[1] Formatted by Karen Ditz, Ichthyology and Herpetology, Royal Ontario Museum, May 1994. Modified March 2002 (Erling Holm). Reformatted and modified (name changes according to Nelson, J.S., E.J. Crossman, H. Espinosa-Pérez, L.T. Findley, C.R. Gilbert, R.N. Lea, and J.D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, Maryland. 386 p.) by Brenda Koenig, 2005.

Adapted from:

D. P. Dodge, G. A. Goodchild, J. C. Tilt, and D. C. Waldriff. 1984. MNR's Manual of Instructions - Aquatic Habitat Inventory Surveys.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4

Assessing Physical Processes and Channel Structure

TABLE OF CONTENTS

INTRODUCTION

The modules in this section provide standard methodologies for assessing habitat in wadeable streams. The data collected will allow analysis of the channel structure (e.g., cover, substrate), channel processes (e.g., hydrology, sediment transport), and the stream's suitability for biota. Standardizing data collection procedures enables comparisons to be made across spatial and temporal scales by reducing error and controlling biases. Providing standard methodologies that vary in the accuracy of the data collected offers flexibility for users to accommodate different study designs.

A summary of the procedures, the effort required to implement them, and the accuracy of data collected for each are provided below. Additional details are provided in the Introduction section of each module.

Some of the modules in this section require the use of transects. These can be used to collect data for more than one module (i.e., modules can be applied individually or in conjunction with each other).

Accepted standard protocols in this section include:

S4.M1: Rapid Assessment Methodology for Channel Structure

This module is designed to provide visual estimates of channel structure, substrate and bank condition. The Rapid Assessment Methodology for Channel Structure (RAM) adapts the point-transect approach, by visually classifying the habitat along transects. RAM can be completed in much less time than it would take to complete the full point-transect method (S4.M2, see below) and produces a more repeatable assessment than conventional visual assessments. RAM is best applied to studies that are designed to evaluate overall conditions across spatial scales.

S4.M2: Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions

This module provides screening level and diagnostic techniques to evaluate the physical conditions important to biota in wadeable streams. Screening level techniques are described for evaluating riparian conditions, bank vegetation, sinuosity, bankfull width, confinement and velocity. Diagnostic techniques offer more precision to quantify channel roughness, low flow width and depth, substrate composition and diversity, amount of wood material, instream cover and vegetation and degree of undercutting. The sampling effort applied for each attribute is determined by the level of precision required to demonstrate the relationships between biota and physical habitat characteristics. This module can be used for studies to evaluate change in conditions across temporal or spatial scales.

S4.M3: Bankfull Profiles and Channel Entrenchment

This module describes a quantitative method for measuring the bankfull cross-sectional profile. Techniques for recording channel entrenchment (i.e., a measure of channel confinement within the floodplain) are also outlined. Two approaches are described for demarcating the line to which the profiles are measured. The use of a laser level is more expensive and slightly more time consuming, but generates a more accurate measure of bankfull area and is therefore considered diagnostic. The standard approach involves using a tape measure that is pulled as taught as possible.

Identifying the bankfull level requires a basic understanding of stream dynamics. While the methods described in this module are intended to provide reliable and repeatable measures, they require interpretative skills. Further, bankfull profile measurements are more easily applied on stable channels. This module is best applied as a monitoring or assessment tool for evaluating changes in the channel profile that may result from geomorphic processes.

S4.M4: Reconnaissance Surveys for Stream Discharge

This module contains instructions for estimating discharge on “all” wadeable streams using qualitative methods. These methods are used mainly for reconnaissance purposes as they confirm the presence of flow, provide a measure of relative discharge, and information on the suitability of sites for more rigorous sampling. The use of these preliminary observations will ensure that field studies are planned and conducted effectively and efficiently.

Data collected using this module will have higher error rates than more quantitative surveys as outlined in S4.M5. This module is best applied by surveyors experienced in measuring discharge at sites and/or using some or all of the methods described in S4.M9 at at least the smaller stream crossings.

S4.M5: Measuring Stream Discharge Quantitatively

This module contains instructions for measuring discharge on wadeable streams, using the Volume/Time Method and the Area Times Velocity Method. The data are useful for long-term monitoring and impact assessment studies. These procedures can be used for characterizing baseflow conditions or for determining a point-in-time response to a storm event.

S4.M6: Crest Stage Gauges: Rapid Assessment of Response to Storm and Drought Events

This module describes an economical and reliable method of measuring the maximum depth of water over a period of time (i.e., typically through a storm event). These methods collect screening level information about the flashiness of a stream and are suitable for large-scale surveys which require an evaluation of many sites. This module can provide an indicator of the watershed's response time and pattern to a storm/drought event.

S4.M7: Standardized Procedures for Measuring Site Slope

This module provides instructions for measuring changes in the elevation of the stream bed or water surface between two or more locations within a site. When combined with site length, the techniques are useful for measuring the average slope of the bed and the water surface in a site. The methods are also appropriate for generating a longitudinal profile of the site if differences in elevation between specific morphologic features (i.e., riffles versus pools) are recorded. These methods can be applied to diagnostic surveys that measure small changes in bed elevation, however there are more efficient, albeit expensive, approaches than those described in this module.

S4.M8: Rapid Assessment Methodology for Instream Substrate Sampling

This module describes techniques for conducting a "hybrid" screening/assessment level assessment of substrate composition through an entire site. The techniques employed are a cross between a traditional Rapid Assessment Methodology (RAM) and a standard survey approach in that crews use rapid assessment approaches to locate sampling points and then apply a standard approach to measure substrate composition. If applied without bias, this approach can generate an accurate assessment of the proportion and sizes of substrate particles throughout a site.

S4.M9: Check Your Watershed Day Surveys for Stream Discharge and Perched Culverts

This module describes a methodology for evaluating the flow conditions and whether culverts are perched using rapid assessment techniques in small (generally < 3 m streams). This protocol is optimally designed to be applied within a single watershed, at a time when the stream is approaching its summer low flow discharge[1]. Under these conditions the flow in the stream is mostly from groundwater discharge. These surveys will provide a measure of the

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[1] The methods are equally applicable for surveys conducted at any time of year or conditions that characterize relative conditions of flow in the watershed.

contribution of flow from headwater systems[2] and if it is applied in conjunction with strategically placed standard discharge surveys (S4.M5) can generate a comparative water budget within a watershed. The techniques can also be applied to a broader geographic area as part of a screening level survey to identify dry and flowing areas and as a means to direct additional sampling.

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[2] Headwater streams are those from small catchments (< approx. 10 km^2) that provide the source water to the main stream systems.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 1

Rapid Assessment Methodology for Channel Structure[1]

TABLE OF CONTENTS

APPENDICES

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[1] Authors: L. W. Stanfield and M. L. Jones

1.0 INTRODUCTION

Techniques for conducting screening level assessments of fish habitat conditions are described in this module. While this methodology is defensible and variance can be quantified, data collected using this tool are mostly visual and are therefore inherently biased. A procedure for calibrating the biases is also described.

This module provides a Rapid Assessment Methodology (RAM) which is a screening level characterization of stream habitat at a site. Data collected includes substrate, depth, instream morphology and bank stability. The RAM incorporates the point-transect approach which improves repeatability over conventional non-point transect visual assessments (Hawkins et al. 1993). It is best applied in studies that have one of the following objectives:

- to evaluate a large number of sites with limited time and resources
- conduct a screening level investigation of habitat suitability at a site for specific fish species.

If more accurate results are required for measuring substrate composition, the module is easily adaptable to incorporating the Rapid Assessment Methodology for Instream Substrate Sampling (S4.M8). If the site is to be a component of a monitoring program or more accurate data for all attributes are required the use of the Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions (S4.M2,) module should be considered.

2.0 PRE-FIELD ACTIVITIES

A typical habitat survey of a site should take between 10 to 20 minutes. A two-person crew is recommended for safety. Field surveys should follow a training program (see Appendix I).

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1, Site Identification and Documentation)
- Equipment check

The following equipment is required:

1. RAM Field Forms on waterproof paper
2. Pencils
3. Metre stick
4. Tape measure
5. Maps

Optional equipment includes:

6. Calculator
7. Hip chain
8. Flagging tape
9. Compass
10. Site marking equipment and
11. Camera

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

Procedures outlined below include defining site boundaries, recording site information, and measurement of channel features, bank conditions and substrate.

3.1 Recording the Site Identification Information

The module should be done in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available.

Record the 'Site Type' as a calibration (C) or survey (S) site. A calibration site is one at which both RAM and the point-transect methodology data are collected and used to develop the correction factors for the RAM data (Appendix 1 and 2).

3.2 Defining the Site Boundaries

The site boundaries are defined as per S1.M1. If no accurate data on site length are available, record the approximate length of the site (±3 m). This is accomplished by either chaining up the centre of the stream (most accurate) or by pacing up the channel or the banks, depending on site conditions. Record the site length on the Site Identification Form, mark with an asterisk (*), if anything other than chaining was used to obtain this measurement, and include an explanation in the 'Comments' section indicating that the site length was estimated. On the RAM Field Form (Appendix 3), record the appropriate unique identifiers for the site (see S1.M1).

3.3 Setting up Transects and Observation Points

Begin at the downstream end of the site and walk upstream (observing and recording the habitat conditions as you go) until the top of the site is reached. If chaining is used to measure site length, crews may mark the transect locations on the banks during the return trip to the bottom of the site. The number of transects required and the number of observation points per transect is determined by the minimum width of the site. If the stream is greater than 3 m wide throughout the site, use 10 transects and six observation points per transect; otherwise estimate the stream width at the narrowest location and refer to Table 1. Transects should be evenly spaced along the site.

Beginning at the first downstream transect, visually locate the appropriate number of observation points along the transect. Depth, velocity and point substrate measurements are made directly below the observation point, whereas cover and maximum particle size measurements are made within a visualized 30 cm ring centered on the observation point (referred to as the ‘observation area’).

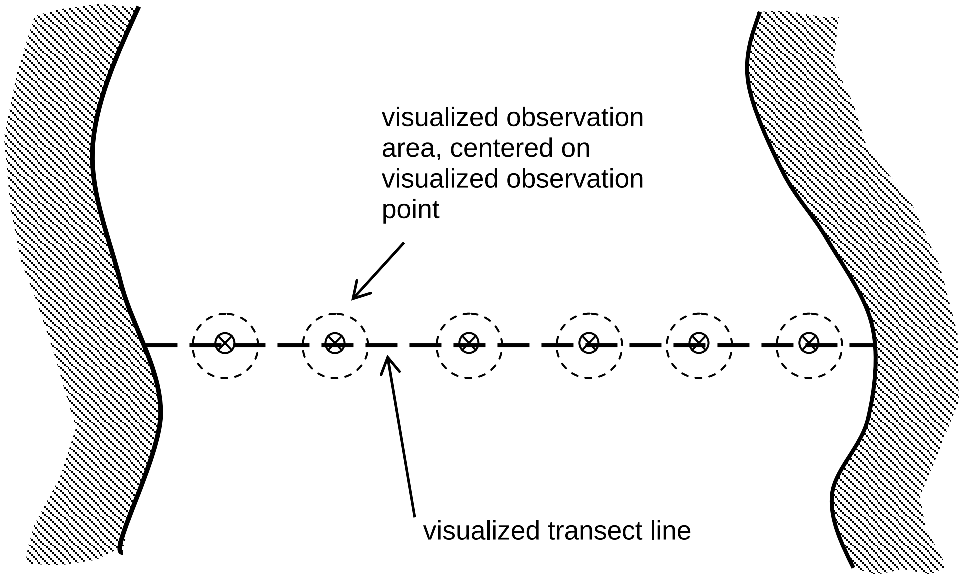


Figure 1: ‘Observation Areas’ (30 cm diameter) and Transect.

Table 1: Relationship Between the Minimum Stream Width and the Number of Observation Points Required per Transect

Minimum Stream Width (m)	Number of Transects	Number of Observation Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.5	15	3
< 1.0	20	2

3.3.1 Channel Structure

A variety of techniques may be used to collect channel structure data, depending on the experience of the crew and the complexity of habitat. Techniques include collecting most of the data from shore in relatively homogenous sites or by walking across each transect, stopping at each observation point to collect data.

At each observation point measure hydraulic head (velocity) to classify habitat into four categories: pools, glides, slow riffles and fast riffles (Table 2). Then measure/estimate water depth to classify points into shallow, moderate, intermediate or deep habitats. Finally, determine whether there is unembedded cover present or absent. Cover is assessed within a visualized 30 cm ring centered on the observation point (see section 3.3.2 Instream Cover of this module). Combine these three measures (hydraulic head, depth and cover) to classify and record each observation in the 'Channel Structure' section of the RAM Field Form using the dot tally method (one dot per observation point).

Hydraulic Head

The difference in height of water between the front and back of a vertically held ruler that is placed at right angles to the flow of water (see S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions for more details).

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

Table 2: Descriptions of Habitat Categories (adapted from Aadland et al. 1991).

Habitat Categories	Descriptions
'Pools'	hydraulic head of 0 to 3 mm
'Glides	hydraulic head of 4 to 7 mm (evidence of little turbulence and moderate velocities)
'Slow Riffles'	hydraulic head of 8 to 17 mm (fast velocities)
'Fast Riffles'	hydraulic head greater than 17 mm (very fast velocities)

3.3.2 Instream Cover

Measure cover within a visualized 30 cm ring centered on the observation point. Record and document the occurrences and all types of unembedded cover present (i.e., cover with interstitial spaces that enable small fish to hide underneath the object) within each sample area, using the dot tally method (Table 3). For example, if there is a boulder and log at one observation point record **one** dot in each of the boxes for 'Cover Types': 'Round Rock' and 'Wood'.

Instream Cover

A cover particle is any object that touches the water within the sample area, is **at least 100 mm wide** along the median axis and of sufficient density to block >75 % of sunlight from reaching the stream bottom. A cover particle can consist of a mat of materials such as twigs, macrophytes, or the bank. The mat must still meet the median diameter size and light penetration restrictions.

Table 3: Definitions for Cover Types.

Cover Type	Description
'Flat Rock'	The longitudinal axis is at least twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis > 2.
'Round Rock'	The longitudinal axis is less than twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis < 2.
'Wood'	Living or dead woody materials (includes mats of twigs, shrubs).
'Macrophytes'	Living aquatic and terrestrial non-woody plants.
'Bank'	Bank material which contain soils (fine materials) i.e., undercuts and slumped banks or parts of banks which have become dislodged and are now lying in the main channel.
'Other'	Any other type of material not covered by the above categories (e.g. tires, refrigerators, cars).

Flat versus Round Rocks

Flat and round rocks are recorded separately based on the different levels of suitability of these cover types for various species of fish (Ed Crossman, Royal Ontario Museum, pers. comm.).

3.3.3 Substrate Types

This section assesses the substrate and sediment transport characteristics of the site, within the context of the type of parent material available to the stream. There are two types of channels, bedrock and alluvial. Bedrock streams can either be erodible (shale) or not (granite). Alluvial streams have parent material of either fine (sand), medium (gravel), or coarse (cobble) particulate materials. In order to understand the relationship of parent substrate materials and bedload transport, measurements and comparisons are made between **maximum particle** and **point particle** sizes.

3.3.3.1 Point Particle

Across each transect, visually estimate the percentage of substrate (in 10% increments) as fines (sand), gravel, cobble or bedrock. Record the percentages using the dot tally procedure, where each dot accounts for 10% of thetransect. For example, if the proportions are sand (10%), gravel (80%) and cobble (10%), there would be one dot for each of fines and cobble, and eight dots for gravel. There should be a total of 10 dots per transect, and 100 dots when 10 transects are completed. If the technique of walking across each transect is used, surveyors may choose to evaluate substrate below each observation point as a more accurate alternative.

3.3.3.2 Maximum Particle

At each observation area (i.e., 30 cm circular sampling area) on the transect, estimate and record (dot tally) the maximum particle size observed based on substrate categories listed in Table 4.

Table 4: Descriptions of Substrate Categories adapted from Dodge et al (1984).

Substrate Categories	Median Axis of Largest Particle Observed is
‘Fines’ (sand, silt, clay)	< 2 mm.
‘Gravel’	2 to 100 mm.
‘Cobble’	101 to 1000 mm.
‘Bedrock’	> 1000 mm.

3.3.4 Habitat Stability

This section provides guidance on how to measure ‘Mean Stream Width’, ‘Mean Depth at Crossover’, ‘Maximum Particle Size’, and ‘Bank Stability (i.e., ‘Eroding Bank’, ‘Vulnerable Bank’, ‘Protected Bank’, ‘Deposition Zone’).

3.3.4.1 Stream Width at Crossover

At the bottom of the site (i.e., at crossover point), measure and record the wetted width of the stream in the box marked ‘Mean Stream Width (m)’. Measure to the nearest tenth of a metre.

3.3.4.2 Mean Depth at Crossover

At the same crossover transect estimate the average water depth. Water depth at crossover points should be relatively uniform across the channel. The measurement could be taken using several techniques (e.g., measurement of several points across the transect with a metre stick or a wading rod). Record the water depth to the nearest 5 mm, (e.g. a water depth of 17 mm should be recorded as 15 mm).

3.3.4.3 Maximum Particle Size

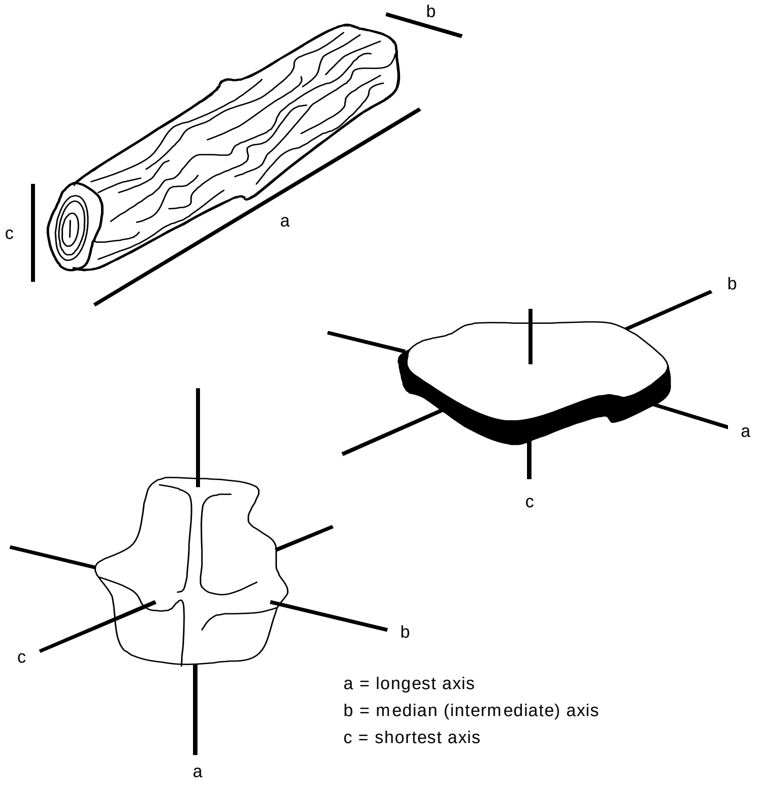
Within the site boundaries, find and measure the largest rock that has been moved by the stream. Ignore rocks that are likely to be erratics or other rocks in the stream that have obviously been in place for long periods of time. For example, if erosion is evident on either side of the rock, it should not be included in this measure. If there are several rocks that are similar in size, a representative rock should be selected. Measure and record the median axis (to the nearest mm) in the ‘Maximum Particle Size’ box on the RAM Field Form.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

3.3.4.4 Bank Stability

Categorize both banks of each transect using the following categories (Table 5). Record using the dot tally method.



a = longest axis
b = median (intermediate) axis
c = shortest axis

Figure 2: Measuring the Median Axis of Cover and Substrate.

Table 5: Descriptions of Bank Stability Categories.

Bank Stability Categories	Interface between Water and Bank	Bank Soil/Substrate	Characteristics of Bank
‘Eroding Bank’	Steep, $>45^{o}$	erodible materials	undercut (by at least 5 cm) or shows signs of recent slumping (i.e. no or little vegetation present
‘Vulnerable Bank’	Steep, $>45^{o}$	erodible materials	shows no recent signs of erosion (i.e., undercuts or slumping) and protected by a mat of live vegetation
‘Protected Bank’	Steep, $>45^{o}$	non-erodible materials (e.g., rock, boulders or hardened clay)	vegetation may or may not be present, includes banks armoured by humans
‘Deposition Zone’	Gentle, $<45^{o}$	generally, materials which have been deposited by the river during its flood condition	

3.4 Tips for Applying this Module

Crews using this module should have experience with the point-transect methodology (S4.M2). It is strongly recommended that crews be trained and have enough field experience to ensure repeatability.

Project managers should establish a training program for crews at the outset of the study and a follow-up assessment to ensure that data are acceptable (Appendices 2, 3).

Data should be recorded while proceeding up the stream and then summarized before leaving the site.

4.0 DATA MANAGEMENT

Upon returning from the field;
1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

If data has been collected at calibration sites use the procedures described in Appendix 3 to develop correction factors for the variables of interest to the project.

5.0 LITERATURE CITED

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Hawkins, C. P., J. L. Kreshner, P.A. Bisson, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman and M.K. Young. 1993. A Hierarchical Approach to Classifying Stream Habitat Features. Fisheries. 18(6):3-12.

Appendix 1

Training Crews in the Use of RAM

RAM data is most valuable when it can be collected by a crew in a consistent manner such that strong correlations can be established between it and more rigorous methods (i.e., S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions). We recommend the following procedures for training field crews in the use of this module to maximize the utility of the data collected:

Carry out the point transect survey and RAM at as many transects as needed for the crew to feel confident in their results. Ensure that the types of habitat assessed cover the range expected in the overall study.

1. Set up a transect line and mark the location of each observation point.
2. Using the criteria on the RAM Field Form, visually classify the instream habitat and substrate at each observation point and then rate the bank conditions as to their vulnerability to erosion.
3. Repeat the process at each observation point and on the banks using the point transect methods described in S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions.
4. Compare the results of the two methods, discussing where results differ and why.
5. Repeat this process until there is congruence between the two methods. Compare results for each category of habitat at the end of each transect and again at the completion of the training period. All visual observations should be within 1 category of the point-transect data and there should be at least 90% agreement in the number of classes determined using each method (i.e., number of shallow pools using point transect / RAM should exceed 0.9).
6. As a final stage, we recommend that several transects be evaluated before the tape measure is set up, to ensure that crews are able to visually establish the appropriate spacing for both transects and observation points.

The time required to train crews will depend greatly on their experience. Managers should be prepared to allocate at least two sites (one day) for this exercise.

Appendix 2

Developing Calibration Ratios for RAM

Introduction

Here we describe how the methods of Doloff et al. (1993) can be used to develop calibration coefficients for data collected using the point transect methodology (S4.M2) and RAM (S4.M1). This enables users to develop a higher degree of accuracy in their estimates of habitat than is generally possible if only RAM is used. This task requires four steps:

- establishing calibration and study sites and the sampling sequence
- collecting field data
- establishing the calibration coefficients
- application of correction factors to data and calculate confidence limits

Step 1: Establishing calibration and study sites and the sampling sequence

Project managers must determine (randomly) how many sites to sample for calibration. This number will be the larger of 10 sites or 10 % of total sample sites. These will become locations where both RAM and the point transect methods will be applied. These sites are referred to as calibration sites. Establish a sampling schedule that balances logistics with the need to spread the collection of calibration site data randomly across the duration of the study.

Note: If multiple crews are used on a survey and there are consistently different biases (i.e., one crew is always high and the other low we recommend that independent calibration be developed for each crew. Any site within your study area or comparable areas of geology can be used as calibration sites for your crews, provided the habitat does not measurably change between the two sample periods. Therefore it may be possible for studies to use data from other studies to develop calibration ratios as a cost saving measure.

Step 2: Field Data Collection

Collect the field data, ensuring that at any calibration site, the RAM data is collected first. Only after the RAM has been collected for the entire site should the point transect surveys be initiated.

Step 3: Developing Calibration Ratios

After entering and verifying that all data is correct, extract the appropriate data required for the study and summarize the results. The data points should be plotted and the R^2 value between the methods should be greater than 0.50. If it is not, do not attempt to create calibration coefficients. Use data from the calibration sites to develop calibration coefficients for each attribute of interest as follows:

$$\hat{Q} = \sum_{i=1}^{n} m_i / \sum_{i=1}^{n} x_i$$

where,
m_i = point transect habitat variable for each calibration site *i*; *i* = 1, 2,... n
x_i = RAM estimate of habitat variable for each site *i*; *i* = 1, 2,... n

For example, the results of a point transect and RAM survey for the percent cover are shown below:

Point Transect:	10, 15, 17, 3, 68, 23, 24, 14, 9, 12 = 195
RAM	5, 10, 20, 0, 50, 10, 20, 20, 10, 10 = 155

The calibration ratio for this variable would be:

$$\hat{Q} = 195/155 = 1.26$$

Step 4: Application of correction factors to data and calculate confidence limits

The adjusted habitat scores ($\hat{M}$) for the study can be estimated by multiplying the mean value for the attribute from all of the sites in the study (T_x) by the calibration ratio ($\hat{Q}$).

$$\hat{M} = T_x \hat{Q}$$

For example if the mean estimate of cover for the entire data set was 24, then the corrected estimate would be:

$$1.26 \bullet 24 = 30$$

This technique is only appropriate for large-scale basin wide surveys as it does not correct individual site biases.

The uncertainty of the estimate for each habitat attribute for the entire survey data set can be calculated from sample data using:

$$\hat{V}(\hat{M}) = \frac{N(N-n)}{n(n-1)} \sum_{i=1}^{n} (m_i - \hat{Q} x_i)^2$$

where

N = the total number of sites surveyed using the point transect technique

n = the total number of sites surveyed using the RAM

m_i = measured estimate of the habitat variable *i.*

$\hat{Q}x$ = predicted estimate of habitat variable *i.*

This equation approximates the variance $(\hat{V})$ for large sample sizes (i.e., > 10 samples). This equation shows that the variance depends on two very different factors, sample size and consistency in application of the RAM. First, variance decreases as the sample size increases, a manager can always reduce variance in the study by increasing the proportion of the sites sampled, using both the point transect and RAM. Second, the summation term expresses the squared differences between the habitat attributes measured using the point transect and RAM. The more closely correlated the results of the two methods are, the lower the variance will be. The other way to reduce variance is to ensure that the field procedures for measuring the RAM and transect methods are applied consistently for all sample sites.

The 95 % confidence intervals for the habitat attributes can be estimated using the following:

$$\hat{M} \pm t_{0.05;\, n\,-\,1}\sqrt{\hat{V}(\hat{M})}$$

For more information on this technique see Doloff et al. (1993).

Note: Check the data for obvious errors and outliers and either correct or delete as appropriate.

Appendix 3

Example Rapid Assessment Methodology Field Form

Rapid Assessment Methodology Field Form

Stream Nam e	Stream Code	Site Code	Year	Sample	Date (YYYY/MM/DD)	Site Type (C – Calibration, S – Survey)
WILMOT CREEK	WM1	3CDW	2000	1	2000/06/21	C

Crew
S. TRUTTA, S. SALAR

Channel Structure

Depth (mm)	Pools (Hydraulic Head = 0 – 3 mm)		Glides (Hydraulic Head = 4 – 7 mm)		Slow Riffles (Hydraulic Head = 8 – 17 mm)		Fast Riffles (Hydraulic Head >17 mm)	
	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present
0 – 100 mm	● ● ● ●	● ●	● ●	● ●	‾ ● ● 5	● ● ● ● 4	● ●	
101 – 600 mm	☐	● ● ●	☐ 2	● ● 2	⧄ 9	● ● ●	●	
601 – 1000 mm	4 ●	2 ●	●● 8	2		●	2	
> 1000 mm	8	3				3		
Total # Points	1 13	1 6	2 12	4	14	1 8	1 3	0

Instream Cover

Cover Types	Flat Rock	Round Rock	Wood	Macrophytes	Bank	Other
Number of Points	●⌉	☒ 10	● ● ● ●	1 ●	● ●	

Substrate Types	Fines (<2 mm)	Gravel (2 – 100 mm) 4	Cobble (100 mm – 1000nn) 2	Bedrock (>1000m)
Maximum Particle 6		☒ ☒ ☒ ●⌉ 36	☒ ⧄	‾ ● ●
Point Particle	☒	☒ ☒ ☒ ●⌉ 36	☒ ● ● 19	● ● 5

Bank Stability

Mean Stream Width (m) 10	5.5	Mean Depth at Crossover (mm)	25	12 Maximum Particle Size (mm)	250

Eroding Bank	●	1	Angle > 45°, erodible soil, undercut or bare soil
Vulnerable Bank	⧄	9	Angle > 45°, erodible soil, no sign of recent erosion
Protected Bank			Angle > 45°, non-erodible material / soil
Deposition Zone	☒	10	Angle < 45°, (gradual slope from river), fine grained sediments

2 Enter dates and initials when data entered in computer.

	Date	Init.
Entered	97 / 09/11	LF
Verified	97/10/12	LA
Corrected	97/10/12	LF

Rapid Assessment Methodology for Channel Structure
updated April 2010

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 2

Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions[1]

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APPENDICES

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[1] Authors: L. W. Stanfield, J. Parish and M. Stoneman

1.0 INTRODUCTION

The data collected using this module can be used to compare physical conditions of streams spatially or temporally. It can also be used to identify limiting features of the physical habitat. The procedures within this module can be completed individually (e.g., to evaluate only substrate) but it is recommended that the entire module be completed. The advantage of this module over the RAM is that all data collected are actual measurements which improves accuracy and allows for a wider range of statistical interpretation of the data because the data are not bound by pre-determined categories. This module also provides the user an opportunity for post-survey interpretation of the data.

Transects established for this module can also be used for S4.M1, Rapid Assessment Methodology for Channel Structure, S4.M3, Bankfull Profiles and Channel Entrenchment and S4.M5, Measuring Stream Discharge Quantitatively.

2.0 PRE-FIELD ACTIVITIES

A three-person (two surveyors, one recorder) crew can complete the survey in two to three hours. A fourth person will expedite the process as they can establish transects while others take measurements. Since most of the time-consuming measurements occur at the ends of the transects (i.e., bank angle, bank vegetation, undercuts etc.), smaller streams will take longer to complete because more transects are required.

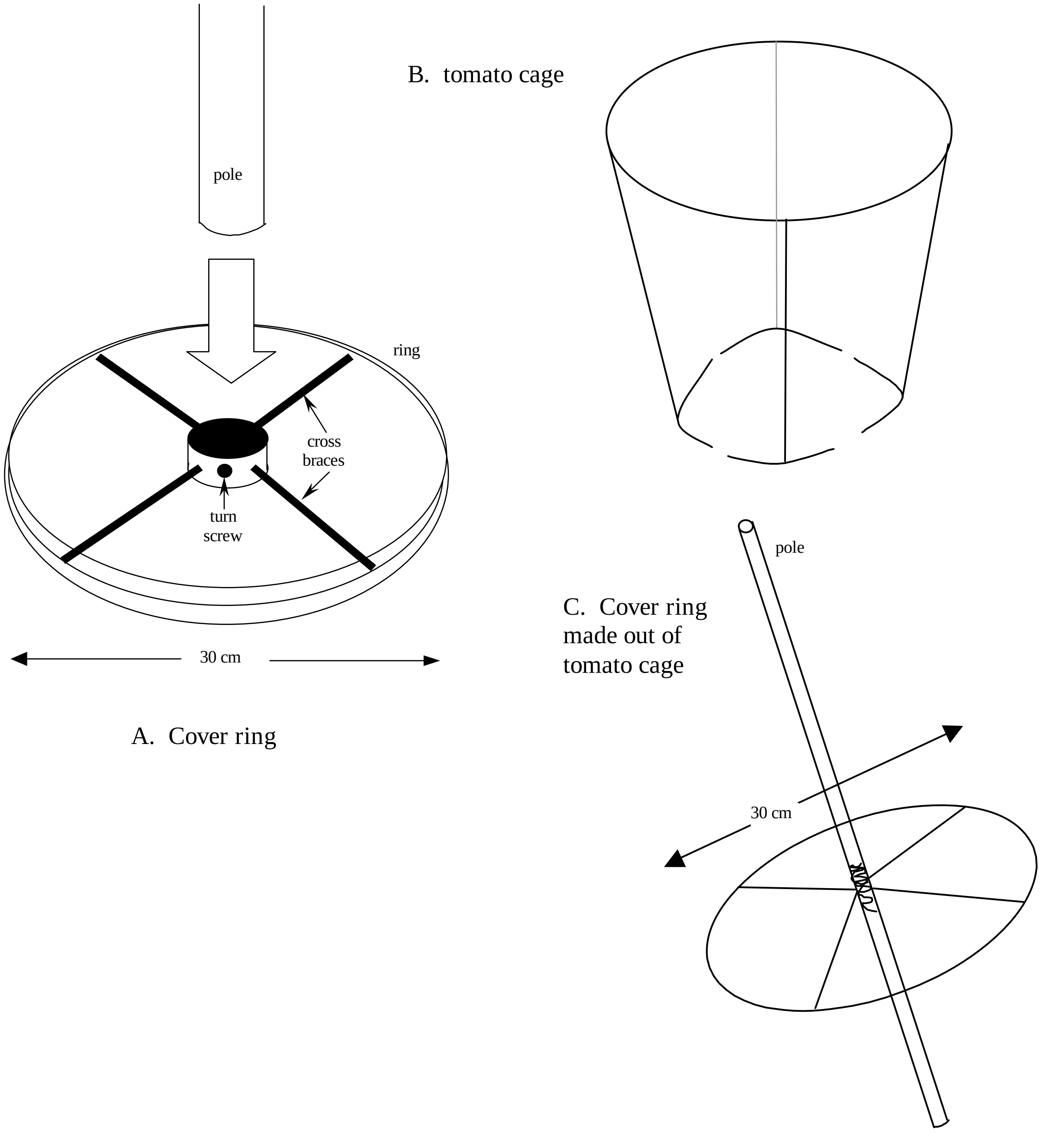
Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this module, the following equipment is required:

1. Channel Morphology Data Form(s) (preferably on waterproof paper)
2. Pencils
3. Metre sticks (two, at least one metre stick must be wooden)
4. Tape measures (two, 30 m or longer)
5. Bank grid (see definition below)
6. Cover ring (30 cm diameter ring mounted on a pole; Figure 1)
7. Flagging tape
8. Spikes or tent pegs (four, 25 cm long) or two bungee cords

9. Ruler (clear, 3 mm thick by 25 mm wide, 25 cm long)
10. Compass
11. Calculator (waterproof, or in re-sealable bag)



A. Cover ring

B. tomato cage

C. Cover ring made out of tomato cage

Figure 1: Cover Ring.
A cover ring can be constructed according to the plan in (A). This requires welding capabilities and results in a ring that moved up and down the pole as required. To construct the cover ring from a suitably sized tomato cage (B), snip the support braces at the junction of the second ring. Fold the braces back and bend them around the support pole (C).

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

Optional equipment includes: bank profile tool (Figure 11), and field calipers. To mark the upstream and downstream boundaries of the site, four metal rods (i.e., Rebar, approximately 1 m in length) can be used.

3.0 FIELD PROCEDURES

This module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available. The survey always begins at the bottom (downstream) end of the site and proceeds sequentially to the top. Each transect begins on the left bank (as determined while looking upstream). The data collection process is detailed below.

3.1 Overview of Sampling Procedures

Step 1: Ensure that site boundaries S1.M1, Defining Site Boundaries and Key Identifiers, Section 3.2, Identifying the Site Boundaries have been established and a sketch of the site can be completed (refer to S1M3 Assessment Procedures for Site Feature Documentation, Section 3.2, Making a Site Sketch).

Step 2: Determine the ‘Minimum Width (m)’ of the stream. This is used in conjunction with the ‘Site Length (m)’ for determining the ‘Number of Transects’ required, their longitudinal spacing (‘Transect Spacing (m)’), and the number of points for each transect (‘Number of Points/Transect (N)’).

Step 3: At the bottom of the site, establish the first transect.

Step 4: At each transect, measure the ‘Active Channel Width’, assess the bank characteristics and vulnerability to erosion, generate a cross-sectional profile of the banks: measure the horizontal depth of undercuts (‘Amount of Undercut’), ‘Bank Angle’, bank (substrate) composition (‘Bank Particle Median Diameters’), vegetative cover (‘# of Vegetated Squares on Bank’), and the ‘Dominant Vegetation Type’.

Step 5: Record the following data at each observation point along each transect: water depth (‘Depth’), ‘Hydraulic Head’, ‘Cover Types Present’, whether or not the cover is embedded (‘Cover Quality’), ‘Aquatic Vegetation Type Present’, substrate particle size immediately below the observation point (‘Particle Sizes’, ‘Point’), and largest substrate particle within the cover ring (‘Particle Sizes’ ‘Maximum in Ring’).

Step 6: At each transect, record the stream bearing (‘Compass Bearing’).

3.2 Site Length, Minimum Width and Number of Transects

Site length is measured by chaining up the centre of the stream. Ensure that the lower and upper boundaries of the site are clearly marked. One person stands at the bottom of the site in the middle of the stream to mark the starting point. A second person proceeds upstream until the stream changes direction (or until the end of the tape is reached). The second person then marks the point, measures the distance, and waits for the first person to reach the mark before proceeding upstream to the next mark location (Figure 2). At the centre of each curve in the stream, the second person should mark the location and call for the first person to move up. Do not simply stretch the rope around the corners, as it will not be measuring up the middle. This process is repeated until the total site length is measured.

Record the site length in metres on the Site Identification and Channel Morphology Data Forms (i.e., 48 m).

The number of transects required and the number of observation points per transect is determined by the minimum width of the site. If the stream is greater than 3 m wide throughout the site, use ten transects and six observation points per transect; otherwise, measure the stream width at the narrowest location and refer to Table 1.

Table 1: Relationship Between the Minimum Stream Width and the Number of Observation Points Required per Transect.

Minimum Stream Width (m)	Number of Transects	Number of Observation Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.5	15	3
< 1.0	20	2

Record the ‘Minimum Width (m)’, ‘Number of Transects’, and the ‘Number of Points/Transect (N)’ on the first sheet of the Channel Morphology Data Form. If the stream width is greater than 3 m, record ‘>3 m’.

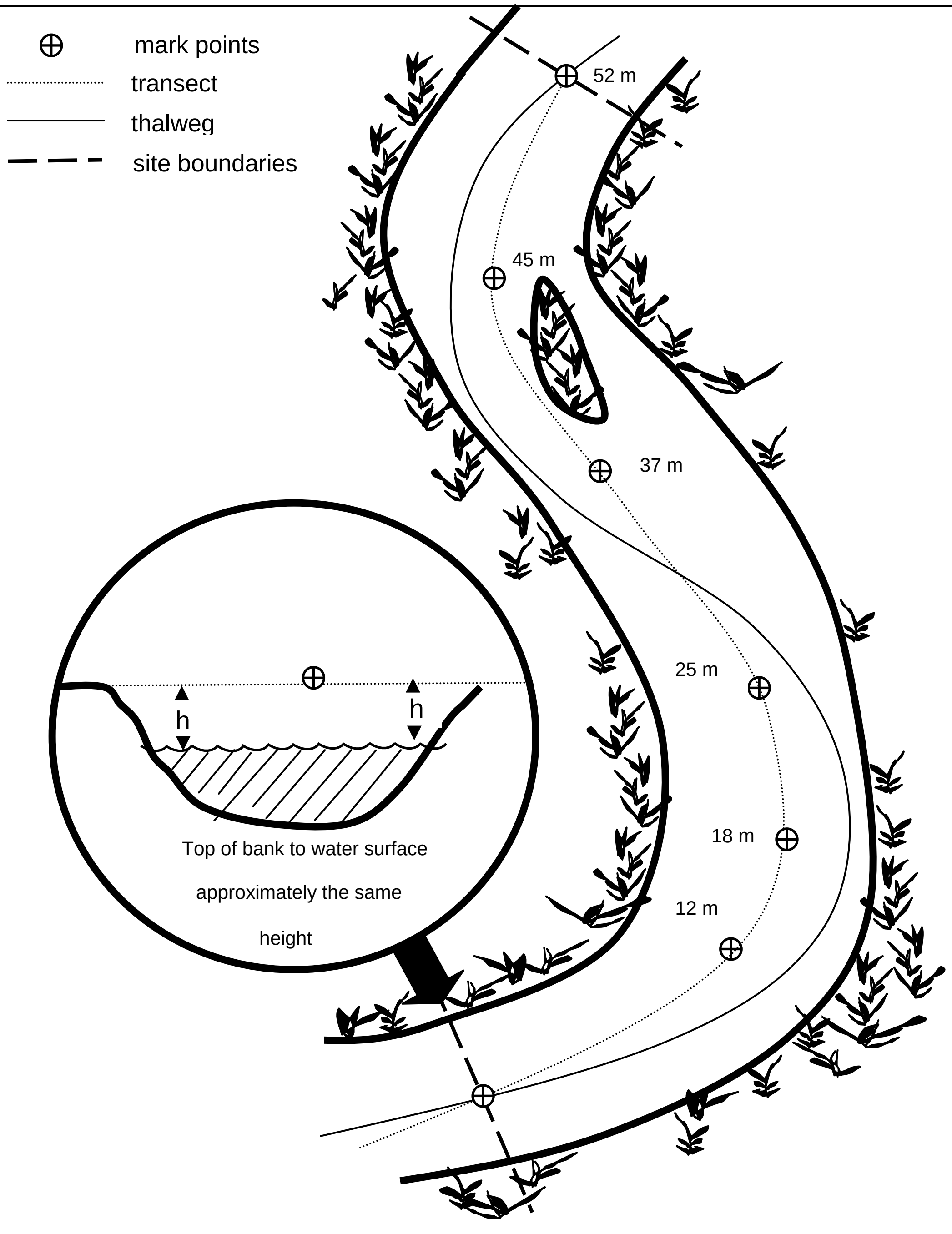


Figure 2: Site Boundaries and Length Determination.
First crossover point occurs at < 40 m, therefore continue to the next crossover.

3.3 Determining the Longitudinal Spacing of Transects

To determine transect spacing within the site, divide the length of the site by the number of transects required minus one (i.e., ‘Transect Spacing’ = ‘Site Length’ / (Number of Transects’ – 1)). For example, if a site is 52 m long and requires 10 transects, the transects would be spaced at 5.8 m (52/(10-1) = 5.8 m). Transects would be situated at the 0, 5.8, 11.6, 17.4, 23.2, 29.0, 34.8, 40.6, 46.4 and 52.2 m marks. The actual transect location can be rounded to the nearest metre. Record the ‘Transect Spacing’ on the Channel Morphology Data Form (Appendix 1). Transect locations should not be shifted.

3.4 Setting Up the Transect and Measuring the Active Channel Width

Transects should be established perpendicular to the general direction of flow (Figure 3). To set up a transect, stake both ends of a tape measure into the banks so that it is reasonably level and taut. Always start on the left side of the river while facing upstream.

***Hint**: To save time when doing bank measurements locate the ends of the tape at least 1.5 m back from the edge of the bank (Figure 4). There are many tools that can be used to secure the tape to the bank including bungee cords, quick release clamps, long spikes, surveyor and gardening stakes. Ensure that the tools are well marked with bright colours.*

Measure and record the active channel width (see definition below) on the Channel Morphology Data Form. Divide the active channel width by the number of observation points (Table 1) to determine panel width. Sampling will be conducted at the mid-point of each panel and these points are referred to as observation points. (see example below and Figure 4). If an observation point falls on an island or point bar within the active channel, treat it as an observation point and record the appropriate information. Mark the location of each observation point on the tape measure using flagging tape before taking any measurements.

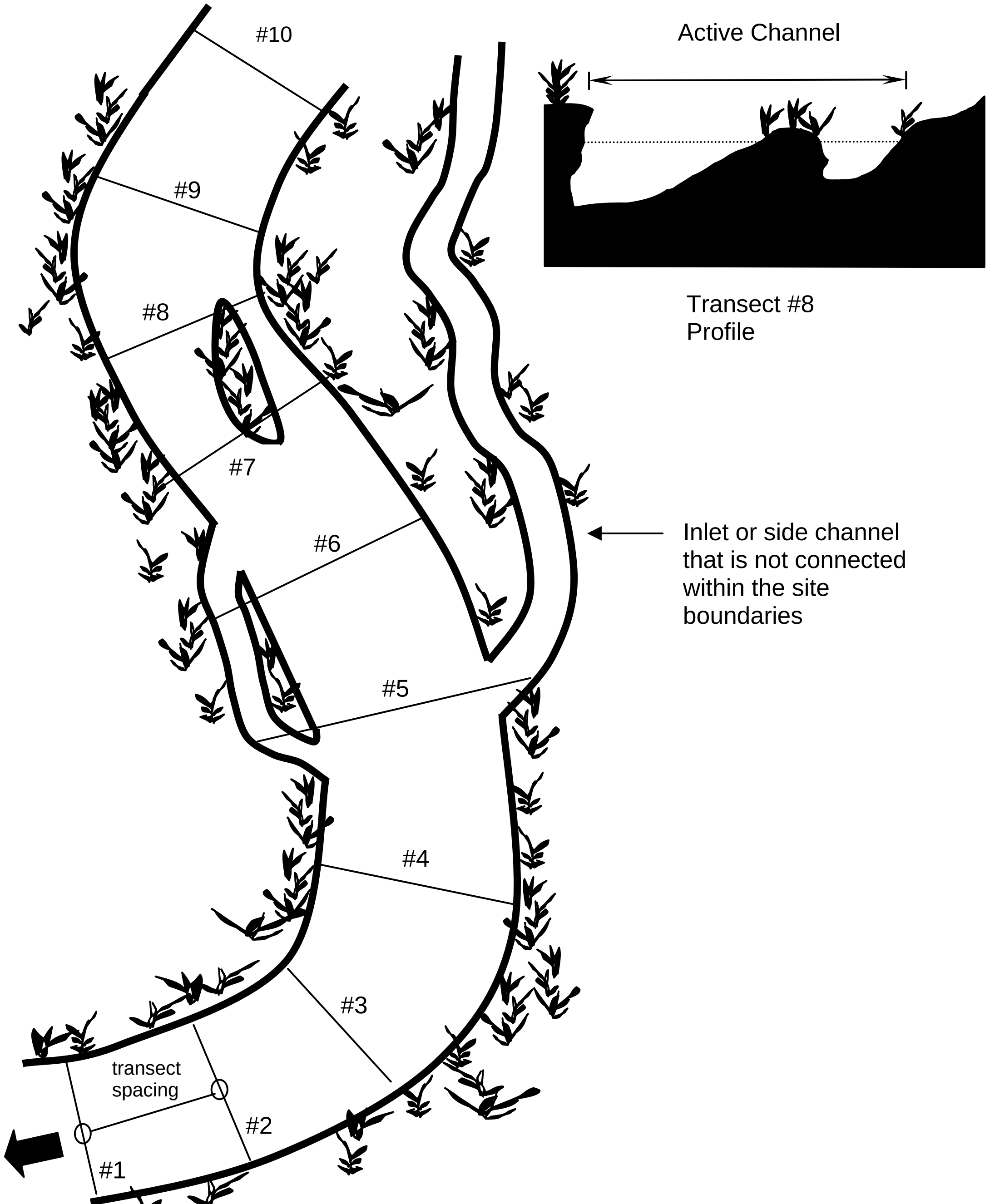


Figure 3: Setting up a Transect Sampling Design.

The thalweg can often be used to assist in determining the appropriate orientation of the transect (angle relative to channel). Transect lines 5 and 6 cross a side channel that is connected within the site and 8 crosses an island. These are considered a part of the active channel. Transect line 5 crosses a side channel that is not connected within the boundaries of the site; and this side channel is therefore not considered to be part of the

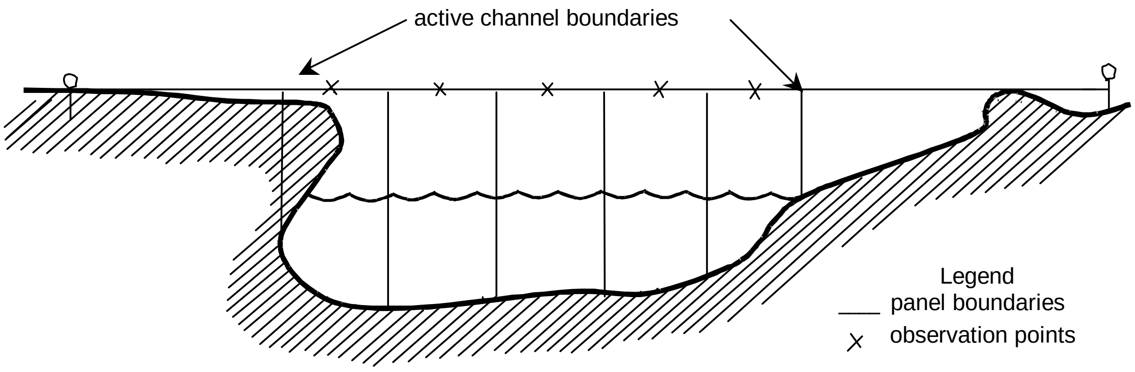


Figure 4: Setting up a Transect Line and Locating the Active Channel.

Active Channel

The active channel is the area between the two outside banks, which includes all connected water at the time of the survey. This includes actively flowing as well as stagnant areas provided there is no land barrier that separates it from the main channel. The transect boundaries are at the bank-water interface (i.e., where the water meets the land; when undercuts are present, see Figures 4 and 5).

Rules for defining the active channel:

1. Side channels or braids are included if both the inlet and outlet occur within the sample site.
2. The mouth of a tributary is included only if it located on a transect
3. Backwater pools (wet areas adjacent to the active channel that are fed by intergravel flow) are included if they are located within the high flow channel, are located below the top of bank, and there is visible flow from the pool into the stream.
4. Mid-channel bars and islands are included in the cross section (Figure 3).

Observation Point Calculation Example

For a stream that has an active channel width of 2.9 m wide, and low variance in velocity, five panels are sampled. The point spacing would be 2.9/5 = 0.58. This number actually represents the boundary of a set of panels that transect the stream, with each observation point located in the centre of each panel. To determine the actual location of the observation points, divide the first panel in half, and for each additional location add 0.58. The first observation point would be at 0.29 m (i.e., 0.58/2 = 0.29). The second point would be at 0.29 + 0.58 = 0.87 m. The complete list of observation points is 0.29, 0.87, 1.45, 2.03 and 2.61 m.

Note: Observation point locations are dependent on whether the tape extends beyond the bank water interface. For example if the left bank water interface occurs at 1.5 m on the tape then the first observation point for the above example would be at the 1.79 m mark on the tape.

Hint: *To help identify the location of the observation points along each transect, tie strands of flagging tape on the tape measure so that they can be easily slid into position to mark each observation point.*

Hint: *Always double-check the spacing of the flagging tape before starting to record the data.*

3.5 Describing the Banks

Measurements of bank undercuts, angle, composition and bank vegetation are made along a 1.5 m extension of the transect line[2] described in Section 3.4, Setting Up the Transect and Measuring Stream Width (see also Figures 5 and 6). Note that all depth or height measurements are to be made in millimeters.

3.5.1 Undercuts

Undercut banks are measured if they occur on the transect line as described in Section 3.3. Note that undercut banks may be out of the water. Only record undercuts if they are greater than 50 mm. Measure and record the maximum depth of the undercut as follows (Figures 5 and 6):

1. Place a straight edge vertically against the outermost protruding edge of the bank.
2. Place a ruler into the deepest part of the undercut perpendicular to the straight edge.
3. Record the depth of the undercut in the box marked ‘Amount of Undercut’, to the nearest 10 mm. If the depth of the undercut exceeds 1000 mm, record as ‘1001’, signifying that the depth is greater than 1000 mm.

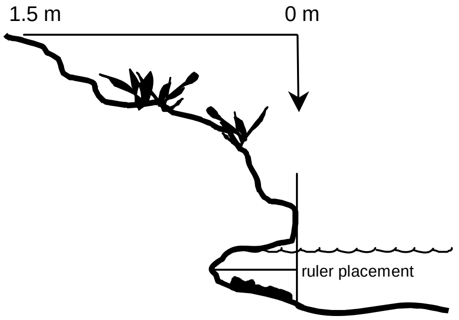


Figure 5: Measuring Depth of Undercuts in the Stream.
The ruler should be moved around until the deepest part of the undercut is located.

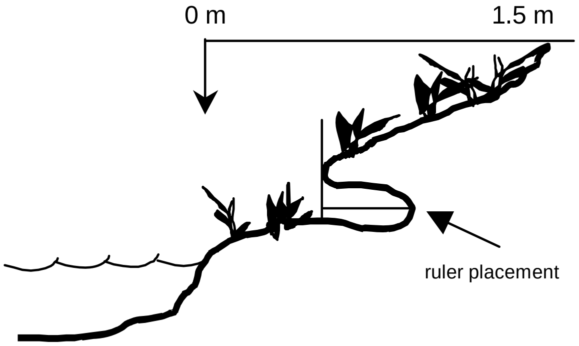


Figure 6: Measuring Depth of Undercuts that are Out of the Water.

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[2] Note, the height of the transect extensions may differ from the original transect line. The 1.5 m extensions do not have to be at the same height on both banks.

3.5.2 Bank Angle

Bank angle is a measure of the slope of the bank which can be used in determining stream bank stability. Four height measurements taken at predetermined horizontal distances from the bank edge are used to determine bank angle.

General principles to be followed are outlined below.

Bank angle is measured from a short profile of the left and right banks of the stream. The profile is obtained by setting a level horizontal line (tape) above the bank extending a minimum of 1.5 m inland from the furthest protrusion of the bank into the stream (Figures 7 - 10) and measuring the distance of the tape to the bank surface. Each bank measurement is independent and the height of the tape does not have to be the same on both sides of the stream.

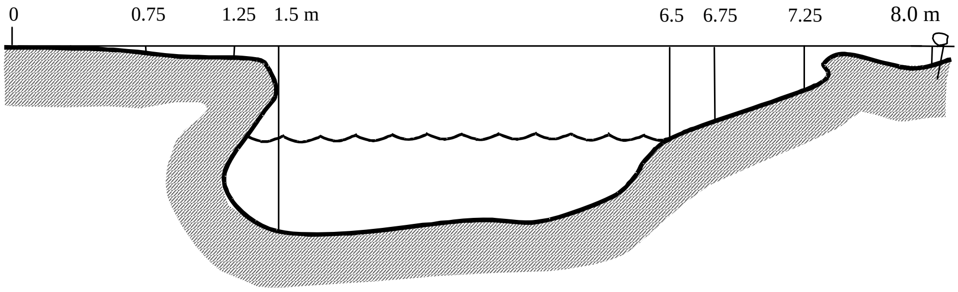

Figure 7: Incorporating Point Measurements Along the Transect.
The tape is anchored at 1500 mm from the furthest protrusion of the bank on both sides of the stream.

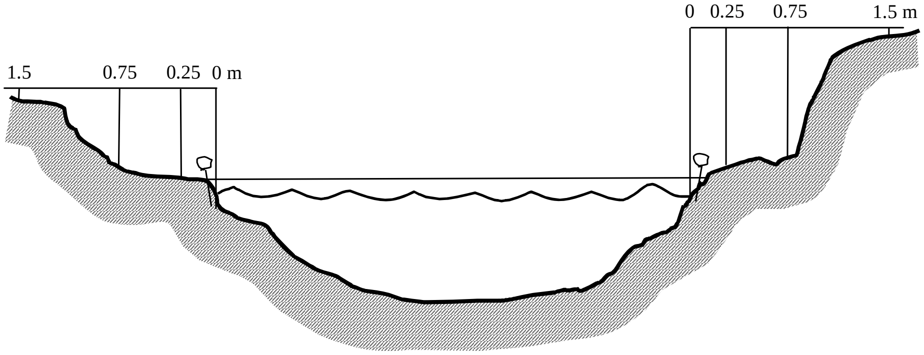

Figure 8: Setting up Independent Bank Transects.
The tapes are at different heights on both banks and are anchored at 1500 mm from the furthest protrusion of the bank on both sides of the stream.

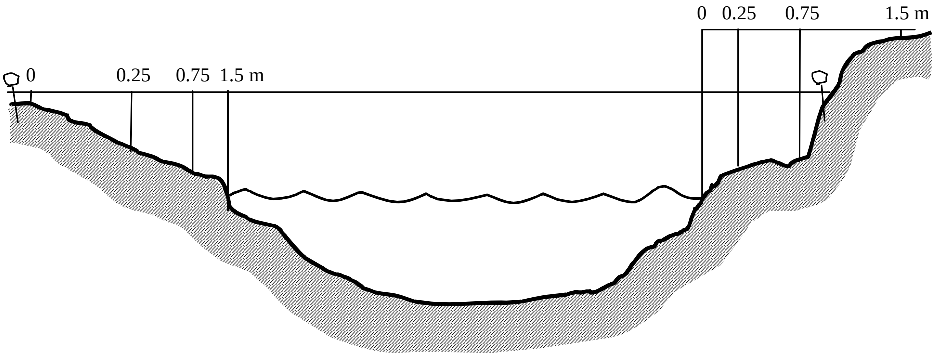

Figure 9: Setting up Separate Transects Incorporating Point Measurements on Both Banks.

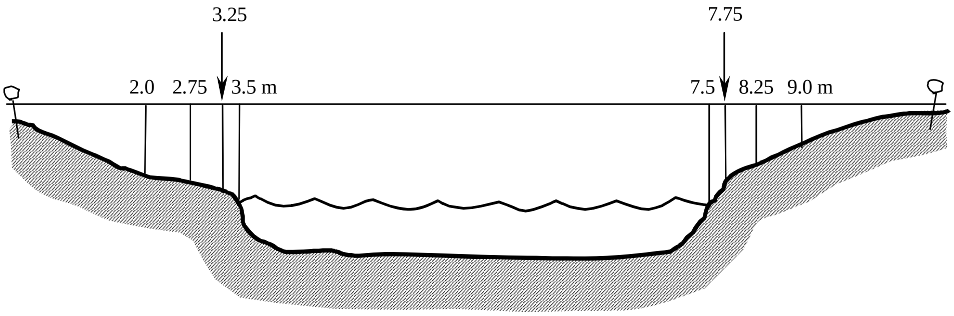

Figure 10: Incorporating Point Measurements Along a Transect That Extends Beyond the Width of the Channel Where Measurements Will be Made.

In this situation the tape extends beyond 1500 mm from the furthest protrusion of the bank on both sides of the stream.

Four vertical measurements are taken from the horizontal tape down to the bank. These vertical measurements are taken at the 0.0 and at 0.25, 0.75 and 1.5 m from the furthest protrusion of the bank into the stream. If any of the vertical heights are greater than 2 m within the transect, the bank is steep and the appropriate box should be marked with an 'X' (i.e. '>2m' for Left or Right Bank) under 'Bank to Tape Height'. No additional vertical height measurements are required if this condition exists.

Different techniques may be used to take measurements that will be used to calculate bank angle (e.g. transect line (Figures 7 - 10) or bank profile tool (Figure 11)). The application of any of these methods will be dictated by existing bank conditions.

Staff from the Toronto and Region Conservation Authority designed a tool to assist them with measuring the bank profiles. The tool consists of two pieces of wood (one with a slot cut through the middle), connected by a wing nut so that it can swivel and move vertically. Ruler markings can be put on the vertical piece to help with the first height measurement and the locations (0.25, .75 and 1.5 m) of the observations points should be marked on the horizontal piece. A small level(s) can be placed on the wood to ensure the tool is at 90°. An adaptation of this device is to hang three tailors tape measures at the appropriate locations on the horizontal bar that can easily be read off as to the height from the ground to the bar.

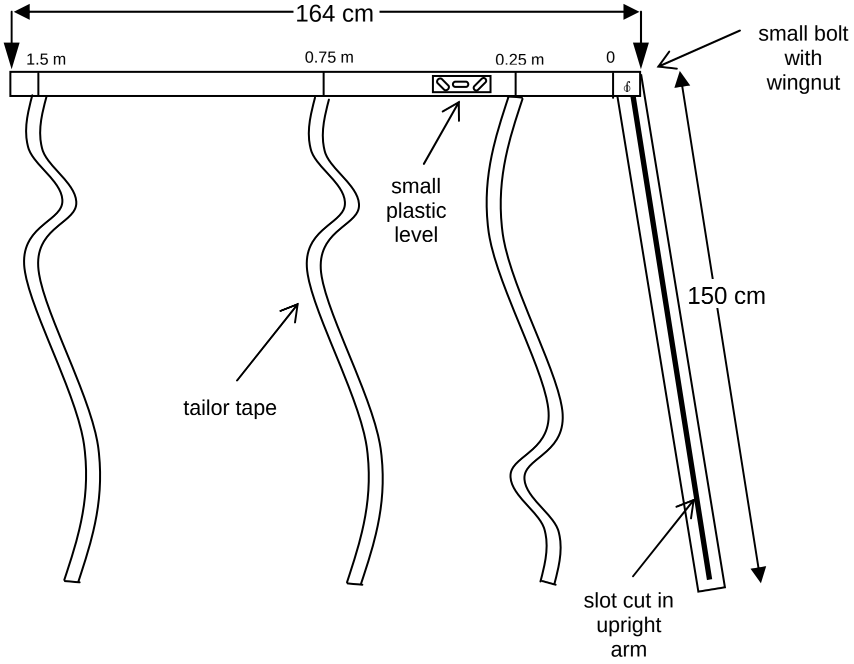

Figure 11: Schematic and Photo of Bank Profile Tool.

Where undercuts are present, the measurements begin at the furthest protruding edge of the bank (i.e., the height measurement at 0.0 m would be from the tape to the stream bottom (Figure 7).

Record each of these measurements to the nearest 5 mm on the ‘Bank Angle’ section of the Channel Morphology Data Form (Appendix I).

Hint: *A vertical measurement greater than 1000 mm may be taken by joining two metre sticks end to end.*

***Hint**: If the transect intersects a tree, move the transect to the nearest side. If a log or brush pile interferes with the vertical measurements, adjust the placement of the metre stick or bank profile tool.*

3.5.3 Bank Composition

This section describes how to determine the soil composition of the banks. The type of substrate that makes up a bank influences its stability; silt and sand are more vulnerable to erosion.

At the four points where the bank angle was measured (i.e., 0.0, 0.25, 0.75 and 1.5 m from the active channel boundary), determine the substrate immediately below each point. While looking away, randomly select a particle and measure the median axis. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Channel Morphology Data Form for the left and right bank; otherwise record standard sizes found in Table 2. Remove undecomposed organic material (e.g. leaves, sticks), before making substrate measurements. Decomposed organic material should be classified as silt.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 12). Rocks will often lie with the median axis at right angles to the flow.

Table 2: Substrate Descriptions and Size Categories.

Material	Description	Size to be Recorded
‘Unconsolidated Clay’	Very hard packed when dry and sticky when wet	‘0.01’
‘Consolidated Clay’	Hard even when wet, slippery, gray in colour, often laminated	‘0.011’
‘Silt’	Feels soft like a powder or flour	‘0.05’
‘Sand’	Gritty, sizes >0.05 and < 2 mm	‘0.10’
‘Bedrock’	Exposed bedrock	‘1111’
Measured particles	Between 2 mm and 1000 mm.	Median axis
‘Large Boulders’	> 1000 mm but not attached to bedrock	‘1001’

Note that large material (i.e., greater than 1000 mm wide) such as concrete slabs, etc., are classified as ‘Large Boulders’. To ensure accuracy of data entry, place a ‘0’ in front of all decimal points (i.e., ‘0.01’). **Be sure to measure all particles that are close to 2 mm in diameter to avoid misclassifying small particles.**

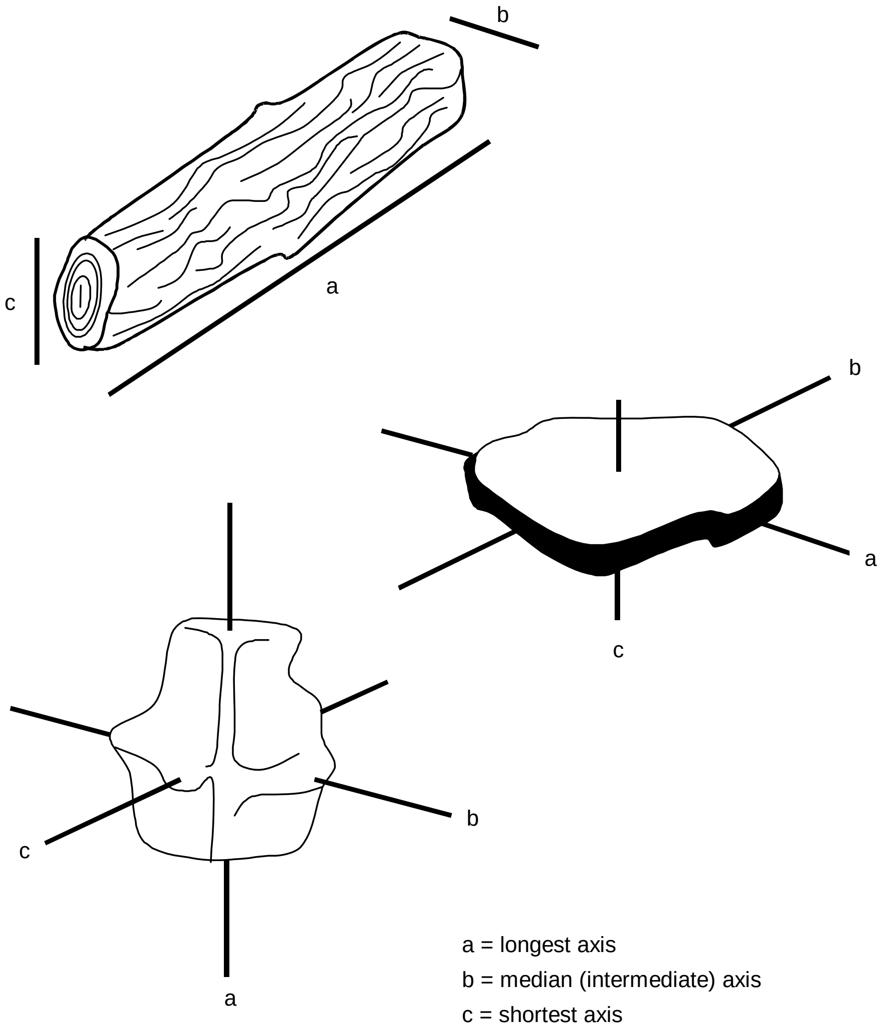

Figure 12: Measuring along the Median Axis of Objects.

3.5.4 Bank Vegetation Cover and Type

This section describes how to identify the dominant vegetation type and measure the amount of rooted vegetation on each bank.

3.5.4.1 Dominant Vegetation Type

The ‘Dominant Vegetation Type’ is assessed within a rectangular plot (2 m x 1 m) which extends 1 m upstream and 1 m downstream of the transect line and 1 m back from the furthest protruding edge of the bank (Figure 13). The dominant vegetation type within the plot is determined using a hierarchical system that is based on the largest vegetation type found: Forest > Scrubland > Meadow > Pasture >Cropland > Lawn > None (the vegetation types are defined in Table 3 below). For example, if a plot includes a tree and a patch of long grass, it would be classified 'Forest'. If the tree were outside the plot, it would be classified as 'Meadow'.

***Hint:** On the Channel Morphology Data Form, put an 'X' in only **one** box under 'Dominant Vegetation Type'.*

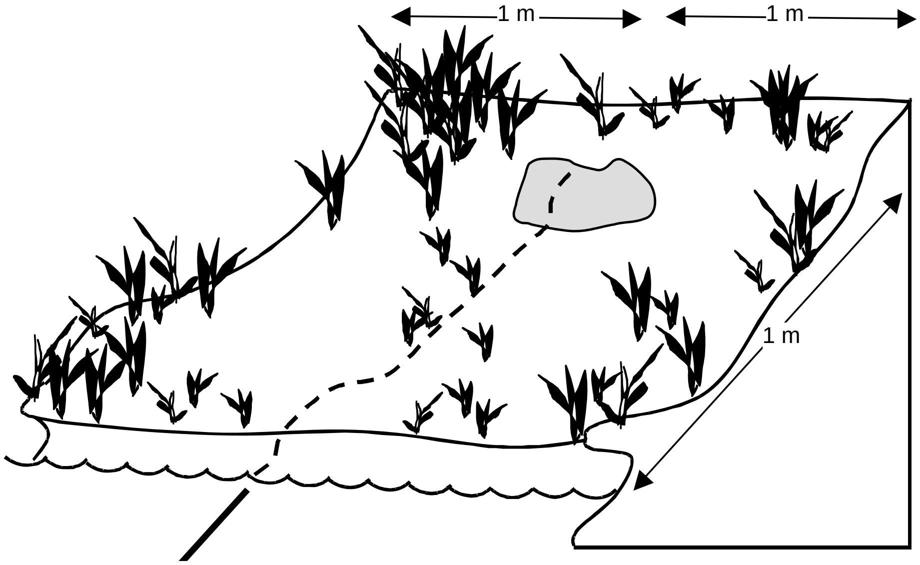

Figure 13: Sketch of the Plot used to Evaluate Dominant Vegetation on the Bank.

Table 3: Bank Vegetation Types.

Vegetative Community	Description
'None'	Over 75% of the soil has no vegetation.
'Lawn'	Grasses that are not allowed to reach a mature state due to mowing.
'Cropped Land'	Planted in agricultural crops in most years; plants typically arranged in rows (due to machine-planting); may be subject to periodic tillage.
'Pasture'	Grasses and sedges that are not allowed to reach a mature state due to grazing by livestock.
'Meadow'	Unmanicured grasses and sedges, no woody vegetation in the plot
'Scrubland'	Small trees or shrubs interspersed with grasses and sedges (a transitional area between meadow and forest, no trees > 10 cm in diameter at breast height).
'Forest'	At least one large living tree > 10 cm dbh, or 5 m in height within the plot

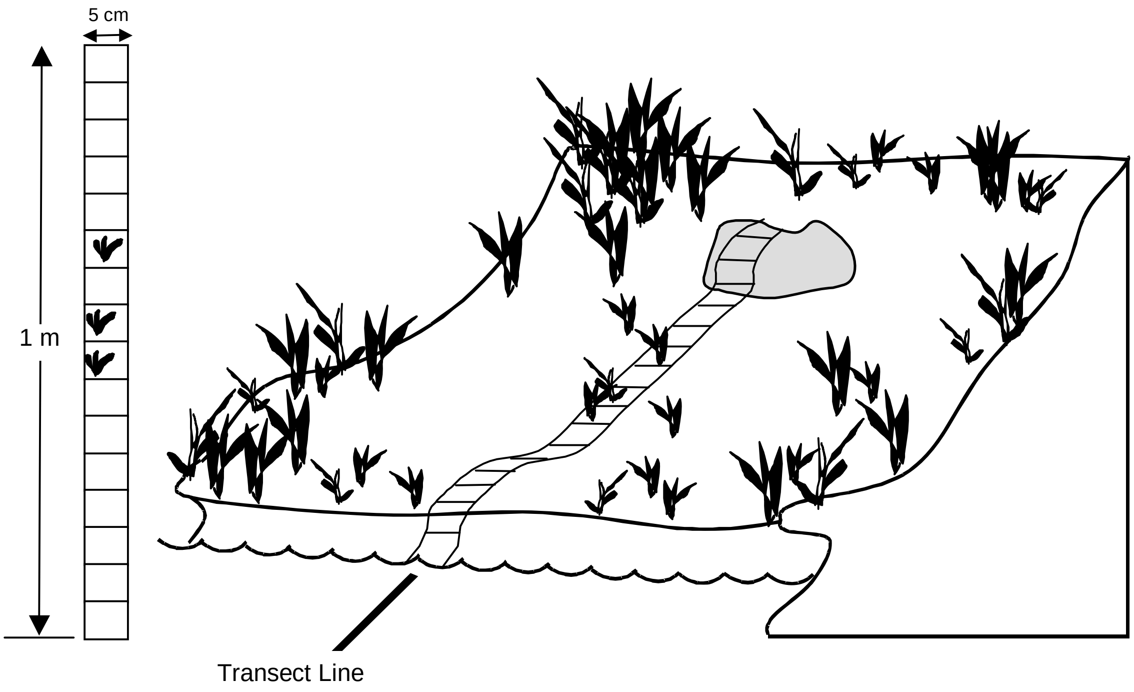

Figure 14: Sketch of the Bank Grid Placement.

3.5.4.2 Rooted Vegetation Measurement

The bank grid is used to quickly estimate the extent of rooted vegetation that acts to stabilize substrate on each bank. Starting at the bank-water interface, lay the bank grid up the bank along the transect line (Figures 14 and 15).

Bank Grid

A bank grid is used to record the amount of living bank vegetation and provides quantitative and repeatable measurements. A bank grid measures 100 cm long by 5 cm wide, and is comprised of 16 (6.25 cm) blocks. Flexible plastic mesh such as C-Flex (manufactured by TENAX) has been used successfully by the Great Lakes Salmonid Unit, but any strong mesh that is of the appropriate size would work. Lengths of C-Flex may be available from L. Allin or L. Stanfield of the OMNR.

Count the number of grid cells that have any **live** rooted vegetation growing within the cell. One blade of grass rooted in the soil constitutes live vegetation in a grid cell, but grass hanging or lying over a cell are not included. **Live roots and moss are also considered live vegetation.**

Figure 15: Measuring Vegetated Squares with a Bank Grid.

Algae and lichens are not considered in this measurement. To qualify as having no live vegetation, all of the soil or substrate in the grid cell must be barren, covered with dead material, or covered with lichens.

Hint: *Where dead materials cover the soil or vegetation is matted down, pull back the material to see whether the soil is exposed or whether live material is growing underneath.*

Record the number of grid cells with live vegetation in the box marked '# of Vegetated Squares on Bank', on the Channel Morphology Data Form.

3.6 Point Measurements Along the Transect

The following six measurements should be made in the stream, at each of the previously identified observation points (i.e., Section 3.4 Setting Up the Transect and Measuring Stream Width) along the transect (Figure 4; specific details in each section below):

- Water depth (or negative height, for islands and other protruding features)
- Hydraulic head

- Cover (amount and type)
- Aquatic Vegetation
- Point Particle Size
- Maximum Particle Size

Obtain a depth and hydraulic head estimate from every point. For observation points that fall on islands, large exposed rocks, etc., measure the negative height, vegetation cover and particle sizes.

3.6.1 Water Depth

At each observation point: stand a wooden metre stick on the pavement boundary (see definition below) with the thin edge facing into the current (Figure 16). If the ruler lands on a boulder or other object above the pavement boundary which is less than 30 cm in diameter (i.e., smaller than the diameter of the cover ring) move the ruler to the nearest edge of the object and measure the water depth at the pavement layer. If the object is larger than 30 cm in diameter, measure the water depth at the observation point. Ensure that the ruler is straight and that it does not dig into the substrate. Always measure the height of water from the mid-point of the ruler (in higher velocity areas, the water will differ in height between the upstream and downstream edges of the ruler).

Pavement Boundary

The pavement boundary represents the bottom of the active flowing channel and is identified as the point where substrate particles form a fairly uniform layer across the bottom (Figures 16 and 17). This may be difficult to determine in areas dominated by coarse material. In these instances, put the ruler between the coarse material to the lowest layer of material that is visible.

Record the water depth in mm in the column marked ’Depth’ on the Channel Morphology Data. This measure should be recorded to the nearest 5 mm. If the water is deeper than 1000 mm, record ‘1001’ mm. If for safety reasons water depth cannot be measured or estimated, record ‘-999’ in the ’Depth’ field.

3.6.1.1 Islands and Large Rocks

Mid-channel islands, bars, and large exposed rocks (i.e., any solid object with a median diameter greater than 30 cm) are measured as negative height. These characteristics contribute to the complexity and roughness of the channel and are used for three-dimensional habitat modeling.

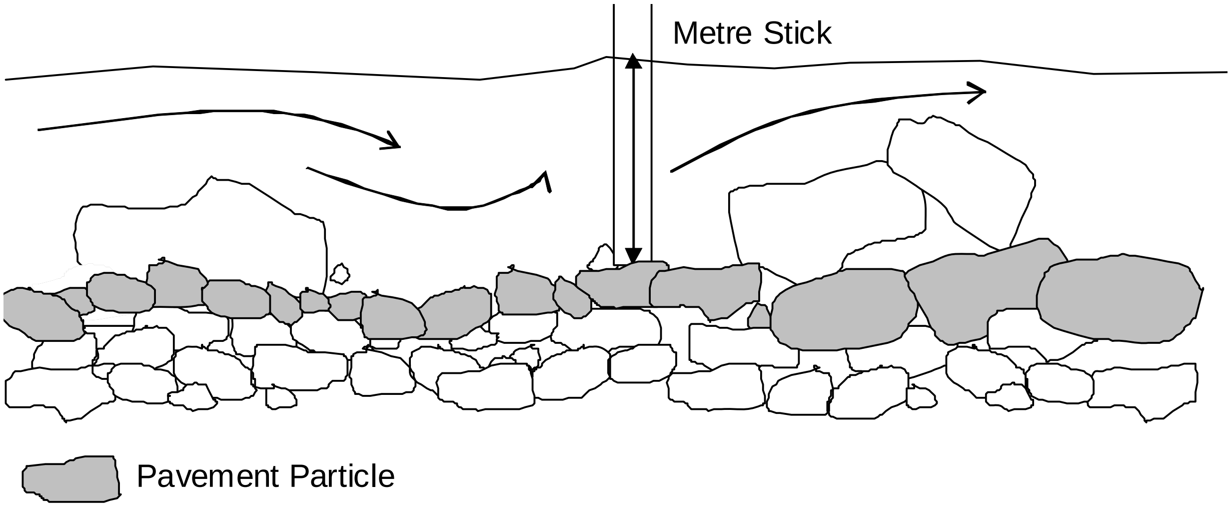

Figure 16: Measuring Water Depth to Pavement Layer.

Figure 17: Photograph of Pavement Distinction.

There are two methods to measure the negative height, one for small features and another for braided channels and large islands.

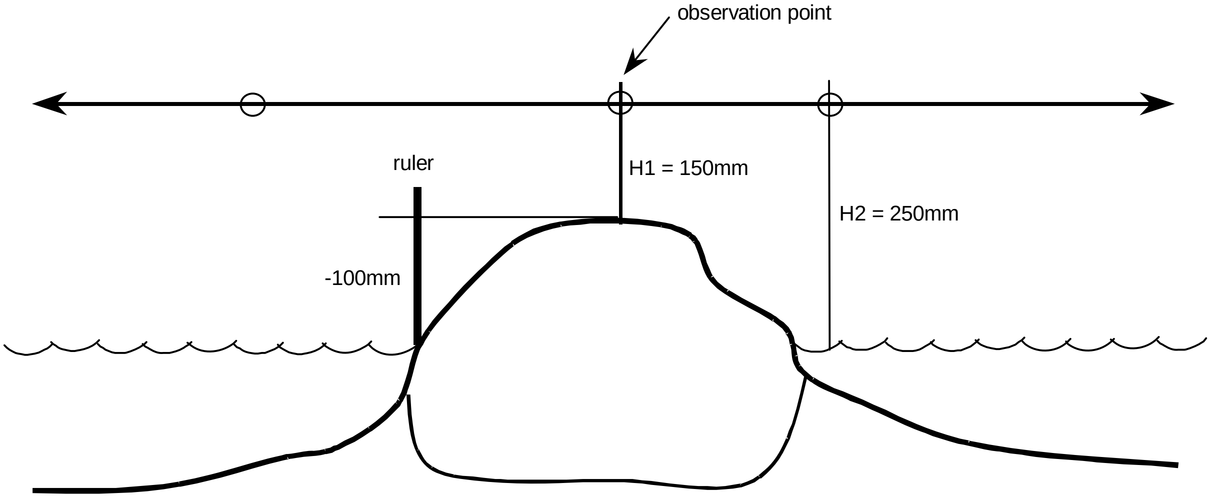

Figure 18: Measuring Negative Height of an Island.
Negative height of island = height from water to ruler laid parallel to water surface (-100 mm), **or** difference in height between H1 and H2 (150 – 250 = -100 mm).

Small features: lay a level ruler across the feature at the observation point and use a second ruler to measure its height above the water level (Figure 18).

Braided channels and large islands: stretch a tape measure across the feature (level the tape by setting it at right angles to the flow and setting it at a uniform height) and measure the height from the water to the tape (H2) and from the island to the tape (H1). The difference between the two heights is the negative depth (or height) at this observation point. Record the height as a **negative** number in the column marked 'Depth'.

3.6.1.2 Undercuts, Log Jams and Other Obstructions

When an observation point falls on an undercut or some other obstruction, record the depth of water under the obstruction (Figure 19). Adapt available tools as necessary (e.g., flexible metal rulers, poles) to measure the depth.

3.6.2 Hydraulic Head

Hydraulic head is measured at each observation point as a surrogate for velocity (adapted from Henderson 1970). If more accurate velocity information is required (e.g., flow monitoring or discharge calculation), a velocity meter can be used to complement the hydraulic head data. These procedures are described in S4.M5, Measuring Stream Discharge Quantitatively.

At the observation point, turn the wooden ruler so that it is vertical and the **wide side with the markings is on the downstream side** (Figure 20). The ruler will create a barrier to flow

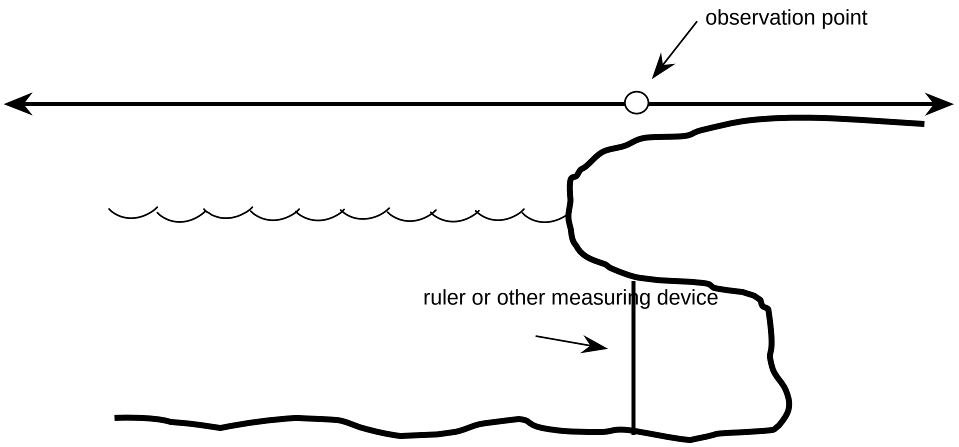

Figure 19: Measuring Water Depth in Undercuts or Log Jams.

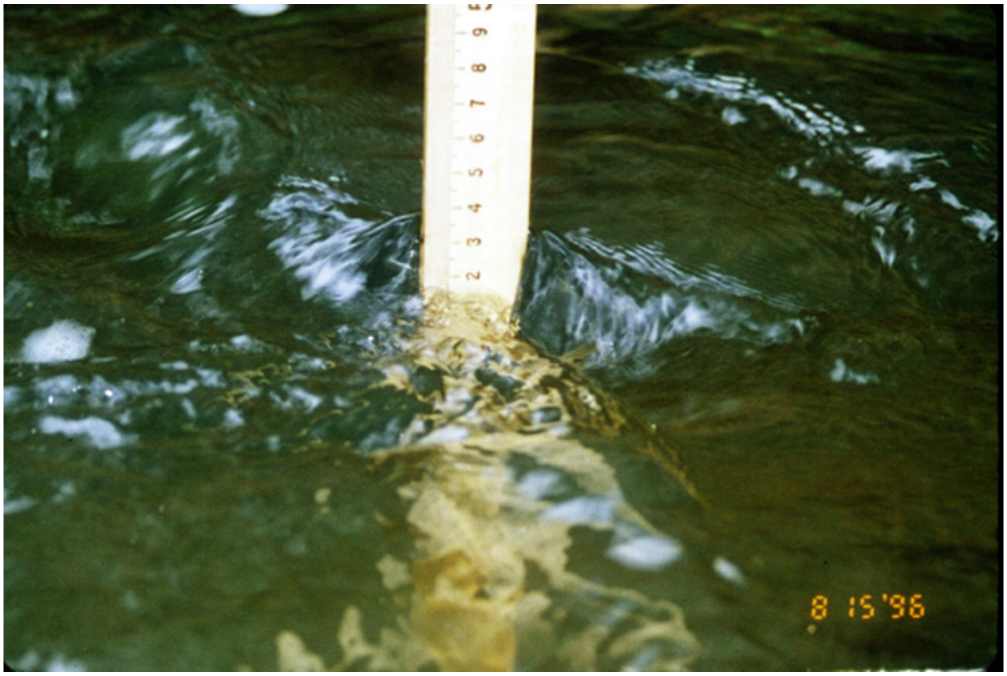

Figure 20: A Point Measurement of Hydraulic Head.

The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which should be recorded as 20 mm (rounded to nearest 5 mm).

measure the height difference between the front and back of the ruler (Figure 20). Measure the maximum height difference observed over a 3-5 second period. Record the hydraulic head to the nearest 5 mm in the box marked ’Hydraulic Head’ on the Channel Morphology Data Form.

It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the differences out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down). Where the water depth is greater than 1 m, brace the ruler on your toe or knee and record the hydraulic head.

3.6.3 Cover for Fish

Cover is traditionally the most difficult attribute of stream habitat to measure repeatably. Cover presence is determined and classified by its quality and type. This technique uses a 30 cm ring attached to a rod by cross bars (Figures 1, 21) to produce repeatable measurements (Stanfield and Jones 1998).

Instream Cover

A cover particle is any object that touches the water within the sample area, is **at least 100 mm wide** along the median axis and of sufficient density to block >75 % of sunlight from reaching the stream bottom. A cover particle can consist of a mat of materials such as twigs, macrophytes, or the bank. The mat must still meet the median diameter size and light penetration restrictions.

Place the centre of the pole on the observation point. Look for any cover which is in the water and in the ring (i.e., within or in contact with the ring). If observation points fall on mid-channel islands, bars or large exposed rocks, cover should still be determined as these areas may be used by fish under conditions of higher flow.

The cover quality is determined with respect to embeddedness. Unembedded cover provides overhead and velocity protection for small fish and has at least a 4 cm overhang. Embedded cover provides only a velocity refuge and has less than a 4 cm overhang (e.g., the interstitial spaces around the cover object are filled with material). This can either be determined visually or by feeling around the object to determine whether there is at least 4 cm of overhang. When an observation is recorded as having only embedded material, this means that this area is not suitable habitat for burrowing fish.

Record the data for each observation point in the ’Cover Quality’ box as follows:

0 = no cover is present
1 = only embedded cover is present
2 = at least some unembedded cover is present

There should only be one number for each observation point.

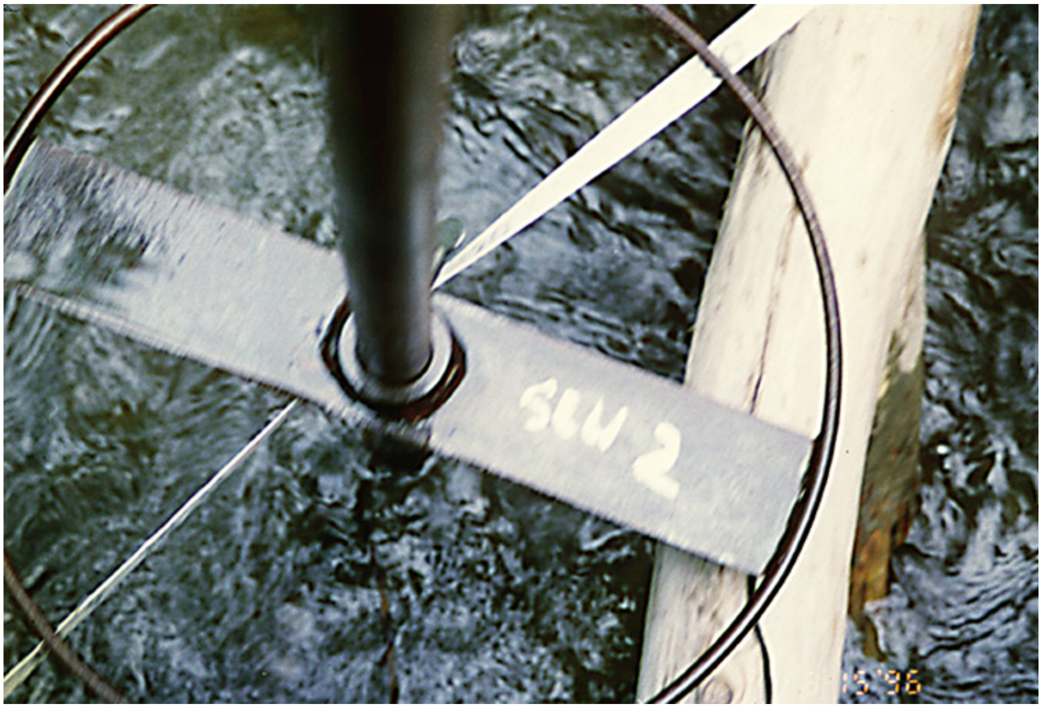

Figure 21: Cover Ring (30 cm in diameter), Showing the 'Observation Area'.

Hint: *Determine whether mats are sufficiently dense by placing a hand under the mat and estimating whether greater than 75% of light is blocked. The cover material must be in contact with the water within the observation area. Finally, for any materials and particularly for wood, measure the median axis on the branch that is* ***within the observation area****. In other words, if the observation area contains a 1 cm wide branch of a large tree, this would not be considered as cover. Conversely, if the observation area contains a 12 cm wide branch of a large tree, this would be considered cover.*

Once the cover quality has been determined, list all the cover types corresponding to the cover quality (cover types are defined in Table 4). For example, if there is an unembedded flat rock and an embedded log, only record the unembedded flat rock. If a point has an unembedded flat rock and an unembedded log, both are recorded. Similarly, if an embedded log and an embedded flat rock are present, record both types. See the Channel Morphology Data Form for these examples.

Table 4: Definitions for Cover Types.

Cover Type	Description
‘Flat Rock’	The longitudinal axis is at least twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis > 2.
‘Round Rock’	The longitudinal axis is less than twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis < 2.
‘Wood’	Living or dead woody materials (includes mats of twigs, shrubs).
‘Macrophytes’	Any living aquatic and terrestrial non-woody plants.
‘Bank’	Bank material which contain soils (fine materials) i.e., undercuts and slumped banks or parts of banks which have become dislodged and are now lying in the main channel.
‘Other’	Any other type of material not covered by the above categories. Typically, this includes tires, refrigerators, cars, etc.

***Hint:** On the Channel Morphology Data Form, ensure that dashes are placed in cover categories that are not present; i.e., empty boxes indicate that an attribute was not assessed, not that that it was not present.*

3.6.4 Aquatic Vegetation

At each observation point, record the presence of any of the following vegetation types which are rooted within the 30 cm ring or attached to substrate or wood within the 30 cm ring: ‘Filamentous Algae’, ‘Non-Filamentous Algae’, ‘Moss’, ‘Macrophytes’, ‘Watercress’, ‘Grass’, and ‘Terrestrial Plants’ (Table 5).

***Hint:** On the Channel Morphology Data Form, ensure that dashes are placed in vegetation categories that are not present; i.e., empty boxes indicate that an attribute was not assessed, not that that it was not present.*

Often, vegetation and particularly moss that is attached to the sides of boulders, cannot be seen. Therefore, pick up and closely examine the substrate for vegetation. Slime and algae must be differentiated by rubbing the objects (see Table 5). A thin layer of slime is not considered vegetation, unless green algae are found when the rock is rubbed.

Note: Crews have had difficulty distinguishing between fine silt, slime and brown algae, therefore recording brown algae and slime is not required.

If any of the macrophytes can be identified, record their common names in the comments box of the Channel Morphology Data Form.

Table 5: Definitions for Aquatic Vegetation Types

Vegetation Type	Description
'Filamentous Algae'	Filamentous green algae, have hair-like filaments, are slimy to the touch, and are often attached to rocks.
'Non-Filamentous Algae'	Non-filamentous green algae are slimy to the touch with no hair-like filaments.
'Moss'	Small plants (2-20 cm) found in a matted colony on coarse substrate and wood. They are distinguished from plants by the absence of a distinctive stem or true leaves. The plant feels rougher than most vascular plants or algae and the rhizoids anchoring the plant are finer than typical plant roots.
'Macrophytes'	Many different species, all are rooted in the stream bottom and have obvious stems or leaves or filaments (examples: *Veronica* spp., pondweed, tape grass, arrowhead, bulrush and cattail).
'Watercress'	Dark green, non-woody stems with flat, broad, opposite compound leaves with 3 to 9 leaflets per stem. Often found in large clusters along margins of stream. They are indicators of groundwater inputs and are also nitrate fixers.
'Grass'	Terrestrial grasses (as opposed to tape grass or eelgrass) which are growing in the stream. Terrestrial grasses tend to be found at the margins of the stream.
'Terrestrial Plants'	Firm stemmed plants that occasionally grow on the margins of streams, such as jewelweed, stinging nettles, poison ivy, willow, dogwood, etc.

3.6.5 Substrate Particle Size Distribution

In this section, point particle and maximum particle size are measured at each observation point. If observation points fall on mid-channel islands, bars or large exposed rocks particle size distribution should still be determined as these areas may be used by fish under conditions of higher flow.

These measures are used to characterize the stream for its suitability for various species and to provide information on geomorphic characteristics (i.e., sediment transport and sorting).

3.6.5.1 Point Particle Size

Select and remove the particle immediately below the observation point and measure its width along its median axis (Figure 12); for very large particles measurements may be taken in the stream. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Channel Morphology Data Form; otherwise record standard sizes found in Table 2. Remove undecomposed organic material (e.g. leaves, sticks), before making substrate measurements. Decomposed organic material should be classified as silt.

3.6.5.2 Maximum Particle Size

After centering the 30 cm ring on the observation point, select the largest particle within or touching the ring and measure its width along the median axis. If the median width is less than 2 mm, estimate its size using the criteria provided in Table 2. Record the particle size in the box entitled ‘Maximum in Ring’ on the Channel Morphology Data Form.

Hint: *If there is a mixture of smaller particles within the 30 cm ring, such as silt/sand or clay/silt, catalogue point particle size as the smaller particle size (e.g., silt (0.05)), and the maximum particle size as the largest particle size (e.g., sand (0.10)). This is to avoid biasing the sample.*

3.7 Recording Stream Bearing

Compass bearings are used to produce scaled maps of the stream channel.

Facing upstream, lay the compass anywhere on the transect tape, lining up the bottom edge of the compass with the tape (i.e., so that the bearing is perpendicular to the transect). Turn the dial on the compass until the north arrow is lined up with the north needle. Then, read and record the compass bearing to the nearest degree on the Channel Morphology Data Form. Using this method, 0° is magnetic north.

3.8 Measuring to the Next Transect

After completion of the measurements for the transect, check over the results to ensure they are complete and legible. Measure the distance to the next transect along the mid-point of the stream, before removing the tape measure. Set up the next transect (Figure 3).

Hint: *Use two tape measures, leaving the first transect in place while the second one is set up. This way, the recorder gets additional time to check for problems with data collected on the previous transect. If problems arise, it is much easier to redo the measurements if the tape is still up, rather than having to set up the transect again.*

3.9 Tips for Applying this Module

Remember that left and right banks are identified while looking upstream.

Learn to identify stinging nettles and poison ivy. Wear elbow-length rubber gloves for doing the vegetation grid count where these species are common.

On every data form, record the standard site identification data and the sample number. On the first sheet, also record the ‘Site Length’, ‘Minimum Width’, and the calculated ‘Transect Spacing’.

Remember that a sample consists of one full set of data for each module, regardless of how many days it takes to do it.

Make sure that all fields have data recorded before taking down the tape measure.

Record ‘-99’ (‘-999’ for depth) to indicate that a measurement could not be performed.

Finally, record any irregularities in the way the data were collected in the ‘Comments’ field.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Henderson, F.H. 1970. Open Channel Flow. MacMillan, New York, NY.

Stanfield, L. W. and M. L. Jones. 1998. A Comparison of Full-Station Visual and Transect-Based Methods of Conducting Habitat Surveys in Support of Habitat Suitability Index Models for Southern Ontario. North American Journal of Fisheries Management 18: 657-675

Appendix 1

Example Channel Morphology Data Form

Please note that this example is from a transect that includes a bank profile measurement on the left bank (extends 1500 mm beyond the bank).

Channel Morphology

Stream Name: WILMOT CREEK

Stream Code: WM1

Site Code: 3CDW

Sample: 01

Transect No.: 01 of 10

Bearing (D): 3

Min. Width (m): 3.2

No. of Transects: 10

Points per Transect: 6

Site Length (m): 52.0

Transect Spacing (m): 5.8

Active Channel Width (m): 3.4

Point Spacing (m): 0.56

Date (mm-dd): 2000-08-01

Transect & Point Layout

Use this table to determine the number of transects & points required, given the minimum stream width.

Minimum Width (m)	No. Transects at Site	Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.49	15	3
< 1.0	20	2

Calculations:

Transect Spacing = Site Length / (No. of Transects - 1)

Point Spacing = Active Channel Width / Points per Transect

1st Point = Point Spacing / 2 (from left bank)

Measure depth & hydraulic head to nearest 5 mm

Point No.	Location (m)	Depth (mm)	Hydraulic Head (mm)	Particle Sizes (mm) Point	Particle Sizes (mm) Max. in Ring	Cover Unmeasurable	Cover Quality	Wood	Round Rock	Flat Rock	Macrophyte	Bank	Other	FL	AL	SS	MC	WC	GR	TR
1	1.78	5	0	3	12	☐	0	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	2.34	45	5	18	135	☐	1	☒	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
3	2.90	95	15	400	400	☐	2	☐	☒	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐	☐
4	3.46	40	10	0.10	180	☐	2	☐	☐	☒	☐	☐	☐	☐	☒	☒	☐	☐	☐	☐
5	4.02	70	30	5	40	☐	1	☒	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
6	4.58	15	5	12	120	☐	2	☒	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐

Bank Angle & Particle Median Diameters
(Bank to tape height; if a height is >2m use check box, else enter values in proper observation points)

		> 2 m 0 mm	250 mm	750 mm	1500 mm	Amount of Undercut (mm)	No. of Veg. Squares on Bank
Left Bank	Height ☐	850	600	240	0	100	8
	Substrate Diameters	240	10	3	1		
Right Bank	Height ☐	700	420	180	0	180	12
	Substrate Diameters	120	50	20	3		

Dominant Vegetation Type
(Check box of the dominant type within the 1 x 2 m area)

	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest
Left Bank	☐	☐	☐	☐	☒	☐	☐
Right Bank	☐	☐	☐	☐	☐	☒	☐

Table Codes

Particle Sizes:
Measure all particles between 2.00mm and 1000mm

Material	Size
Unconsolidated Clay	0.01
Consolidated Clay	0.011
Silt	0.05
Sand	0.10
Large Boulders	1001
Bedrock	1111

Cover Quality:
0 = No Cover
1 = Embedded Cover
2 = Unembedded Cover

Aquatic Vegetation Types:
FL = Filamentous Algae
AL = Non-Filamentous
SS = Moss
MC = Macrophytes
WC = Watercress
GR = Grass
TR = Terrestrial Plants

Comments: CLAY EXPOSED ON LEFT BANK.

Crew Leader (initial & last name): S BEAL

Crew	Recorder	Ent/Scanned	Verified	Corrected
J.BYE, S. SALAK	S.S.	2000/10/18 J.B.	2000/11/10 A.C.	2000/11/11 S.B.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 3

Bankfull Profiles and Channel Entrenchment[1]

TABLE OF CONTENTS

Appendices

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[1] Authors: L. W. Stanfield and J. Parish

1.0 INTRODUCTION

This module outlines methodologies for measuring bankfull profile and the entrenchment of wadeable streams.

In alluvial streams, bankfull stage (i.e., depth of flow) is defined as the point at which the channel is completely full just prior to flows overtopping the banks and occupying the floodplain (Wolman and Leopold 1957). The flows at bankfull stage are typically considered the channel forming flows.

In streams flowing through channels that are affected by bedrock, roots and woody material, large glacial deposits etc., an equivalent to the bankfull stage (trim line depth) is identified as the upper limit of a regularly scoured zone and a distinct change in vegetation.

Stream surveys are rarely conducted during the bankfull stage of flow because of the risk to safety of surveyors etc. Usually the depths of flow during conditions that enable sampling and measurement-taking are lower than bankfull stage flow and this parameter must therefore be estimated (Newbury and Gaboury 1993). This module provides methods for consistently and accurately measuring the bankfull level, providing an approximation of bankfull stage flow.

This module also provides methodologies for measuring entrenchment, the degree to which the stream is restricted from accessing the floodplain, or how incised the stream is within the valley (i.e., the valley width/bankfull width). Entrenchment width is the width of the flood-prone area of a channel at twice the height of its maximum bankfull depth from the channel bed. If the channel is not entrenched this may be a very high value in low relief landscapes.

This module builds on data collected in S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions, and is used to assess channel processes and diagnose potential channel instability. It also provides a means of quantifying the rate of change in the channel width:depth profile.

Although the bankfull profile may be used to estimate channel forming discharge in certain cases, the procedure required for this is not covered in this manual. This module provides an evaluation of the bankfull profile that is independent of the flow conditions in the stream. Bankfull profile is more reliable for monitoring changes in the channel geometry and stability than the profiles produced in S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions.

The bankfull profile methods have been tested for repeatability by comparing the measurements made by inexperienced and experienced crews. The test results showed a high degree of consistency.

This module can be used independently or in conjunction with S4.M5, Measuring Stream Discharge Quantitatively, and/or S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions (i.e., at all or a subset of the transects).

2.0 PRE-FIELD ACTIVITIES

A crew of two to three people is required to complete this module in 10 to 15 minutes per transect.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment list is required:

1. ‘Diagnostic Indicators of Channel Stability’ forms on waterproof paper
2. Pencils
3. Metre sticks (two)
4. Tape measures (two, 30 m long)
5. Flagging tape
6. Spikes (four, 25 cm long), tent pegs (four)
7. bungee cords or spring clamps to ensure tape is taught (two),
8. Calculator (waterproof or in re-sealable bag)

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

The application of this module is determined by study design. Sampling design should consider transect location (i.e., regular spacing or just on crossovers), number of bankfull profile measurements, site length, and number of sites to be sampled. Adding additional transects to the study design reduces the error of the measurement for the entire site.

3.0 FIELD PROCEDURES

This module must be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. Record the site identification data (‘Stream Name:’, ‘Stream Code’, ‘Site Code’), the ‘Sample #:’, the ‘Site Length (m):’, the calculated ‘Transect Spacing (m):’ and the “Transect # ____ of ____’ in the site identification area on the Diagnostic Indicators of Channel Stability field form (Appendix 1). Use one form per transect. Ensure that transect numbers are consistent with other modules being applied at the same site.

3.1 Bankfull Profile Procedure

The bankfull profile protocol is most effective when completed on crossovers[2]. An overview of the data collection procedures is described below:

1. Use previously established site boundaries to determine the location for the bankfull profile (where applicable)

2. Identify the bankfull level (where applicable)

3. Establish the transect, measure the channel width and determine spacing for observation points

4. Measure the height of the channel at all appropriate locations on the transect

5. Repeat Steps 1-4 for remaining transects as defined by the study design

3.1.1 Determining Transect Location to Identify Bankfull Level

The first transect is established at the downstream end of the site provided there are no obscuring features present (Table 1). If no obscuring features are found mark the box entitled ‘None Present’ on the Diagnostic Indicators of Channel Stability form and set up the transect. If any obscuring features (Table 1) are observed relocate the transect since these features will affect flow (Figure 1) and bias the data. If the transect needs to be relocated, mark an ‘X’ on the field form to indicate the type of obscuring feature. The location of subsequent transects will be determined according to the study design.

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[2] The crossover is located where the thalweg is in the middle of the channel at bankfull discharge. It also represents the location where velocity is uniform across the channel and is at the lowest velocity during a bankfull discharge event.

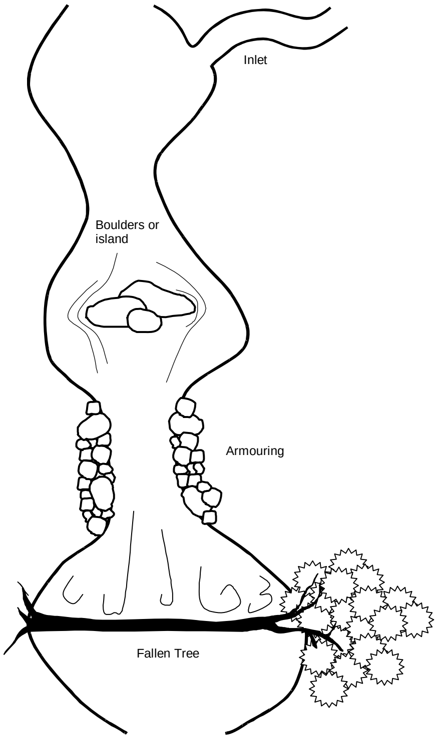


Figure 1: Effects of Obscuring Features on Channel Morphology.
If any of these features are observed refer to Table 1.

Table 1: Criteria for Identifying Obscuring Features that Necessitate Transect Relocation

Obscuring Feature	Distance of Feature from Transect	Description
'Trampled Banks'	within 5 m	Trampled banks from animals or machinery.
'Wood Deflectors'	within 5 m	Large logs or trees which impede the flow causing bank erosion on either side of the deflector.
'Inorganic Deflectors'	within 5 m	Mid-channel islands, large rocks (erratics), etc., that are sufficiently large to cause erosion on either bank.
'Armouring'	within 5 m	Rip rap, gabion, concrete, etc., placed on the banks.
'Inlets'	within two stream widths upstream or six stream widths downstream	Presence of tributaries that provide sufficient discharge to produce a plume or delta, or major outfalls emptying into the channel.

Possible options for sampling designs include:

- profiles conducted on one or more crossovers (i.e., upstream and/or downstream site boundaries, other crossovers located within these limits)
- for surveys that are performed in conjunction with S4.M2, Point Transect Sampling for Channel Structure, Substrate and Bank Conditions, profiles can be conducted along all transects as defined in that module
- profiles conducted at selected locations within the site where the bankfull channel is well defined

3.1.2 Identifying the Bankfull Level

There are two ways of identifying the bankfull level: 1) using visual indicators of bankfull level or by 2) using the minimum width:depth ratio indicator. The latter involves the least error (high reliability) but is labour intensive and is mainly used on terraced streams or to corroborate the visual indicators of the bankfull level method. The bankfull level can be identified in the field using the minimum width:depth ratio or it can be determined after the field survey, in the office. The latter requires that the data collected for the bankfull profile (i.e., 'Vert Ht to Tape (mm)') are corrected, yielding the 'Vert Ht to Bankfull Level (mm)'.

3.1.2.1 Visual Indicators of Bankfull Level Method

Examine each bank for visual indicators of the bankfull level (Table 2). The left and right banks are defined when looking upstream. Visual indicators are features that provide evidence of the boundaries of the bankfull channel. Visual indicators of the bankfull level should be found on both banks at the transect and at other locations up and downstream.

Table 2: Visual Indicators of the Bankfull Level (a detailed description of the indicators is provided in Appendix 2).

Indicator	Reliability Rating
• 'Inflection Point' (i.e., change in bank slope)	High
• Change in 'Bank Material' sand/silts to clays or gravels • 'Top of Point Bar' or terraces • Changes in 'Vegetation' from alders to willows or from grasses to tall herbaceous vegetation	Medium
• Lichens, Water Stains and Thatch • Worm Holes and Swallow Nests	Low

Each indicator has been rated from high to low in terms of its reliability. In some instances, high reliability indicators (i.e., inflection points) will occur on one bank while low reliability indicators occur on the other bank. In these instances, the higher reliability indicator takes precedence.

However, it is best to use a variety of indicators and/or the minimum width:depth ratio method to corroborate the bankfull level. The height of the bankfull indicators above the water surface should be similar on both sides of the channel and should be comparable at different locations within the site and the surrounding reaches.

For each bank, document the indicators used in determining the bankfull level by marking an 'X' in the appropriate box(es).

In uniform reaches, or selectively at crossover transects of similar width, the height of the bankfull indicators above the water surface should be similar. Bankfull heights that are widely different should be re-inspected before leaving the reach. It may be useful to string a measuring tape or survey ribbon between strong indicators along the banks to see if the heights are confirmed by indicators between the transects.

Hint*: It is often useful to hold the hand level at the height of a likely indicator and scan upstream, downstream, and across the channel for similar indicators. These can then be checked by sighting back from the other side of the stream to confirm the general height of the scour line or bankfull indicators on and adjacent to the transect.*

3.1.2.2 Minimum Width:Depth Ratio Indicator Method

The bankfull level occurs at the minimum width to depth ratio in the profile (Figure 2). To determine this measurement in the field, measure the width of the channel and the height to the inflection point (tape) at each inflection point (i.e., each potential location of the bankfull level). Calculate the width:depth ratio at each location and establish which one represents the bankfull level. Then set up the tape at this location as outlined in Section 3.1.3, Setting up the Transect.

Alternatively, the bankfull level can be calculated later in the office. With this scenario, the tape is set up so as to include the widest part of the channel. The height to the tape ('Vert Ht to Tape (mm)') and location on the tape ('Horiz Loc (m)') are recorded at every inflection point in the profile (along with the locations described below). With this scenario, the bankfull height is determined in the office using the procedures illustrated in Figure 3, by correcting the field data (yielding the 'Vert Ht to Bankfull Level (mm)').

Resources and crew experience will determine which option is chosen with respect to bankfull level identification and bankfull profile measurements (i.e., field identification of bankfull level or correction of bankfull profile (vertical) measurements).

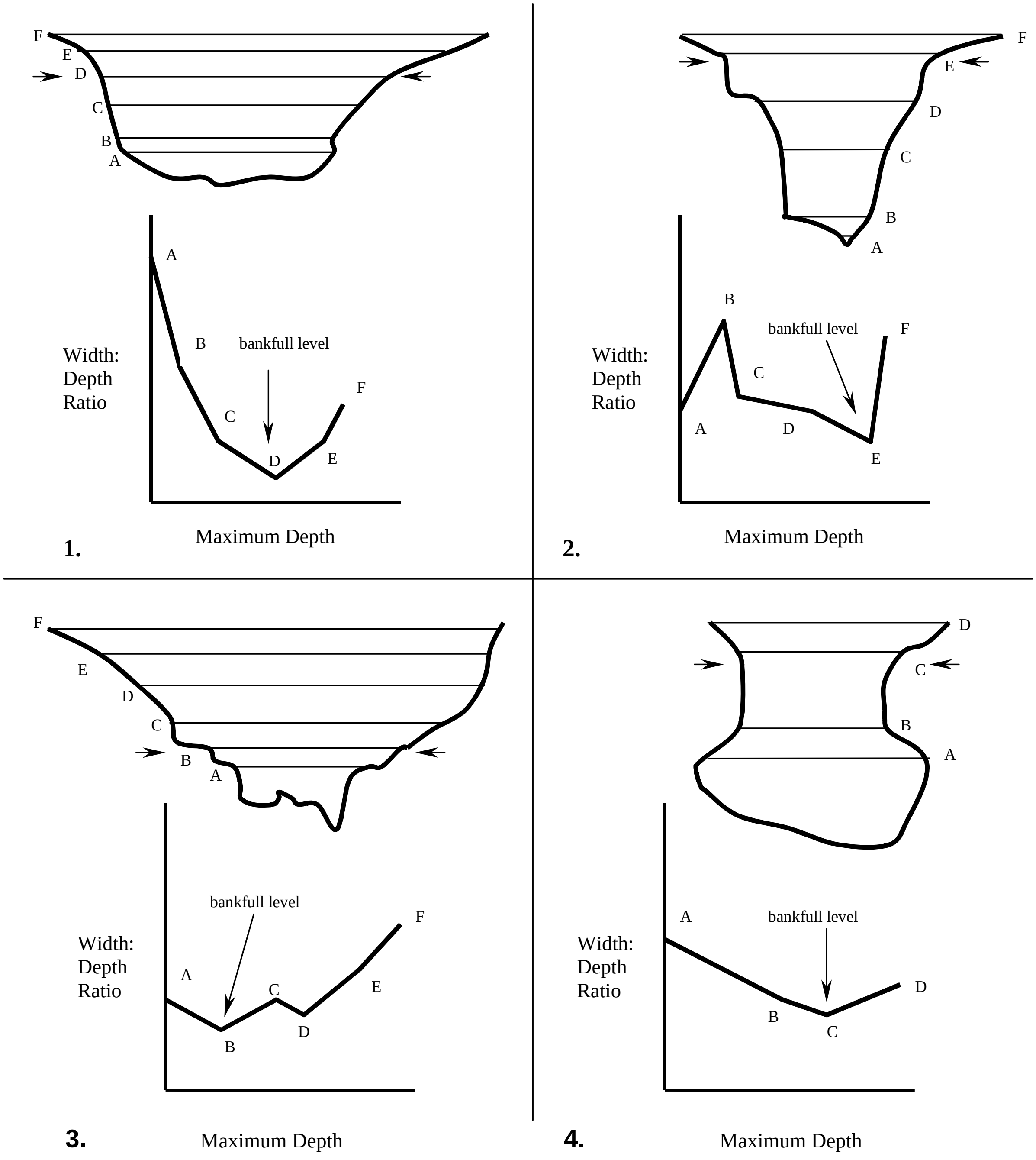
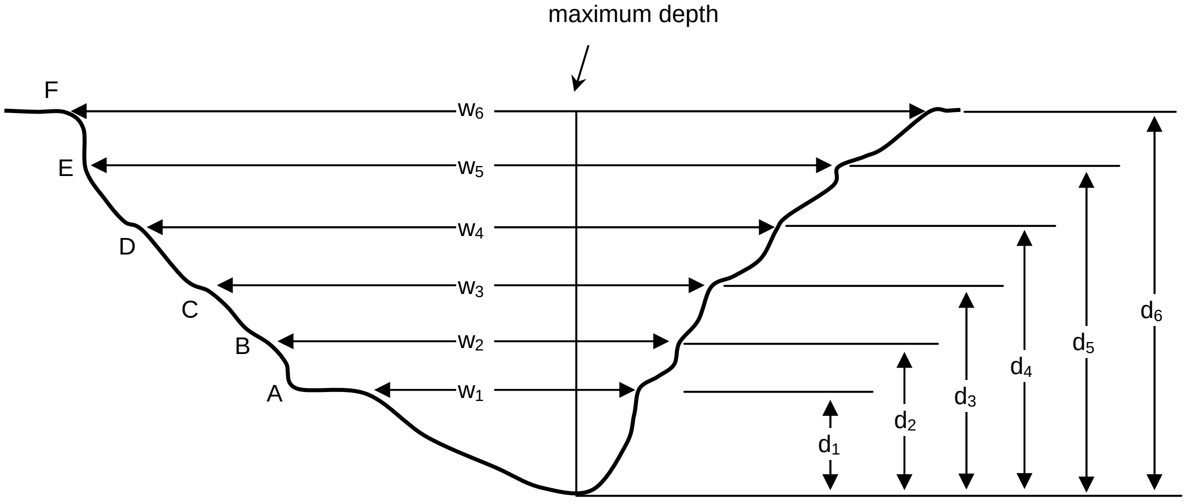


Figure 2: Determination of Bankfull Level Using Minimum Width:Depth Ratio.

Letters indicate the location of inflection points, with arrows indicating the major inflection point to be used to determine bankfull level. As can be seen in each accompanying graph, the major inflection point also has the lowest width:depth ratio. Abandoned terraces can be distinguished from bankfull level using this same graphing method.



$$W:D_{i\ (i=A...F)} = \frac{w_{i\ (i=1...6)}}{d_{i\ (i=1...6)}}$$

Figure 3: Calculation of Width:Depth Ratio for Determination of Bankfull Level and Correction Factor to Convert the High Terrace Profile to the Bankfull Level.

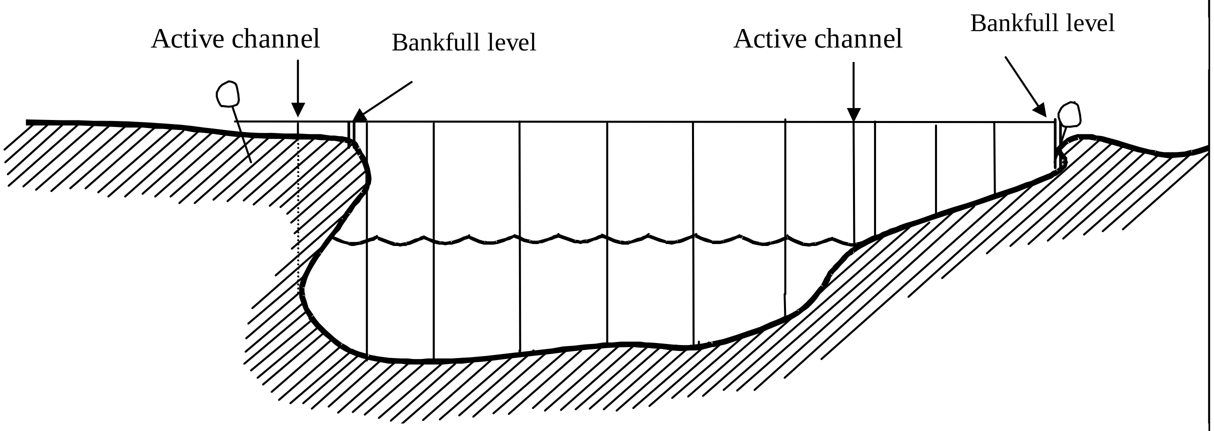
To estimate the height of the Bankfull channel, use the graphical methodology illustrated in the previous figure. If the Bankfull level is determined to be D, then the correction factor used to convert the profile from F to the bankfull profile at D is given by d_6-d_4. Each height taken on F that lies within the bankfull width (i.e., w_4) should have d_6-d_4 subtracted from it to obtain the height for the bankfull profile.

On the field form, indicate that the minimum width:depth ratio was used to determine bankfull level, by marking an ‘X’ in the appropriate box.

3.1.3 Setting up the Transect Cross-section

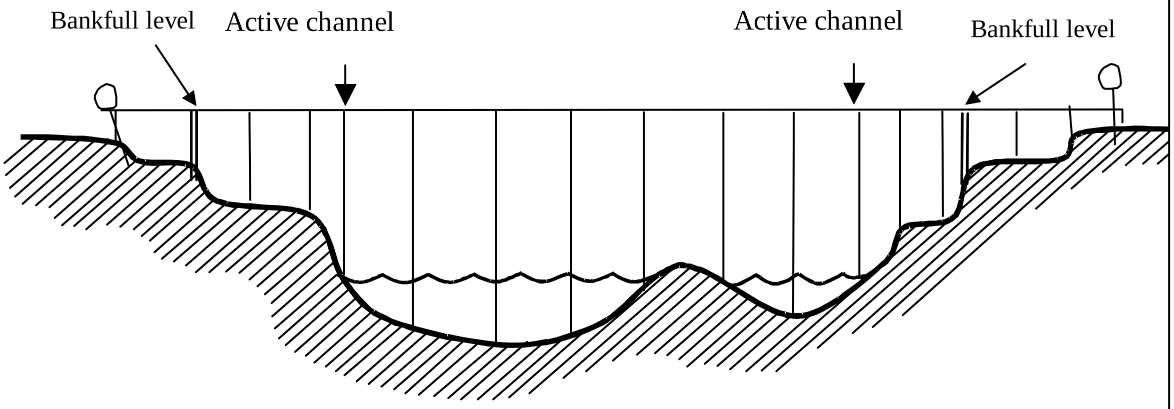
Stretch and secure the tape measure taut and level across the channel at the height of the bankfull level, or at the top of the terrace (depending on the methodology used). The tape can be secured with bungee cords or spring clamps at the appropriate locations. Check that it is level by setting at equal heights above the water surface. A laser level can also be used to establish the reference level where the width of the stream makes it difficult to keep the tape level (see below).

Set up the transect as shown in Figure 4 if only this module is being completed and refer to Figure 5 if this module is being completed in conjunction with S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions. If this module is being done in conjunction with S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank



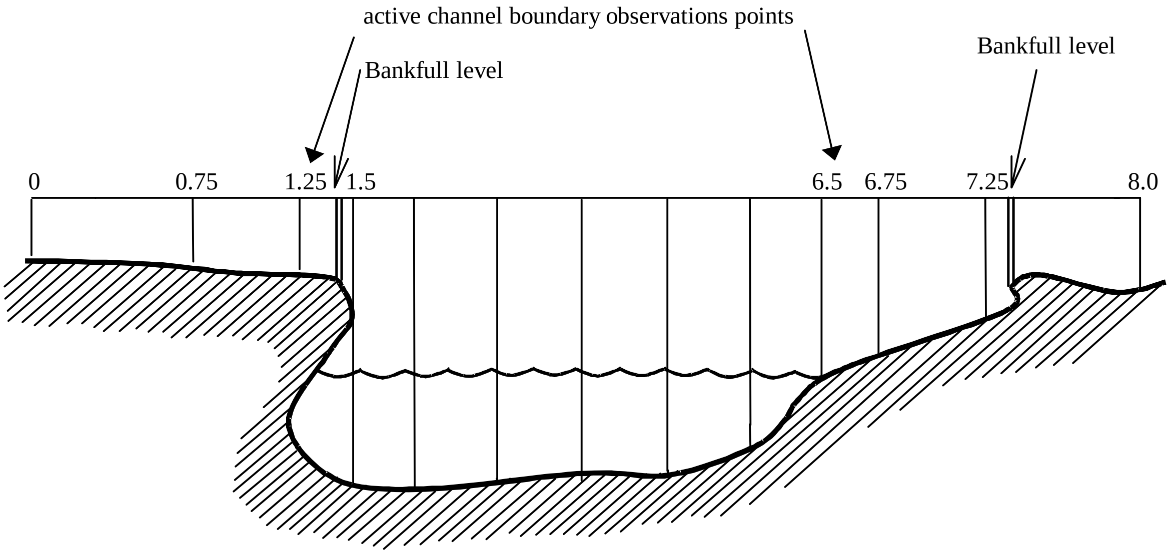
Left bank active channel location can be identified, height to tape is from bank. Height from water level is recorded at bank edge.

A. Outside bend with point bar.



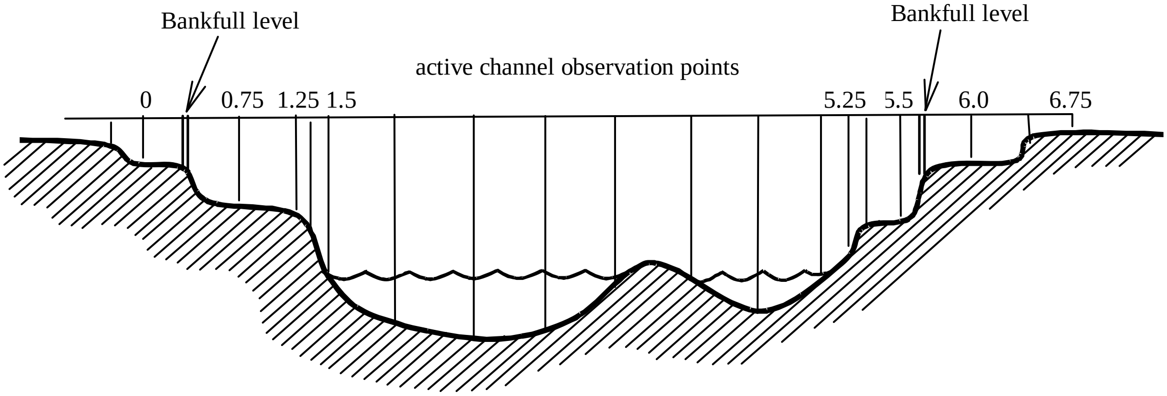
B. Terraced channel at cross-over.

Figure 4: Measuring Bankfull Level Cross-sectional Profiles (i.e., if only completing this module).



Note: measurement of height from water surface to tape is typically done on the left bank.

A. Outside bend with point bar.



Note: application of this module in conjunction with S4.M2 will result in additional observation points.

B. Terraced channel at cross-over.

Figure 5: Measuring Bankfull Level Cross-sectional Profiles (e.g., with S4.M2 data also being collected).

Using a laser level to identify a level line for depth measurement

Position the laser on one side of the stream, level with the top of the tape measure and aim it so at to intersect with the top of the tape on the other side of the stream. Use the tape measure to mark locations of measurements and make depth measurements to the laser line. Make sure to wear the appropriate safety glasses during the survey.

The number of observation points vary with stream width (Table 3 and Point Observation Calculation Example). In channels that have uniform depth, the stream width is divided by the number of observation points to determine panel widths. The observation points are located in the centre of each panel. Mark each observation point and the inflection points on the tape. Also locate and mark the deepest part of the channel. Depth at this location is used in subsequent analysis to verify the bankfull location (Figure 2).

Table 3: Relationship Between the Stream Width and the Minimum Number of Panels to Sample for Low Variance and High Variance Sites.

	Number of Panels to Sample	
[redacted]	**Transects with Low Variance in Velocity or Depth**	**Transects with High Variance in Velocity or Depth**
> 3.0	minimum 8*	minimum 10*
1.5 – 3.0	5	8
1.0 – 1.5	3	6
< 1.0	2	4

* Add one panel for every 2 m increase in stream width i.e., 9 m wide = 11 (low variance) or 13 (high variance) panels.

Observation Point Calculation Example

For a stream that has an active channel width of 2.9 m wide, and low variance in velocity, five panels are sampled. The point spacing would be 2.9/5 = 0.58. This number actually represents the boundary of a set of panels that transect the stream, with each observation point located in the centre of each panel. To determine the actual location of the observation points, divide the first panel in half, and for each additional location add 0.58. The first observation point would be at 0.29 m (i.e., 0.58/2 = 0.29). The second point would be at 0.29 + 0.58 = 0.87 m. The complete list of observation points is 0.29, 0.87, 1.45, 2.03 and 2.61 m.

Note: Observation point locations are dependent on whether the tape extends beyond the bank water interface. For example if the left bank water interface occurs at 1.5 m on the tape then the first observation point for the above example would be at the 1.79 m mark on the tape.

3.1.4 Measuring the Water Level and Depth Profile Across the Channel

Measurement points for depth measurements will be located at:

- the outside edges (start and finish) of the transect;

- the location of the bankfull level on both banks;
- the active channel boundary on both banks
- calculated observation points
- inflection points
- the deepest point in the channel

Figure 6: Measuring Height from Channel Bottom to Tape at the Active Channel Boundary.

Start the measurements on the left bank[3]. Record the height from the bank to the tape measure at the start of the transect. Record this height (in mm) in the row entitled ‘Measurement 1’ on the field form. Measure the height of the channel (i.e., the height from the channel bottom (substrate) to the tape) at each observation point (as shown in Figure 6), inflection point, active channel boundaries, and at the location of the maximum depth. For each observation point location, record the tape measure reading location in m to the nearest 0.01 m (i.e., ‘Horizon. Loc (m)’) and the height in mm as observed (e.g., 18 mm) or rounded to the nearest 5 mm (e.g., 20 mm), whichever is easier for the crews. The accuracy of these height measures is considered to be 5 mm for all interpretations..

The active channel boundaries mark the area between the two outside banks which includes all connected water at the time of the survey. This includes actively flowing as well as stagnant areas provided there is no land barrier that separates it from the main channel (see S4.M2, Point Transect Sampling for Channel Structure, Substrate, and Bank Conditions). Regardless of where the active channel boundary occurs i.e., at the bank-water interface or under an undercut, measure and record the height from top of bank to the transect tape (Figure 4A, left bank). Also record the depth of water at the boundary of the active channel, even if it is zero. Where undercuts are present, obtaining depth measurements may require the use of alternate tools to obtain the measurement (i.e., shorter rulers, sticks, boots).

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[3] It may be easier to mark the locations of all the observation points prior to making the measurements.

3.2 Channel Entrenchment Procedure

Entrenchment measurements are best completed at crossover locations. This method assumes the maximum depth of the channel to bankfull level has been determined from procedures listed above. Place a metre stick vertically on the left bank at the bankfull level. At a height equivalent to the maximum channel depth, (i.e., two times the bankfull maximum depth) estimate the horizontal distance to the valley wall. If it is obviously greater than 40 m, simply record ‘41’ in the ‘Total Entrenchment Width (m)’ on the field form. For purposes of this manual (i.e., wadeable streams), an unentrenched stream has an excess of 40 m of floodplain on either bank.

If this distance is less than 40 m, extend a tape measure from the metre stick at a height equivalent to the maximum channel depth and extend this tape away from the channel – parallel to and level with the transect – until it meets the ground (Figure 7). Repeat this procedure on the right bank. Measuring the valley width at two times the bankfull depth is the convention adopted in this procedure. The entrenchment ratio is the total width/bankfull width.

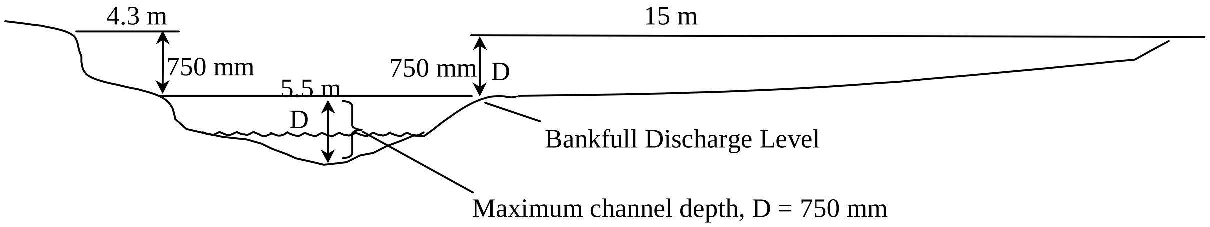


Figure 7: Measuring Channel Entrenchment.
The left bank entrenchment width is 4.3 m, the right is 15 m and the total width is 24.8 m.

Record the distance in the appropriate entrenchment width box (i.e., ‘Left Entrenchment Width (m):’ or ‘Right Entrenchment Width (m):’) to the nearest 0.1 m.

With a three-person crew, the tape can often be extended across the channel to measure the total entrenchment width at once, rather than measuring the width on each bank separately. If this is the method used, record the total entrenchment width in the appropriate box on the data form (i.e., ‘Total Entrenchment Width’).

3.3 Tips for Applying this Module

Before measuring the bankfull profile and entrenchment at any transect, it is recommended that the field crew completes an initial reconnaissance of the site for bankfull indicators and the height of the bankfull level.

Since it may be difficult to identify bankfull level using channel indicators, it is recommended that replicate sites be used in the study design. This will allow quantification of variability among crews.

If indicators can only be found on one bank, use corroborative evidence to verify the location of the bankfull channel on the opposite bank. This method uses triangulation (Figure 8) to determine the height of the bankfull level (i.e., locations up and downstream and on the opposite bank are used to estimate the bankfull level).

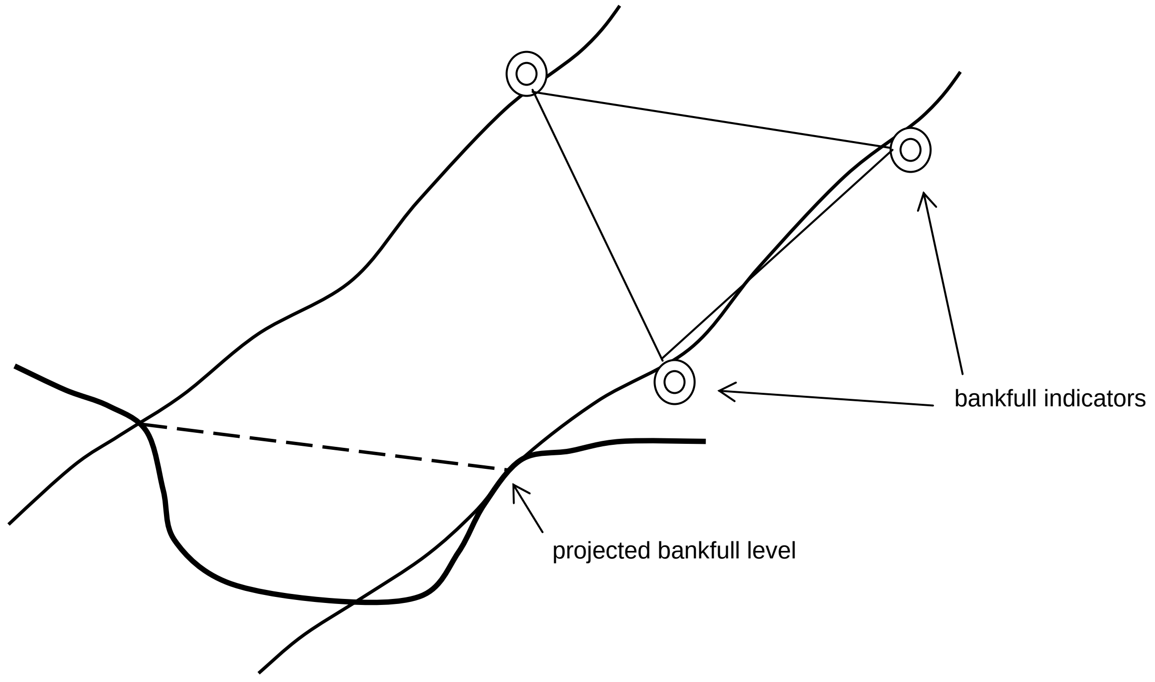


Figure 8: Bankfull Level Triangulation.

These procedures are designed to work on streams with natural banks and should not be used on streams with hardened or channelized banks. It is also very difficult to apply these methods on streams with very high roughness caused by an abundance of large woody materials, or streams that flow through wetlands.

A sample (i.e., ‘Sample #’) consists of one full set of data for each module, regardless of how many transects are surveyed or how many days are required to complete data collection.

The indicators should be applied in a hierarchical way, giving more weight to those with greater reliability. Multiple indicators should be used wherever possible.

The tape should be reasonably level and taut. A bungee cord can be used at the handle end of the tape measure to tighten the tape. Once the tape has been stretched, the handle should be locked in place and the bungee cord anchored to the nearest solid object.

Flagging tape should be tied loosely on the tape measure so that measurement points can be easily shifted.

The spacing of the observation points should be checked before recording data. All height measurements can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

All field equipment should be marked with bright paint or flagging tape to increase visibility.

4.0 DATA MANAGEMENT

Upon returning from the field:

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Harrelson, C.C., Rawlins, C.L. and Potyondy, J.P. 1995. Stream channel reference sites: an illustrated guide to field technique. General Technical Report RM-245. USDA Forest Service.

Newbury, R.W. and M.N. Gaboury. 1993. Stream analysis and fish habitat design: A Field Manual. Co-Published by Newbury Hydraulics Ltd., the Manitoba Heritage Corporation and Manitoba Natural Resources, Gibsons, British Colombia.

Wolman, M.G. and L.B. Leopold. 1957. River flood plains: Some observations on their formation. USGS Prof. Paper 282C.

Appendix 1

Example Diagnostic Indicators of Channel Stability Field Form

Note that the survey was done in conjunction with S4M5 Measuring stream discharge quantitatively. The crew determined that the site was 5.25 m wide and there was minimal variance in the depth and velocities across the profile. Therefore, nine (minimum 8, + 1 observation point because the stream is 2 m wider than 3 m) equally-spaced observation points were established. The transect was set up such that Point-transect Sampling for Channel Structure, Substrate and Bank Conditions (S4:M2) measurements could also be conducted. The tape was set up at 1.5 m from the left bank.

Diagnostic Indicators of Channel Stability Form

Transect No. 1 of 1

Stream Name	Stream Code	Site Code	Sample	Date (yyyy/mm/dd)
WILMOT CREEK	WM1	3CDW	1	2000/08/10

Crew Leader	Crew	Recorder
J. BEAL	A. CONE, S. BYE	S. BYE

Comments
* OBSERVATION POINT TOO SHALLOW, HYDRAULIC HEAD MEASURED INSTEAD

Transect and Point Layout

Use this table to determine the number of measured points per transect, given the minimum stream width

Min. Width (m)	Low Variance in Velocity or Depth	High Variance in Velocity or Depth
>3.0	8 + 1 every 2m	10 +1 every 2m
1.5-3.0	5	8
1.0-1.49	3	6
<1.0	2	4

Point Spacing = Active Channel Width / Points Per Transect

1st Point = Point Spacing / 2 (from left bank)

Site and Transect Measurements

Site Length (m)*	44.2
Transect Spacing (m)*	4.91
Active Channel Width (m)	5.25
Point Spacing (m)	0.58

**Record only on 1st transect*

Discharge Approximates Baseflow?
☒ Yes ☐ No

Obstructions to Flow *(check all applicable)*

☐ None
☐ Trampled Banks
☒ Wood Deflectors
☐ Inorganic Deflectors
☐ Armouring
☐ Inlets
☐ Other: _________

Indicators of Bankfull Level

Left Bank	Right Bank	
☐	☐	Inflection Point
☐	☐	Bank Material
☒	☒	Top of Point Bar
☐	☐	Vegetation
☐	☐	Min. Width:Depth
☒	☒	Other:___________
☐	☐	___________

Measures of Channel Entrenchment*

**Record either left, right, or total width*

Left Entrenchment Width (m)	
Right Entrenchment Width (m)	
Total Entrenchment Width (m)	24.8

Entrenchment Height = 2 x Max. Channel Depth

Entrenchment Width = horizontal distance from location of max. channel depth to bank at entrenchment height

	Horiz. Loc (m)	Vert. Ht. (mm)	Ht. Represents Bankfull?	Velocity Meter Type	Depth Ratio Used
Left BFD	1.50	960	☒ Yes ☐ No	Marsh McBirney	☒ 0.4 ☐ 0.2/0.8
Right BFD	8.24	847			

	Horiz. Loc (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/Min	Calc.	Velocity (m/s)
Max. Chann. Depth	2.56	1765					
Left Active Chann.	1.50	960	0	—	—	—	—
Right Active Chann.	6.74	1280	0	—	—	—	—
Obs. 1	1.79	1640	300	180	—	—	0
2	2.37	1702	405	210	—	—	12.2
3	2.96	1728	515	309	—	—	20.6
4	3.54	1515	310	205	—	—	18.8
5	4.12	1435	235	141	—	—	15.9
6	4.71	1375	190	120	—	—	16.8
7	5.29	1353	160	96	—	—	18.8
8	5.87	1305	175	100	—	—	15.4
9	6.45	1290	215	129	—	—	14.7
				—	—	—	—
	7.5	900	0				
10							

			Velocity Measurements				
Obs.	Horiz. Loc (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/Min	Calc.	Velocity (m/s)

Entered	Verified	Corrected
L.A.	J.B.	S.C.

Appendix 2

Examples of Visual Indicators of the Bankfull Level

Inflection Points (Reliability: High)

An inflection point is a change in the bank slope caused by a change in erosive power. For example, an inflection point occurs where slope changes (e.g., vertical to sloping, sloping to vertical, or from vertical/sloping to flat). Many banks have multiple inflection points (Appendix 2, Figure 1) that may reflect stream terraces or old floodplains. Therefore it may be difficult to select the appropriate inflection point (i.e., that caused by bankfull discharge).

As the erosive power of a stream increases with greater discharge, stress on the banks increases until the stream overflows the banks. Once the stream overflows its banks, erosion rates begin to decline as energy is dissipated over the flood plain. This change from an erosive to depositional state often causes an inflection point or change in bank slope to occur at the channel-defining stage. Where the banks are relatively steep, this inflection point can easily identified, and is usually just below the top of bank (Appendix 2, Figure 2).

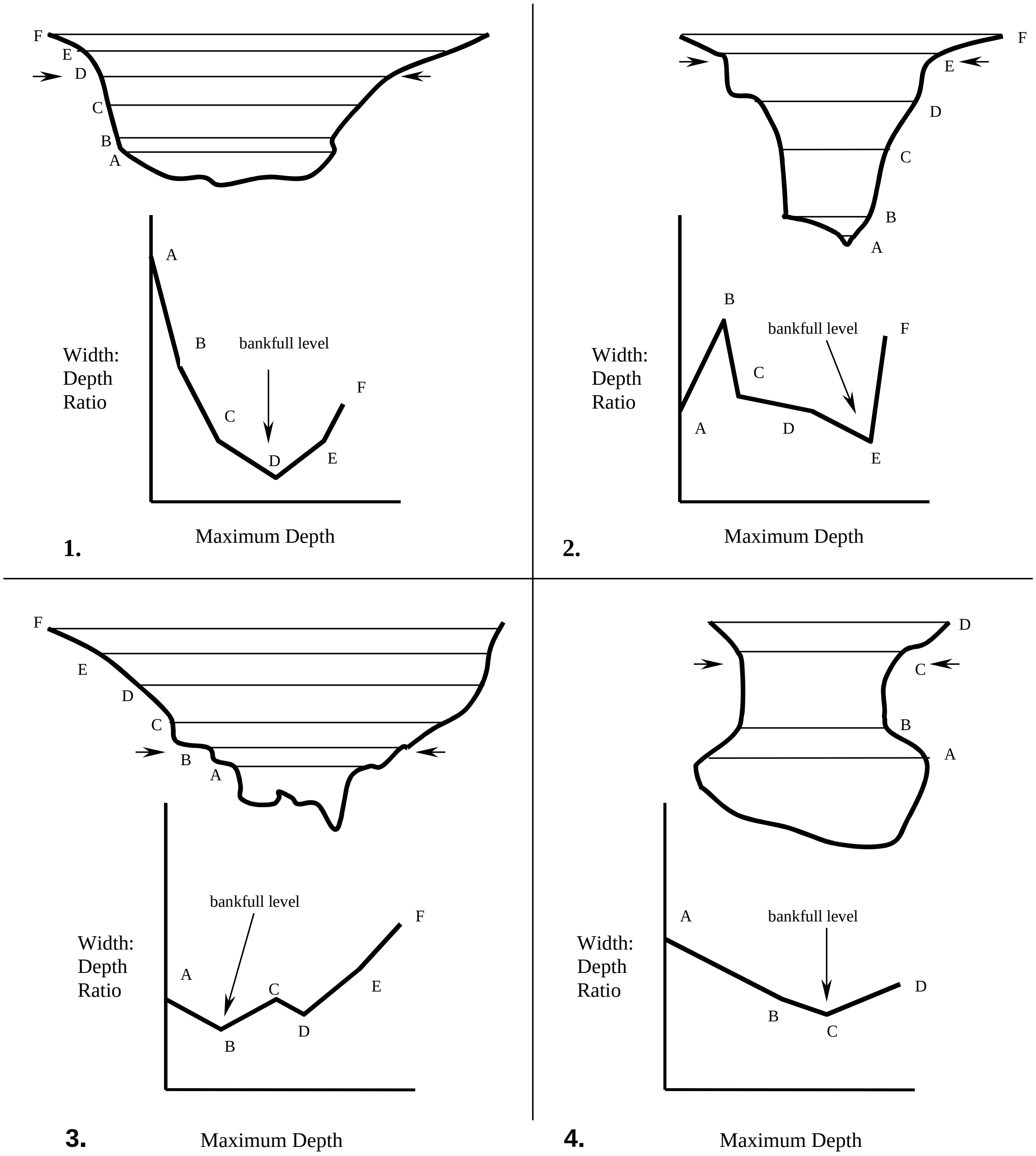
The bankfull level identified using inflection points should be verified using other indicators. For example, perennial vegetation often indicates older terraces or a humus layer is often observed between old and new terraces (Harrelson et al. 1995).

Changes in Bank Material (Reliability: Medium)

The dynamic forces leading to a change in bank slope can also produce a change in bank material from a coarser material (inorganic) on the bottom to a finer (organic or loam) material on top. This change in bank material can be an indicator of bankfull level (Appendix 2, Figures 3, 4) only when the finer material is loose and is a result of stream deposition and not a feature of the bank parent material (i.e., unconsolidated).

Top of Point Bars (Reliability: Medium)

Point bars are formed on the inside bend of scour pools (Appendix 2, Figure 5A). During bankfull discharge the top of the point bar is just submerged, providing an indicator of bankfull level. A cut bank or inflection point adjacent to the point bar may also be observed (Appendix 2, Figure 5B, Figure 6). This is another indicator of the depth of flow at bankfull level. The easiest way to identify the top of the point bar is by the presence of a small inflection point or a change in substrate material (i.e., coarser on the point bar to finer material in the flood plain).

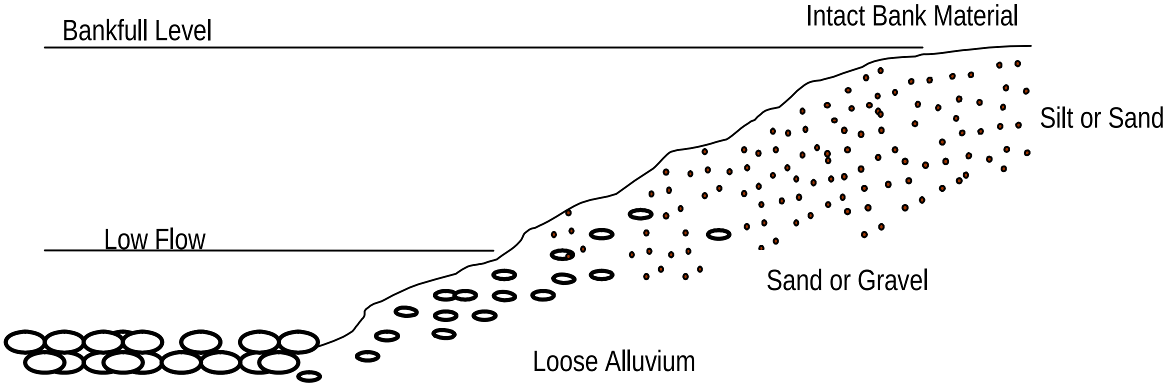


Appendix 2, Figure 1: Determination of Bankfull Level Using Lowest Width to Depth Ratio.

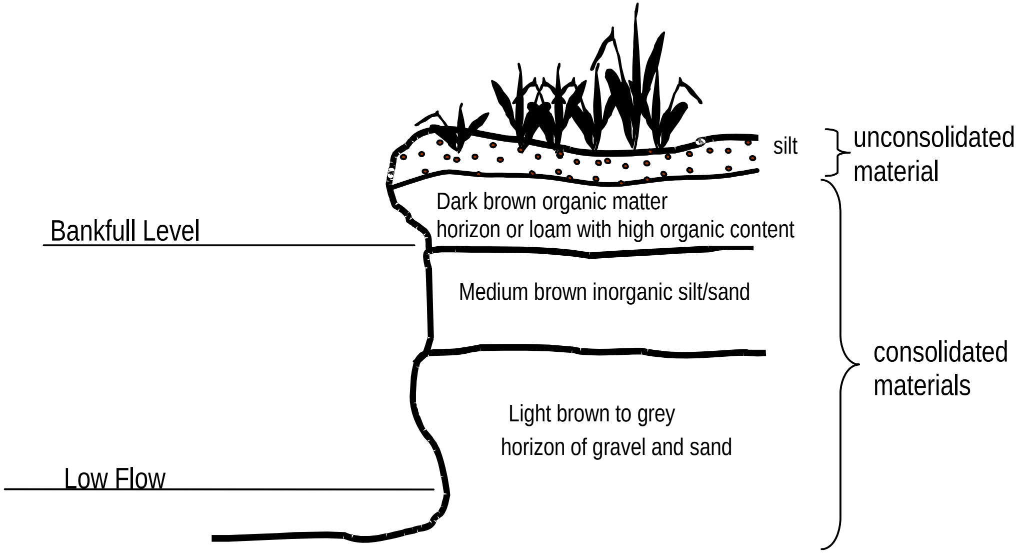
Letters indicate the location of inflection points, with arrows indicating the major inflection point to be used to determine bankfull level. As can be seen in each accompanying graph, the major inflection point also has the lowest width:depth ratio. Abandoned terraces can be distinguished from bankfull level using this same graphing method.

Appendix 2, Figure 2: Inflection Point As An Indicator of Bankfull Level.

Appendix 2, Figure 3: Change in Bank Material as an Indicator of Bankfull Level.

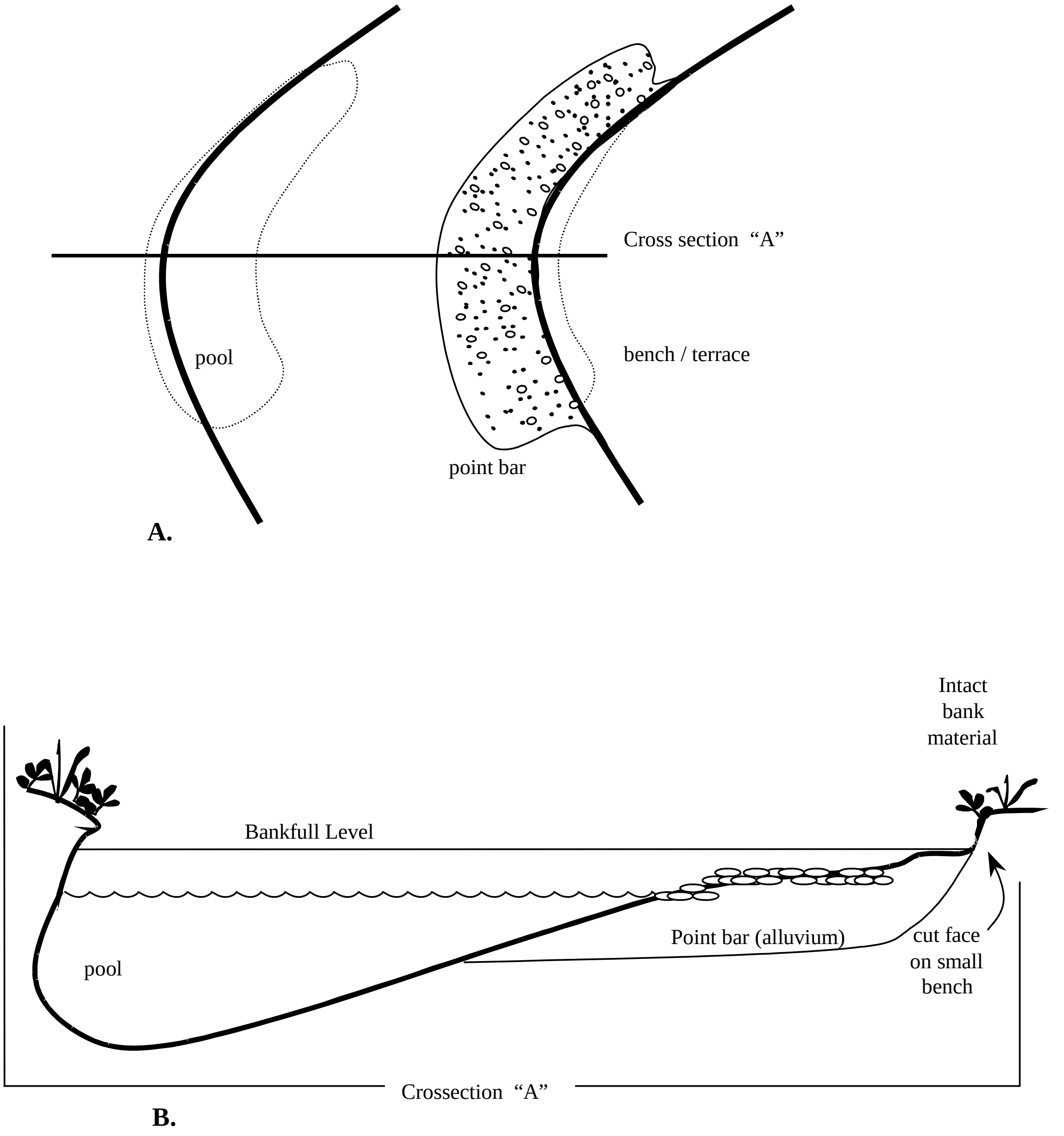


A. Banks with Low Transverse Profile



B. Steep Banks

Appendix 2, Figure 4: Change in Bank Material as an Indicator of Bankfull Level. Note the change from consolidated to unconsolidated materials which corroborates and inflection point.



Appendix 2, Figure 5: Using the Top of Point Bars to Identify the Bankfull Level

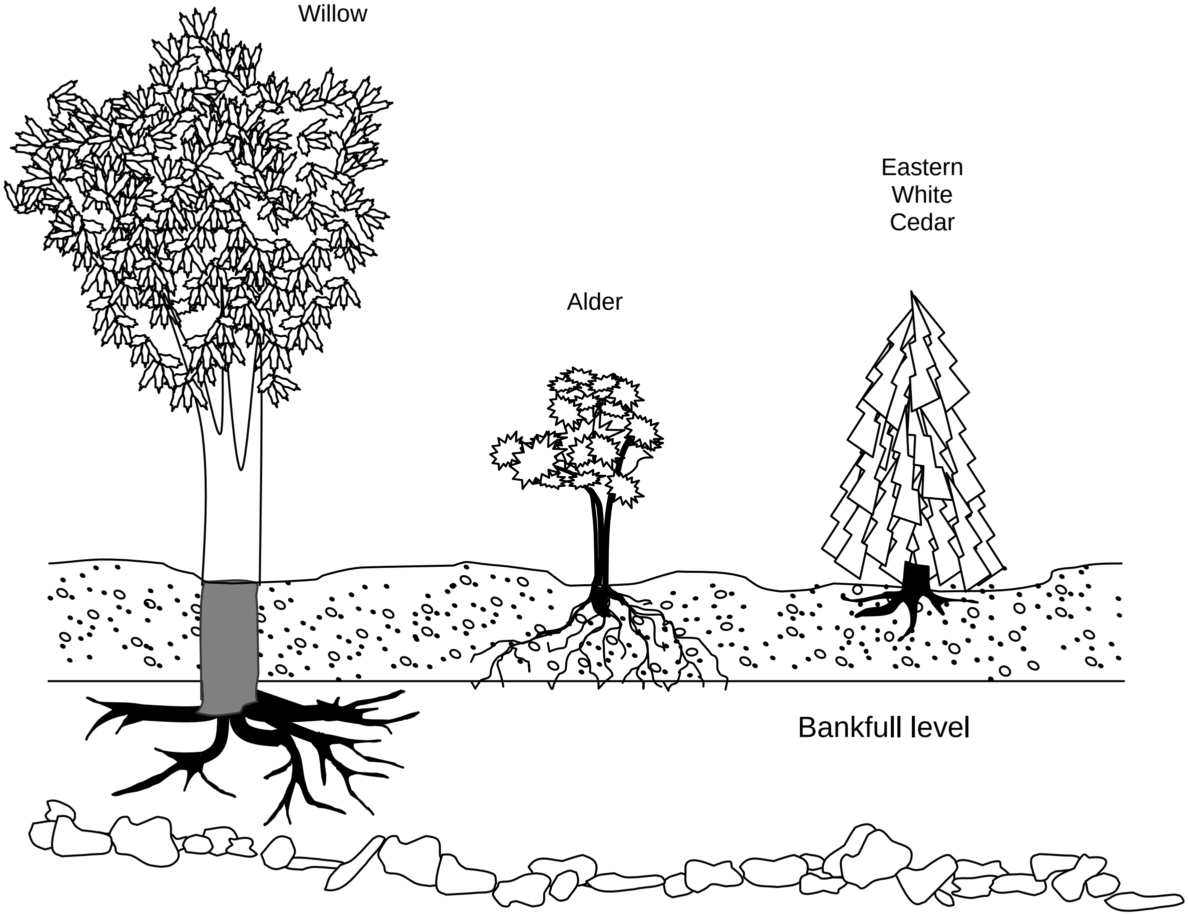
Appendix 2, Figure 6: Top of Point Bar as an Indicator of Bankfull Level.

Changes in Vegetation (Reliability: Medium)

The location where changes in composition of vegetation or root depth occurs can be used to corroborate other indicators of bankfull level. The roots of some water intolerant plants such as alder and to a lesser extent cedars will be above the layer of soil that is saturated with water for extended periods. This saturated soil level is generally 1 to 5 cm above the bankfull level. Willows (reddish roots) can tolerate more water and will extend below the bankfull level (Appendix 2, Figure 7). Ideally, if a bank has both alder and willow, the bankfull level will be located somewhere between the upper extent of the willow roots and the lower extent of the alder roots.

Changes in the Presence of Lichens, Water Stains and Thatch: (Reliability: Low)

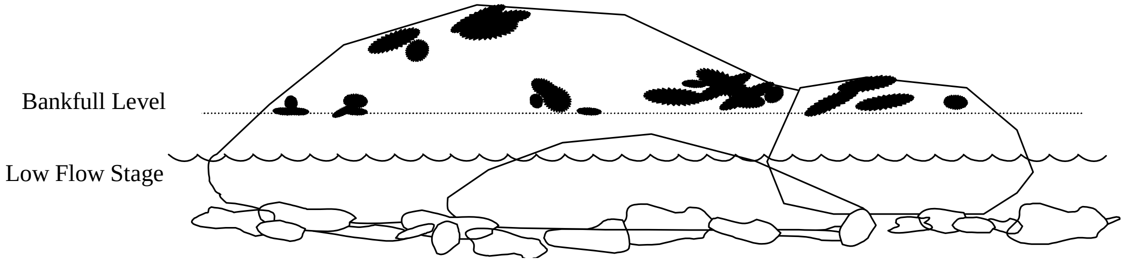
Lichens are able to attach and survive on boulders that are infrequently inundated with water, and are typically found above the bankfull level. A fairly distinct line generally indicates the part of the rock that is scoured clean of lichen (Appendix 2, Figure 8A). This line approximates the bankfull level.



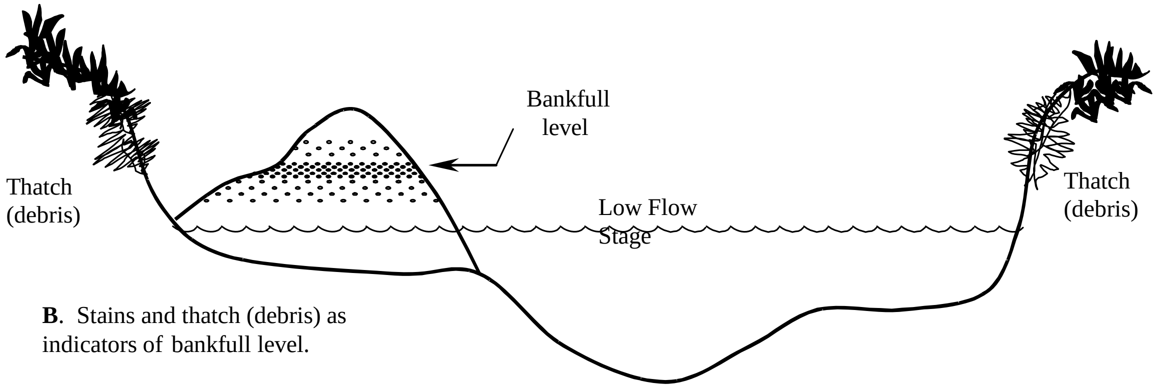
Appendix 2, Figure 7: Vegetation Roots as an Indicator of Bankfull Level. Eastern white cedar and alder roots will not extend below bankfull level, while willow and dogwood roots do.

Water stains are usually poorly defined and reflect a continuum of flows that have produced the marks. Sometimes three separate bands are distinguishable: an upper faint stain, a middle dark stain and a lower lighter stain. Bankfull level is often approximated as the upper limit of the middle, darker band (Appendix 2, Figure 8B).

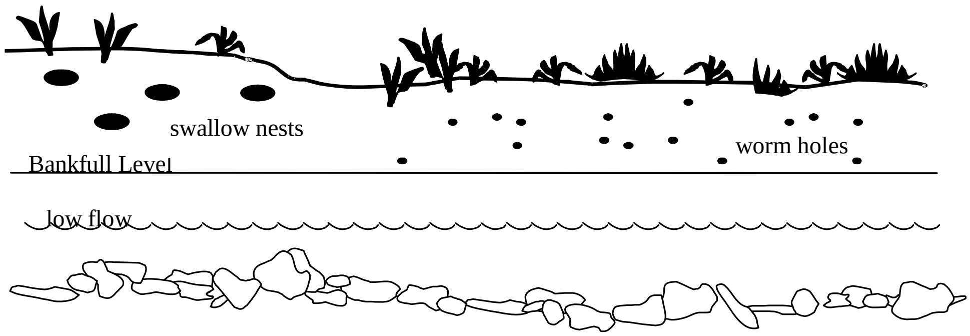
Thatch on the bank (debris and dead grass, Appendix 2, Figure 9) provides a low reliability indicator. (Appendix 2, Figure 8B) because intense flood events may redeposit these materials at a level not related to the bankfull level. This indicator should only be used if prior knowledge indicates that the stream has been recently exposed to a bankfull flow event.



A. Lichens as an indicator of bankfull level. Lichens live on boulders down to the bankfull level.



B. Stains and thatch (debris) as indicators of bankfull level.



C. Animal burrows as indicators of bankfull level.

Appendix 2, Figure 8: Other Indicators of Bankfull Level.
A) Lichens, B) Water Stains and Thatch (debris), and C) Animal Burrows.

Appendix 2, Figure 9: Recent Thatch on the Bank.

Presence and Absence of Worm Holes and Swallow Nests: (Reliability: Low)

Animals also like to keep their burrows or nests above the bankfull level. The presence of either wormholes or swallow nests will almost always be at or above the bankfull level (Appendix 2, Figure 8C).

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 4

Reconnaissance Surveys for Stream Discharge[1]

TABLE OF CONTENTS

APPENDICES

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[1] Authors: L.W. Stanfield and M. Hinton

1.0 INTRODUCTION

This module contains instructions for estimating discharge on wadeable streams using qualitative methods. This survey is mainly used for reconnaissance purposes as it provides a measure of relative discharge (relative to other sites), and provides information on the suitability of sites for more rigorous sampling. The use of these preliminary observations will ensure that field studies are planned and conducted effectively and efficiently. Techniques described and the field sheets available in S1.M9, Check Your Watershed Day Protocol for Stream Discharges and Perched Culverts, are a good companion to this module where streams being surveyed are < 3 m in wetted width.

The amount of water within any stream channel is an important attribute to aquatic biota. Changes in discharge reflect both the natural hydrologic cycle and anthropogenic alterations to this cycle. It is essential to have information about flow conditions in order to understand how changes in flow are related to development and weather patterns.

The reconnaissance survey fulfils several goals by identifying:

- suitable locations and methods for stream gauging
- sites with high or low discharge
- if a stream is flowing at a point in time (i.e., intermittent versus permanent) and
- improving the field technicians' familiarity with the hydrological conditions and controls within the watershed.

The time and effort invested in a reconnaissance survey results in better baseflow surveys, improved knowledge of the watershed and additional information to supplement the interpretation of baseflow surveys.

Data collected using this module are less accurate and are biased compared to quantitative surveys (i.e., methods described in S4.M5, Measuring Stream Discharge Quantitatively). However, if the bias is consistent, users may be able to develop calibration ratios to adjust the data (see S4.M1, Rapid Assessment Methodology for Channel Structure).

2.0 PRE-FIELD ACTIVITIES

A typical crew consists of two people (a surveyor and a recorder). Survey time varies with distances between sites, and a crew can visit approximately 30 to 50 sites per day. This assumes that permission to access property has been obtained.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this module, road crossings over streams are ideally suited for baseflow surveys because they can be readily accessed and because they are public lands. Study design and selection of sampling sites are primarily determined by accessibility and predicted locations of major changes in discharge within the watershed (i.e., suspected groundwater discharge zones, sites near the confluence of tributaries, and sites upstream and downstream of water sources or sinks (e.g., outfalls, dams, pumping sites)). Additional discharge sampling sites must be separated by at least 40 m and two crossovers (see Section 1, Site Identification and Documentation).

The following equipment is required:

1. Topographic or road maps with field site locations marked
2. Field sheets (Site Identification Form, Site Features Form, Discharge Measurements Form: Non-Point Transect Methods)
3. Pencils and pens
4. Metre stick and measuring tape
5. Floats (plastic golf balls with holes, cork fishing floats etc.) or food dye
6. Watch and stopwatch

Optional equipment includes field notebooks, calculator and other maps (geology, soils etc.)

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

Reconnaissance surveys should be conducted during low flow conditions. These measurements are best made along any stream section that is of uniform depth (typically from 100 to 400 mm deep) with a level pavement layer that consists of small gravel (5-40 mm) where the flow is relatively uniform[2]. Ideally there should be no obstructions to flow within 5 m of either side of where visual estimates are being made. The module should be done in conjunction with

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[2] These areas are typically found in the transitional area between a riffle and a pool often referred to as a flat or glide.

S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation.

At each site, fill out the site descriptors that identify the unique sample and its location (i.e., ’Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample #’ and ‘Date’). Record whether the flow conditions at the site approximate baseflow conditions[3] , by marking either ‘Yes’ or ‘No’ with an ‘X’ in the box titled ‘DISCHARGE APPROXIMATES BASEFLOW’. Record comments about the site’s suitability for obtaining a measure of discharge in the ‘Comments’ box. Document the names of the crew members and the survey date. Note that measurements are required at only one transect within the site to estimate discharge.

3.1 Direct Measurement of Stream Discharge

If drop structures (e.g., perched culvert, weir, flume) are present, discharge should be measured using the Volume/Time method as outlined in S4.M5, Measuring Stream Discharge Quantitatively. This method provides greater accuracy with little increase in time spent at the site.

3.2 Determining Discharge using Area and Estimated Velocity

Once the location for the observations is defined, determine the area of the wetted cross-section of the channel. Water depths at three equally-spaced locations across the channel are measured to calculate the average depth. Stream width is the wetted width of the stream and is measured to the nearest tenth of a metre. Water velocity is determined by timing the movement of a surface float or food dye over a fixed distance (i.e., 1-2 m). It should be recognized that this method generally overestimates the velocity by about 25% in rough cobble bed streams and 10% in smoother bed streams.

Actual measurements are required unless stream access or safety reasons prohibit the collection of these data[4]. If measurements cannot be obtained, visually estimate the values following the guidelines outlined above.

Record the stream width, average depth and average velocity and the method used (i.e., ‘measured’ versus visually ‘estimated’).

---

[3] Baseflow can be defined as the portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion or other human activities (William et al. 1997). The baseflow conditions exists when there is no evidence in the stage discharge hydrograph of any recent storm events.

[4] A combination of measured and estimated values may be required at some locations.

3.3 Tips for Applying this Module

Crews traveling to many sites in a day may find it more efficient to record multiple observations on a spreadsheet style field sheet and transfer the data to the individual field sheets in the office. Ensure that each site can be uniquely identified and access routes can be documented at a later date. Double check data between the forms for accuracy.

Water depth measurements can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

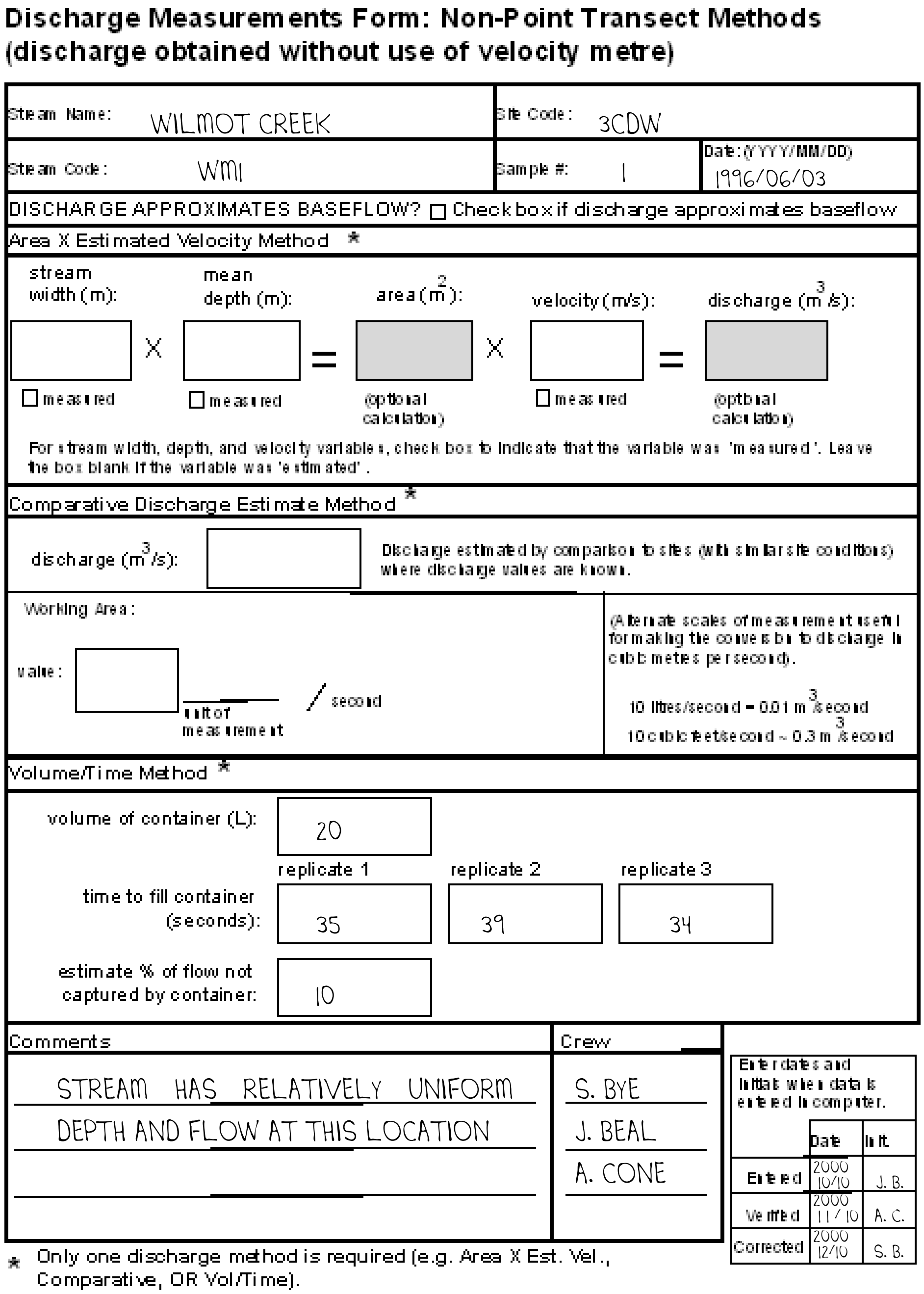
By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

William, J.E., C.A. Wood and M.P. Dombeck (Eds). 1997. Watershed Restoration: Principles and Practices. American Fisheries Society, Bethesda, Maryland. pp 561.

Appendix 1

Example Discharge Measurements Form:
Non-Point Transect Methods



Discharge Measurements Form: Non-Point Transect Methods (discharge obtained without use of velocity metre)

Stream Name: WILMOT CREEK

Site Code: 3CDW

Stream Code: WM1

Sample #: 1

Date: (YYYY/MM/DD) 1996/06/03

DISCHARGE APPROXIMATES BASEFLOW? ☐ Check box if discharge approximates baseflow

Area X Estimated Velocity Method *

stream width (m):		mean depth (m):		area (m^2):		velocity (m/s):		discharge (m^3/s):
	X		=		X		=	
☐ measured		☐ measured		(optional calculation)		☐ measured		(optional calculation)

For stream width, depth, and velocity variables, check box to indicate that the variable was 'measured'. Leave the box blank if the variable was 'estimated'.

Comparative Discharge Estimate Method *

discharge (m^3/s):

Discharge estimated by comparison to sites (with similar site conditions) where discharge values are known.

Working Area:

value: ______ / second

unit of measurement

(Alternate scales of measurement useful for making the conversion to discharge in cubic metres per second).

10 litres/second = 0.01 m^3/second

10 cubic feet/second ~ 0.3 m^3/second

Volume/Time Method *

volume of container (L): 20

	replicate 1	replicate 2	replicate 3
time to fill container (seconds):	35	39	34

estimate % of flow not captured by container: 10

Comments

STREAM HAS RELATIVELY UNIFORM

DEPTH AND FLOW AT THIS LOCATION

Crew

S. BYE

J. BEAL

A. CONE

Enter dates and initials when data is entered in computer.

	Date	Init.
Entered	2000 10/10	J. B.
Verified	2000 11/10	A. C.
Corrected	2000 12/10	S. B.

* Only one discharge method is required (e.g. Area X Est. Vel., Comparative, OR Vol/Time).

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 5

Measuring Stream Discharge Quantitatively[1]

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APPENDICES

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[1] Authors: L. W. Stanfield, M. Hinton and S. Jarvie

1.0 INTRODUCTION

This module contains instructions for measuring discharge in wadeable streams using the Area Times Velocity Method and the Volume/Time Method. This module can be completed individually, or in conjunction with any of the modules that use a transect to collect data.

The amount of water within any stream channel is an important attribute to aquatic biota. Changes in discharge reflect both the natural hydrologic cycle and anthropogenic alterations to this cycle. It is essential to have information about flow conditions in order to understand how changes in flow are related to development and weather patterns.

The data collected are useful for long-term monitoring and impact assessment studies. These procedures can be used for characterizing baseflow conditions or for determining a point-in-time response to a storm event. When applied throughout a storm event, a stage response curve can be developed and used to calibrate the Rapid Assessment Methodology for Hydrologic Response to Storm Events (S4.M6).

If the study objective is to assess causes of stream instability, it is recommended that the bankfull profile (S4.M3, Bankfull Profiles and Channel Entrenchment) and at minimum the substrate component (3.6.6 Substrate Particle Size Distribution) of S4.M2, Point Transect Sampling for Channel Structure, Substrate and Bank Conditions also be evaluated.

The methods described in this module have been modified from Gore (1996) to provide a balance between precision and efficiency. These methods are detailed in manuals produced by Water Survey of Canada (Terzi 1981) and the United States Geological Survey (Rantz 1982). The manuals recommend that more panels be sampled per transect than this module and contain information about site selection, study design and data interpretation. If sites are intended as long-term gauging stations, refer to these manuals as the standard.

The methods described in this module are suitable for streams which have:

- a maximum depth of less than 30 cm along the transect (greater depths require an additional velocity measurements at each observation point)
- sufficient depth to enable the current meter to work effectively or
- discharge low enough that it can be captured in a measuring device (e.g., bucket)

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people (a surveyor and a recorder). Survey time varies with the precision required (number of panels sampled) but typically takes anywhere from 15 to 90 minutes to complete.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment list is required:

1. Discharge Measurements Form: Non-Point Transect Methods and Diagnostic Indicators of Channel Stability field form(on waterproof paper if possible)
2. Pencils
3. Wooden metre sticks
4. Tape measures (30 m or longer)
5. Flagging tape
6. Spikes or tent pegs (four, 25 cm long) or bungee cords
7. Two spring-loaded clamps with rubber edges (to hold tape)
8. Calculator (waterproof, or in resealable bag)
9. Calibrated current meter2
10. Buckets, assortment of sizes (10 – 25 L)
11. Stopwatch
12. Funneling or ramping device to direct water into bucket

Optional equipment includes a tool kit (hammer, duct tape, wrench, screw drivers).

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

---

[2] Although several designs and models of current meter exist, this method specifically describes the use of Price AA and mini (Pygmy) vertical axis flow meter. Other current meters can be used provided they are suitably calibrated and used according to their instructions.

3.0 FIELD PROCEDURES

The module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3 Assessment Procedures for Site Feature Documentation. At each site, fill out the site descriptors (i.e., ’Stream Name’, ‘Stream Code’, ‘Site Code’, ‘Sample #’ and ‘Date’) and record the names of the ‘Crew’. Record whether the flow conditions at the site approximate baseflow conditions[3] (‘DISCHARGE APPROXIMATES BASEFLOW’) on the Discharge Measurements Form: Non-Point Transect Methods (Appendix 1) or the Diagnostic Indicators of Channel Stability field form (Appendix 2), by marking either ‘Yes’ or ‘No’ with an ‘X’. Record comments about the site suitability for obtaining a measure of discharge in the ‘Comments’ box.

The Volume/Time Method (Section 3.1) is used at sites with low discharges that have either a drop structure or sufficient head to enable a drop structure to be temporarily installed. The Area Times Velocity Method (Section 3.2) is used in all other circumstances.

3.1 Measuring Discharge using the Volume/Time Method

For those locations where the stream is sufficiently small and flowing through a drop structure (e.g., perched culvert or weir) or has sufficient head to enable a drop structure to be temporarily installed, a bucket and a stopwatch can be used to measure discharge. In some situations a funnel can be used to direct the water into a measuring device.

Measure the time it takes to collect a known volume of water. Repeat this procedure until three similar times (<10% difference from the average) are obtained (the same volume of water is collected for each of the three measurements). Record the volume and the times on the Discharge Measurements Form: Non-Point Transect Methods (Appendix 1).

There is often leakage and/or spillage associated with this technique that can be minimized by using various tools (i.e., plastic bags[4], funnels, larger measuring device). The amount of water that is missed should be visually estimated and recorded in the appropriate category on the data form.

---

[3] Baseflow can be defined as the portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion or other human activities (William et al. 1997). The baseflow conditions exists when there is no evidence in the stage discharge hydrograph of any recent storm events.

[4] In small shallow channels a plastic bag may be held on the bottom of the cross-section and opened for a short period to capture the flow.

3.2 Measuring Discharge Using the Area Times Velocity Method

For this method fill out the transect identification information i.e., 'Transect #___of ___' on the Diagnostic Indicators of Channel Stability field form. This method can be conducted at one of the transects used in S4.M3, Bankfull Profiles and Channel Entrenchment, preferably where the flow is most uniform,.

It is important to have a calibrated current meter[5] and the following sampling conditions at each transect (adapted from Rantz 1982):

- water depth is greater than 0.1 m at all observation points along the transect;
- flow is uniform, constant over time and greater than 0.1 m/s at all observation points;
- flows are free of eddies, slack water and excessive turbulence, approximating laminar in the sample area; and
- the streambed is relatively uniform and free of obstacles (i.e., boulders, heavy aquatic growth or mid channel islands within 5 m of the transect).

Where these criteria are not met, first consider whether minor modifications (e.g., relocating an upstream rock or moving to an area with less aquatic growth) may correct the problem. Second, if velocity is heterogeneous, consider whether the discharge can be measured by increasing the number of panels. Finally, the transect can still be established if the area that does not meet the above criteria is relatively small (i.e., less than 10% of the cross-sectional area). For example, large velocity variations (and shallow depths) near the stream edges are common, yet quantifying flows in these areas with accuracy may be of minor importance if the proportion of flow in these sections is only a small fraction of the total discharge. Where these point observations cannot be measured using a velocity meter, the hydraulic head can often be used as a coarser measure of the velocity (see below).

The spacing of observation points and the intensity of sampling at each point will influence the accuracy of the discharge estimate. Guidance on spacing is provided in Table 1. Use as many panels as necessary to capture the variance in velocities in the channel. Project managers must determine the desired accuracy of the survey, as this influences the number and duration of velocity measurements. For further information consult the Hydrometric Field Manual – Measurement of Streamflow (Terzi 1981).

---

[5] Current meters should be regularly checked to ensure that impellors are intact and spin freely and evenly. Refer to specifications stipulated by the manufacturers.

3.2.1 Setting up the Transect:

Transects should be established perpendicular to the general direction of flow. To set up the transect, stake both ends of a tape measure into the banks so that it is reasonably level and taut.

Measure and record the active channel width (see definition below) to the nearest 0.1 m on the Diagnostic Indicators of Channel Stability field form. Divide the active channel width by the number of observation points (Table 1) to determine panel width. Sampling will be conducted at the mid-point of each panel (see example below and Figure 1). Mark the location of each observation point on the tape measure and record the 'Horizon. Loc (m)' to the nearest 0.05 m.

Table 1: Relationship Between the Stream Width and the Number of Panels to Sample for Low Variance and High Variance Sites.

Channel Width (m)	Number of Panels to Sample	
	Transects with Low variance in velocity	Transects with High variance in velocity
> 3.0	minimum 8*	minimum 10*
1.5 – 3.0	5	8
1.0 – 1.5	3	6
< 1.0	2	4

* Add one panel for every 2 m increase in stream width i.e., 9 m wide = 11 (low variance) or 13 (high variance) panels.

Active Channel

The active channel is the area between the two outermost banks, which includes all active flow (i.e., moving water) at the time of the survey. The transect boundaries are at the bank-water interface (i.e., where the water meets the land; when undercuts are present, see Figures 4 and 5).

Rules for defining the active channel:

1. Side channels or braids are included if both the inlet and outlet occur within the sample site.
2. Only the mouth of a tributary is included, i.e., the transect does not extend over a bank.
3. Backwater pools (wet areas adjacent to the active channel that are fed by intergravel flow) are included if they are located within the high flow channel, are located below the top of bank, and there is visible flow from the pool into the stream.
4. Mid-channel bars and islands are included in the cross section (Figure 3).

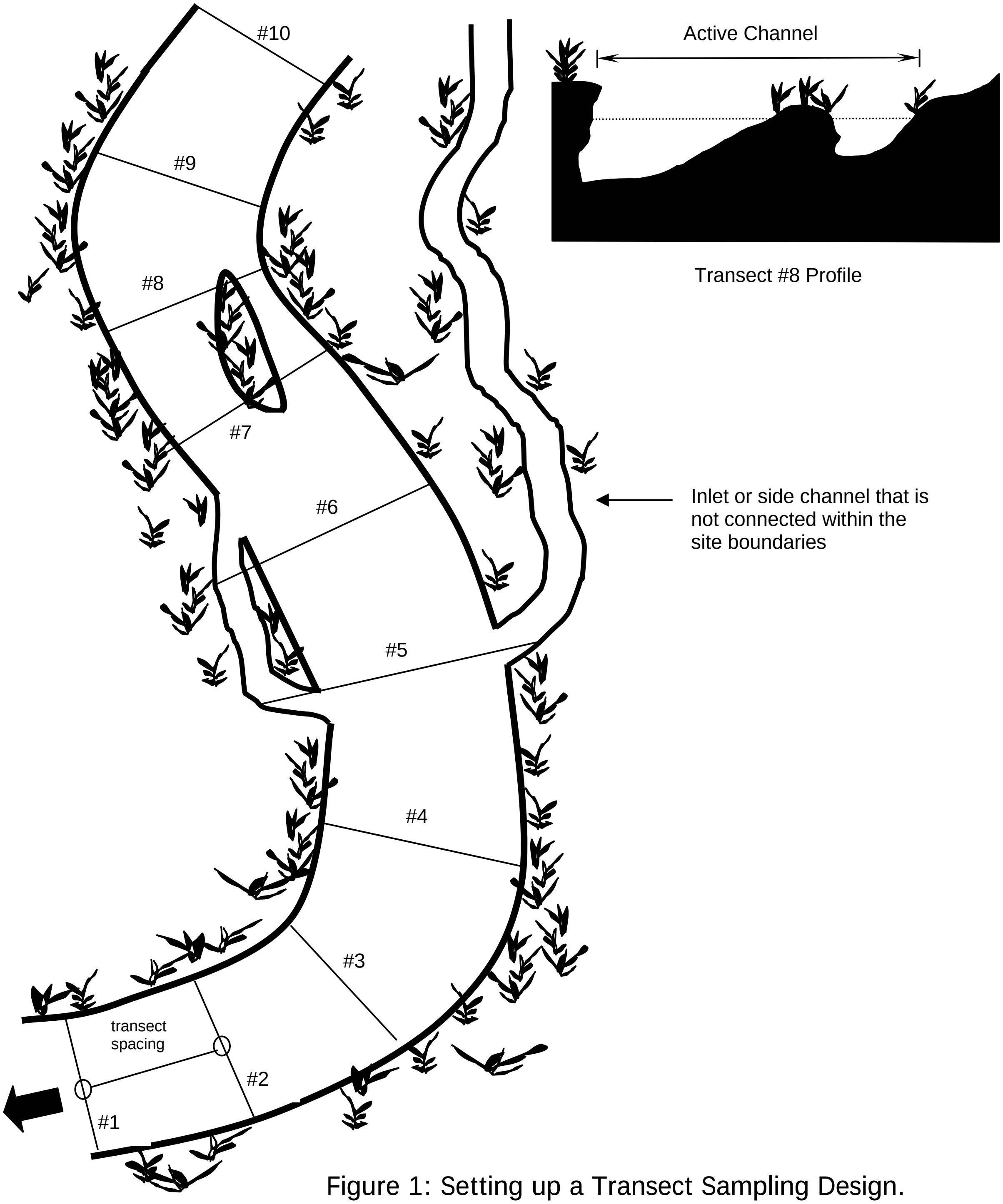

Figure 1: Setting up a Transect Sampling Design.

The thalweg can often be used to assist in determining the appropriate orientation of the transect (angle relative to channel). Transect lines 5 and 6 cross a side channel that is connected within the site and 8 crosses an island. These are considered a part of the active channel. Transect line 5 crosses a side channel that is not connected within the boundaries of the site; and this side channel is therefore not considered to be part of the 'active channel'.

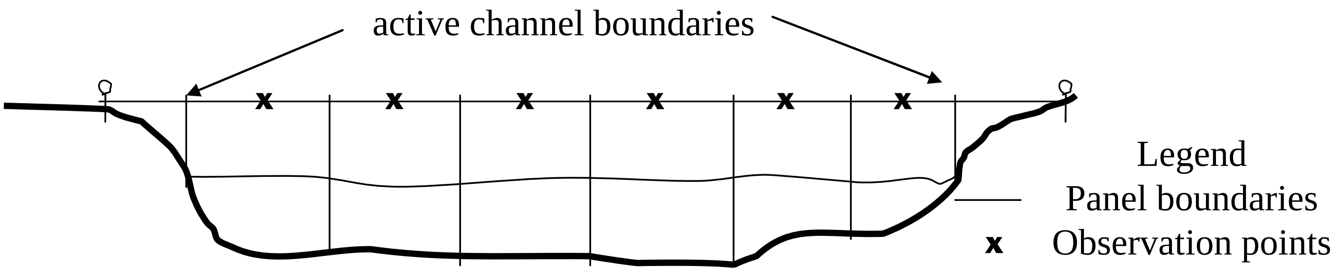

Figure 2: Setting up a Transect Line and Locating the Active Channel

Observation Point Calculation Example

For a stream that has an active channel width of 2.9 m wide, and low variance in velocity, five panels are sampled. The point spacing would be 2.9/5 = 0.58. This number actually represents the boundary of a set of panels that transect the stream, with each observation point located in the centre of each panel. To determine the actual location of the observation points, divide the first panel in half, and for each additional location add 0.58. The first observation point would be at 0.29 m (i.e., 0.58/2 = 0.29). The second point would be at 0.29 + 0.58 = 0.87 m. The complete list of observation points is 0.29, 0.87, 1.45, 2.03 and 2.61 m.

Note: Observation point locations are dependent on whether the tape extends beyond the bank water interface. For example if the left bank water interface occurs at 1.5 m on the tape then the first observation point for the above example would be at the 1.79 m mark on the tape.

The following data are collected at each observation point. Use the most efficient sampling strategy to obtain the data.

3.2.2 Measuring Water Depth

At the observation point, stand the metre stick on the stream bottom and measure the water depth in mm to the nearest 5 mm. Record this depth on the Diagnostic Indicators of Channel Stability field form (Appendix 2).

3.2.3 Measuring Water Velocity

Set the height of the velocity sensor to 0.4 times the depth of the water from the stream's pavement layer and record this 'Observation Depth (mm)' to the nearest 5 mm (i.e., if water depth is 200 mm, the sensor would be placed at 0.4 x 200 = 80 mm from the stream bottom).

The current meter rod should be held vertical and the operator should stand far enough downstream so that the velocity readings are not affected. Once the flows have stabilized, measure the velocity for 60 seconds and record the number of rotations (‘Turns/Min’) over that period[6]. Depending on the unit used, record either the average velocity (‘Velocity (m/s)’) or the number of rotations. **Ensure that the number of rotations is converted to a velocity measure using the calibration table for that particular meter and record this on the field form as soon as possible.**

If water depth is insufficient to obtain a quantitative measure of velocity at an observation point, measure the hydraulic head and record this in the ‘Turns/min’ column. Mark this with an asterisk and record in the ‘Comments’ that this refers to a hydraulic head measurement. To measure hydraulic head, orient the wooden ruler at the observation point so that it is vertical and the **wide side with the markings is facing away from the current** (see Figure 3). Avoid standing in front or too close behind the ruler as this can obstruct the flow. The ruler will create a barrier to flow causing the water to climb up the front of the ruler. The height the water climbs is referred to as the hydraulic head. If there is no difference in water level between the front and back of the ruler then hydraulic head is 0, indicating very low velocity. If a difference in height is observed, then measure the height difference between the front and back of the ruler (Figure 3) in mm as observed or rounded to the nearest 5 mm. It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the differences out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down). Measure the maximum height difference observed over a 3-5 second period.

Use the following formula to estimate velocity (v) in m/s from hydraulic head (HH, measured in mm):

$$v = 0.625\sqrt{0.02(HH)} \qquad \text{(modified from Rantz 1982)}$$

Therefore, if the hydraulic head was measured as 15 mm, the estimated velocity is approximately 0.625 $\sqrt{0.30}$ or 0.36 m/s.

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[6] In some situations it may be feasible to sample for less than 60 s, where flows are stable. In these situations make sure to sample for at least 30 s and then standardize (i.e., multiply by 2) the rotations to 1 minute.

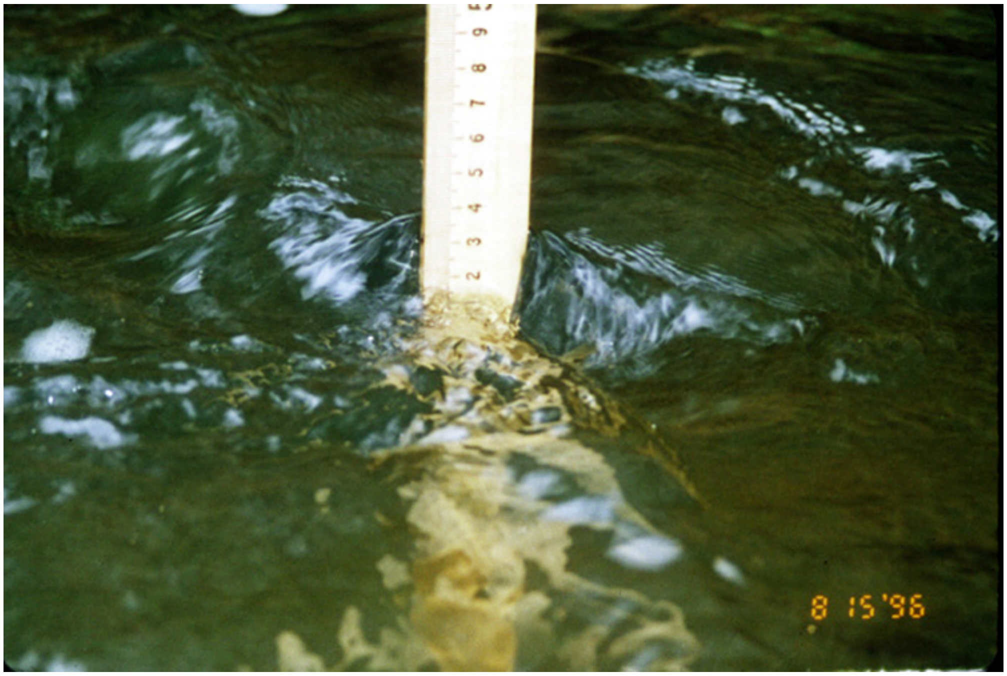


Figure 3: A Point Measurement of Hydraulic Head
The upstream reading is measured as 35 mm, the downstream as 16 mm, therefore the hydraulic head is 19 mm, which can be recorded as 19 or 20 mm (rounded to nearest 5 mm).

3.3 Tips for Applying this Module

All depth measurements (water, hydraulic head) can be either recorded as observed (i.e., 18 mm) or can be rounded to the nearest 5 mm (i.e., 20 mm), whichever is easier for the crews. The accuracy of these measures is considered to be 5 mm for all interpretations.

Tie several pieces of flagging tape loosely on the tape measure that can be slid to each observation point.

Do not forget to use the protective brake or travelling pin on the current meter when in transit and to remove these prior to use in the stream. Keep the current meter well lubricated and turning freely.

Make sure the tape is reasonably level and taut. Clamps or a bungee cord can be used at the handle ends of the tape measure to tighten the tape. Once the tape has been stretched, lock the handle in place and anchor the bungee cord to the nearest solid object.

Always double-check the spacing of the observation points before starting to record the data.

Mark all field equipment with bright paint or flagging tape to increase visibility and prevent loss.

A top setting wading rod will save a great deal of time in setting up the rod to take the velocity measurements.

Make sure that all fields have data recorded before taking down the tape measure.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Gore, J. A. 1996. Discharge Measurements and Streamflow Analysis. *in* Hauer F. R. and G. A. Lambert (ed.) Methods in Stream Ecology. Academic Press. p 53- 74

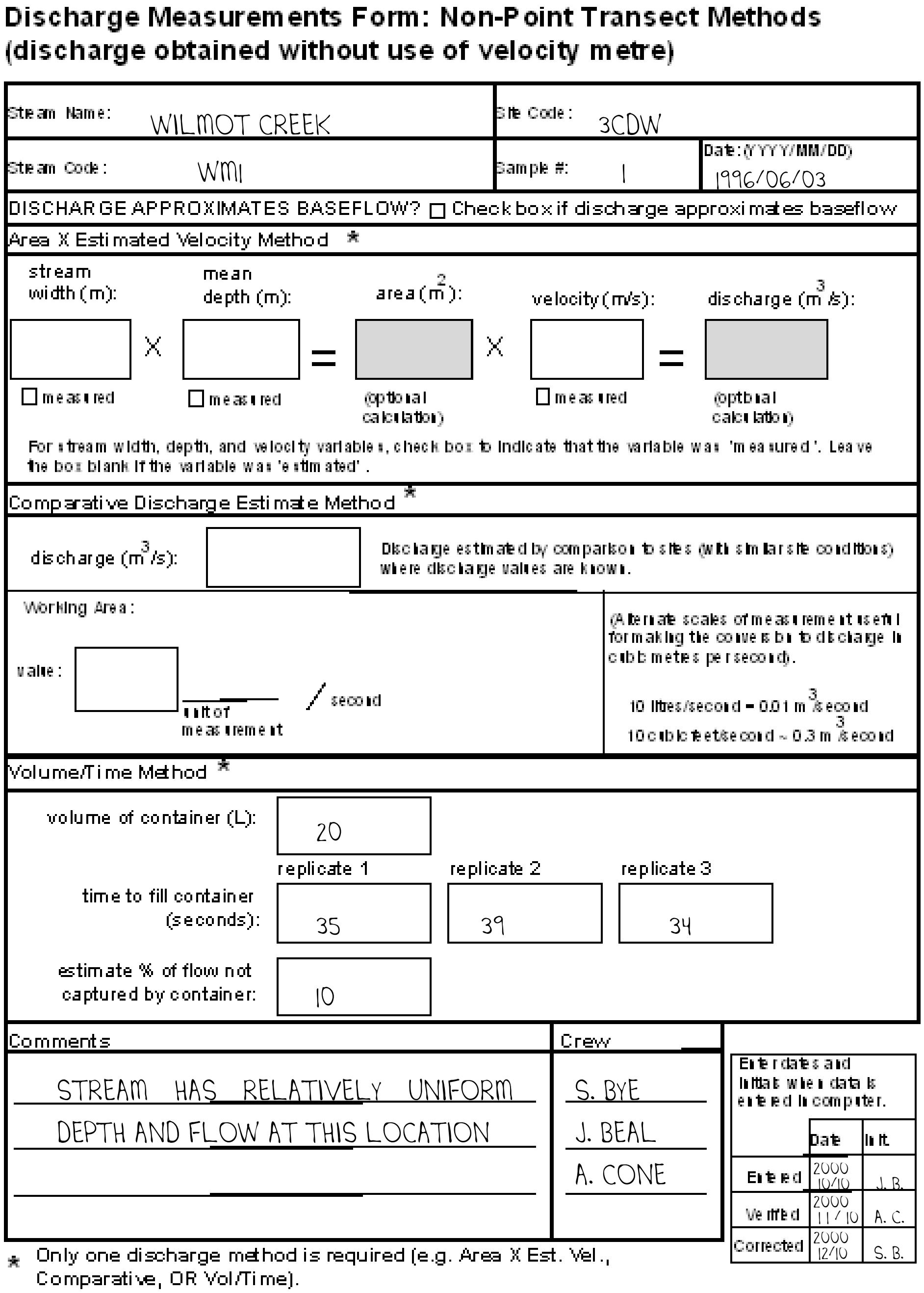
Rantz, S.E. 1982. Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge. Geological Survey Water-Supply Paper 2175. U.S. Government Printing Office, Washington, D.C. 284 pp.

Terzi, R.A. 1981. Hydrometric Field Manual - Measurement of Streamflow. Inland Water Directorate, Water Resources Branch, Environment Canada, Ottawa, Ontario, 37 pp.

William, J.E., C.A. Wood and M.P. Dombeck (Eds). 1997. Watershed Restoration: Principles and Practices. American Fisheries Society, Bethesda, Maryland. pp 561.

Appendix 1

Example Discharge Measurements Form: Non-Point Transect Methods, Volume / Time Data



Discharge Measurements Form: Non-Point Transect Methods (discharge obtained without use of velocity metre)

Stream Name: WILMOT CREEK	Site Code: 3CDW		
Stream Code: WM1	Sample #: 1	Date: (YYYY/MM/DD) 1996/06/03	

DISCHARGE APPROXIMATES BASEFLOW? ☐ Check box if discharge approximates baseflow

Area X Estimated Velocity Method *

stream width (m): ☐ measured × mean depth (m): ☐ measured = area (m^2): (optional calculation) × velocity (m/s): ☐ measured = discharge (m^3/s): (optional calculation)

For stream width, depth, and velocity variables, check box to indicate that the variable was 'measured'. Leave the box blank if the variable was 'estimated'.

Comparative Discharge Estimate Method *

discharge (m^3/s):

Discharge estimated by comparison to sites (with similar site conditions) where discharge values are known.

Working Area:

value: ______ / second
unit of measurement

(Alternate scales of measurement useful for making the conversion to discharge in cubic metres per second).

10 litres/second = 0.01 m^3/second
10 cubic feet/second ~ 0.3 m^3/second

Volume/Time Method *

volume of container (L): 20

	replicate 1	replicate 2	replicate 3
time to fill container (seconds):	35	39	34

estimate % of flow not captured by container: 10

Comments
STREAM HAS RELATIVELY UNIFORM
DEPTH AND FLOW AT THIS LOCATION

Crew
S. BYE
J. BEAL
A. CONE

Enter dates and initials when data is entered in computer.

	Date	Init.
Entered	2000 10/10	J. B.
Verified	2000 11/10	A. C.
Corrected	2000 12/10	S. B.

* Only one discharge method is required (e.g. Area X Est. Vel., Comparative, OR Vol/Time).

Appendix 2

Example Diagnostic Indicators of Channel Stability Field Form, with Velocity Data

The crew determined that the site was 5.25 m wide and there was minimal variance in the depth and velocities across the profile. Therefore, nine (minimum 8, + 1 observation point because the stream is 2 m wider than 3 m) equally-spaced observation points were established. The transect was set up such that Point-transect Sampling for Channel Structure, Substrate and Bank Conditions (S4:M2) measurements could also be conducted. The tape was set up at 1.5 m from the left bank. Note that the depth of water was insufficient to use the velocity meter at the 10th measurement mark. Therefore hydraulic head was measured here as identified by the asterisk and notation in the comments. Velocity was later determined for this observation using the formula provided earlier in the module.

Diagnostic Indicators of Channel Stability Form

Transect No. 1 of 1

Stream Name	Stream Code	Site Code	Sample	Date (yyyy/mm/dd)
WILMOT CREEK	WM1	3CDW	1	2000/08/10

Crew Leader	Crew	Recorder
J. BEAL	A. CONE, S. BYE	S. BYE

Comments
* OBSERVATION POINT TOO SHALLOW, HYDRAULIC HEAD MEASURED INSTEAD

Transect and Point Layout

Use this table to determine the number of measured points per transect, given the minimum stream width

Min. Width (m)	Low Variance in Velocity or Depth	High Variance in Velocity or Depth
>3.0	8 + 1 every 2m	10 +1 every 2m
1.5-3.0	5	8
1.0-1.49	3	6
<1.0	2	4

Point Spacing = Active Channel Width / Points Per Transect

1st Point = Point Spacing / 2 (from left bank)

Site and Transect Measurements

Site Length (m)*	44.2
Transect Spacing (m)*	4.91
Active Channel Width (m)	5.25
Point Spacing (m)	0.58

*Record only on 1st transect

×

Discharge Approximates Baseflow?

☐Yes ☐No

Obstructions to Flow
× (check all applicable)

- ☐ None
- ☐ Trampled Banks
- ☐ Wood Deflectors
- ☐ Inorganic Deflectors
- ☐ Armouring
- ☐ Inlets
- ☐ Other: _________

Indicators of Bankfull Level

Left Bank	Right Bank	
☐	☐	Inflection Point
☐	☐	Bank Material
☐	☐	Top of Point Bar
☐	☐	Vegetation
☐	☐	Min. Width:Depth
☐	☐	Other:___________
☐	☐	___________

Measures of Channel Entrenchment*

*Record either left, right, or total width

Left Entrenchment Width (m)	
Right Entrenchment Width (m)	
Total Entrenchment Width (m)	

Entrenchment Height = 2 x Max. Channel Depth

Entrenchment Width = horizontal distance from location of max. channel depth to bank at entrenchment height

	Horiz. Loc (m)	Vert. Ht. (mm)	Ht. Represents Bankfull?		Velocity Meter Type	Depth Ratio Used
Left BFD			☐Yes	☐No	Marsh McBirney	☒ 0.4 ☐ 0.2/0.8
Right BFD			Velocity Measurements			
Max. Chann. Depth			Water Depth (mm)	Observ. Depth (mm)	Turns/Min	Calc.	Velocity (m/s)

	Horiz. Loc (m)	Vert. Ht. (mm)	Water Depth (mm)	Observ. Depth (mm)	Turns/Min	Calc.	Velocity (m/s)
Left Active Chann.	1.50		0	———	———	———	———
Right Active Chann.	6.74		0	———	———	———	———
Obs. 1	1.79		300	180	———	———	0
2	2.37		405	210	———	———	12.2
3	2.96		515	309	———	———	20.6
4	3.54		310	205	———	———	18.8
5	4.12		235	141	———	———	15.9
6	4.71		190	120	———	———	16.8
7	5.29		160	96	———	———	18.8
8	5.87		175	100	———	———	15.4
9	6.45		50	———	———	———	0.55*

Obs.	Horiz. Loc (m)	Vert. Ht. (mm)	Velocity Measurements Water Depth (mm)	Observ. Depth (mm)	Turns/Min	Calc.	Velocity (m/s)

Entered	Verified	Corrected
L.A.	J.B.	S.C.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 6

Crest Stage Gauges: Rapid Assessment of Response to Storm and Drought Events[1]

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Appendices

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[1] Authors: L.W. Stanfield

1.0 INTRODUCTION

This module describes a low-cost method (using a crest stage gauge or CSG) for measuring the maximum or by subtraction minimum depth of stream flows that occur between two visits. This provides information on responses to flow events (rainfall or snow-melt) or by tracking decreases in stage over time, the response to drought. The measures can be converted to the area of a channel occupied by flow during the period of time between visits to a site, but this requires additional data collection and some calculations. In addition, temporal measurements enable the preparation of a stage height graph (depth of water over time) and indicate how quickly the system responds and recovers from a storm event (flashiness). Flashy streams have fast response times, high peak flows and are more prone to erosion problems such as scouring, undercutting and bank collapse. Comparisons can be made among sites on the same stream or to reference locations in order to detect impacts.

This approach is complementary to approaches which provide continual measures of stage height such as are employed at traditional water survey gauging stations or technologies such as pressure transducers. In fact several studies have used CSG's at locations where pressure transducers are employed as a validation mechanism for maximum stage depth.

Measures of stage height can be converted to estimates of stream discharge by developing a stage response curve for each site. This is achieved by using module S4.M5, Measuring Stream Discharge Quantitatively, under varying flow conditions that include high flows and developing a line of best fit between the stage and discharge measures. Alternatively, stage response can at minimum be converted to a measure of the cross-sectional area of channel occupied by water at the peak stage discharge. This is achieved by linking the CSG measures to a detailed cross-sectional profile of the stream channel (S4.M3, Bankfull Profiles and Channel Entrenchment) (see Stanfield 2009 for details). Measures of wetted channel area can be converted to measures of discharge by estimating the average velocity using Manning's equation (Manning 1891 - see Stanfield 2008 for details).

This module can be used on any stream where the crest stage gauge can be anchored and protected to withstand a storm event.

2.0 PRE-FIELD ACTIVITIES

A typical crew consists of two people and survey time varies with the number of readings. Each reading takes approximately 1 minute to perform. Installation of the crest stage gauge (PVC pipe) requires 10 to 30 minutes.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment list is required:

1. Water level record (ideally on waterproof paper) for individual or group readings
2. Pencils
3. Metre stick
4. Clear plastic pipe (approx. 4 cm diameter), cut to a minimum height of bankfull depth + 0.5 m
5. 2 pieces rebar (3 foot long minimum)
6. 4-6 tie cables
7. 1 hammer for putting in rebar
8. 1 plastic bottle or other capping device
9. 1 meter stick
10. Flagging tape or other marker to identify reference pipe
11. Tape measure and 2 stakes
12. Talc-based baby powder (i.e., hypoallergenic)
13. Water and rag for dampening inside of pipe and cleaning

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

The module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation. At each site, fill out the site descriptors (i.e., 'Stream Name', 'Stream Code', 'Site Code', 'Sample #' and 'Date'). These data should also be recorded in the appropriate fields on the Water Level Record.

The crest stage gauge used in this module consists of a clear pipe that is coated on the inside with baby powder (Figure 1). The powder dissolves as the water rises, leaving a mark on the pipe at the maximum depth attained during an event. Conversely, if water levels drop over time the observed water level will be lower than the mark on the pipe when it was installed. If the device is being deployed to generate a stage response curve the sampling should follow a time schedule dictated by the hypothesized shape of the curve for a stream.

The crest stage gauge can be installed at any time and left in place throughout the study. Stream responses can be measured several times during a season with each storm event being a separate sample comprised of multiple readings. Drought responses can also be recorded over time as these are indicated as the change (decrease) in water depth between two observation points. The survey results from each hydrologic event represent a sample for this module. For example, regardless of whether sampling occurs once or multiple times during a storm event, all of the data are recorded as one sample (see Appendix I). Multiple observations recorded during a single rain or drought event are considered replicates. Two field sheets are provided for this module; one for individual records associated with a flow events (Water Level Record Field sheet for single observation rain events); and another for replicate observations within a single event (Water Level Record Field sheet for replicate observations on individual rain events).

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Figure 1: Crest stage gauge attached to both rebar and a tree

3.1 Overview of Sampling Procedures

Step 1: Ensure that site documentation information is completed to the degree of detail required by the study being conducted (Section 1).

Step 2: Install a crest stage gauge (CSG) in an appropriate location within the site (e.g. that provides protection from debris/vandals and has uniform channel depth and bank heights (e.g., close to a crossover). Label one of the rebar stakes as a reference bar. Wet the inside of the CSG using a rag and coat it with baby powder.

Step 3: Take initial measures of the CSG including; current water depth and distance from the reference rebar to the top of the CSG. If stream response is to be converted to a measure of area of wetted channel, conduct a detailed cross-sectional profile of the channel at the CSG location following methods described in S4.M3: Bankfull Profiles and Channel Entrenchment.

Step 4: Once an event has occurred or is in progress, return to the CSG to capture the response in the stream during or following an event (e.g. rainfall, melt or drought) as dictated by study design. Record the stream response and existing water level conditions as well as the distance of the top of the CSG to the reference rebar. Reset the CSG.

Step 5: If required, record the appropriate measure of the event condition. Examples include the depth and duration of rainfall; number of days without rainfall; depth and duration of snowmelt.

3.2 Installing the Water Level Gauge

Prepare the clear plastic CSG for installation by drilling four 6 mm holes on two sides of the bottom end of the pipe. This will ensure the free flow of water into the pipe and prevent it from becoming plugged with sediment or debris. Plastic pipe can be purchased from central vacuum supply companies and generally comes in 8 foot lengths. Pipe length is determined by the stream type but should exceed bankfull height by at least 0.5 m.

Place a label with information about the CSG's purpose, owner, contact information and the station's unique site code near the top of the pipe.

Select a location where flows are constricted and a similar bank profile exists on both sides of the stream. If multiple locations within the stream meet these criteria, try to select a sheltered location that offer the CSG protection from debris flows etc. Attach the CSG to an existing structure such as a tree or fence post and/or drive at least two pieces of rebar (or other stakes) into the substrate at a sufficient depth to stabilize the CSG. Rebar should be placed at right angles to the flow (Figure 1). It is not critical that the CSG be perfectly vertical provided subsequent measurements are taken using a ruler held vertically. Tie the CSG firmly to the rebar stakes using zip ties and pliers. If the stream is expected to have high sediment loads, a 1 cm gap should be left between the stream bed and the bottom of the pipe; this will reduce the potential for the pipe to become clogged and impede water from entering the pipe.

Mark one of the stakes (or place a mark on a tree, fence post, etc.) to identify the reference height (top of rebar). This mark is used to confirm that the CSG has not moved vertically in the time between visits. Clean and dampen the CSG with water and a wet cloth tied to the end of a stick as long as the pipe (e.g. a meter stick). Wait 10 to 20 seconds or until the inside is damp but not dripping and squirt a talc-based baby powder into the pipe (sold as hypoallergenic baby powder). Note that cornstarch-based powder should not be used as slugs and worms are attracted to the powder and will remove it from the inside of the pipe. Once powder is applied, place a cap (e.g. plastic bottle) over the pipe to keep precipitation from dissolving the powder. The cap should fit snugly but not be so tight as to create a vacuum. Plastic water bottles, particularly those that are hourglass shaped work well for this purpose. If possible, slide one side of the cap between the stake and the CSG to help keep it in place.

3.3 Initial Crest Stage Gauge Readings

Take the following initial measurements.

1. Total length of the CSG pipe (mm).
2. Vertical distance from the top of the CSG to the top of the reference stake or mark. If the top of the CSG is below the reference point, record the distance as a negative number (e.g., -150 mm).
3. Vertical distance from the bottom of the CSG to the current water level (include the measurement to the stream bed if the stream is dry and record a negative depth if the water level is below the bottom of the CSG). If the stream is dry record the water depth as -99 (i.e., it is dry and you can’t measure this attribute).

Hint: It is much easier to manage the data (not have to remember whether it is +ve or –ve) if all pipes are set up so that the stake is below the pipe.

Record each of these measurements to the nearest 1 mm on the ‘Water Level Record Field Sheet for CSG Installation’ (Appendix I).

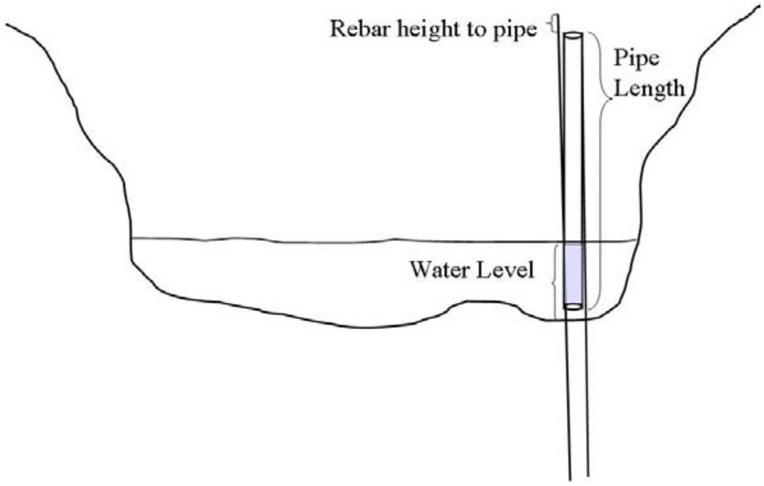

Figure 2: Initial measures to be taken on installing a crest stage gauge.

3.4 Determining and Documenting the Hydrologic Response

The study design will dictate the timing of subsequent samples. Upon revisiting the site, measure the stream response by taking a measurement from the bottom of the tube to the middle of the line that demarcates the stage height (i.e., the extent of dissolved powder) (Figure 3). Measurements are made at the mid point of the CSG to accommodate differences in water levels between the front and back of the CSG (e.g., hydraulic head). Note that above this line the powder may appear to be “clumped”. This occurs when water rises up the sides of the CSG but as no lateral flow through the pipe exists powder does not dissolve. Also record the distance from the top of the CSG to the top of the reference mark.

Once a reading has been taken from the CSG, check to ensure it is still secure and take any steps to re-secure it if necessary[2]. Clean and reset the CSG with powder as described above then measure and record the current distance from the bottom of the pipe to the water line and distance from the top of the CSG to the reference mark. In most instances this measurement will not have changed from the previous observation.

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[2] Note: if the readings are being used to generate wetted area of stream per event, make sure the reference rebar itself does not move, or if it must be moved, then re-measure the distance from the reference point to the tape height.

Figure 3: Example of Crest Stage Gauge with response

Record all data to the nearest millimetre.

The following data must be recorded for each sampling event: ‘Date (YYYY/MM/DD)’, ‘Time (24hr clock)’.

3.5 Tips for Applying this Module

Mark all sampling equipment to reduce the potential for tampering/vandalism.

If possible, place the CSG in shade to reduce condensation and the potential for streaking or dissolving of the powder.

Make sure caps fit snugly but do not prevent air exchange.

Have a selection of rebar/stake lengths so that the rebar can be driven far enough into the stream bed to provide support and still leave a sufficient length to tie the CSG to the rebar at several locations.

Make sure to mark the site code on the CSG for ease data recording and to prevent errors.

Mark the reference rebar for consistency of repeat measurements.

Place the CSG higher off the stream bed and consider putting more holes in the pipe in high silt load streams to prevent the base from becoming clogged with sediment.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Manning, R. 1891. On the flow of water in open channels and pipes. Institute of Civil Engineering, Ireland Transactions 20: 161-207.

Stanfield, L. W. 2009. Understanding the factors that influence headwater stream flows in response to storm events. University of Toronto, Masters Thesis. 75 pp. + appendices.

Appendix 1

Example Field Sheets for Initial Observations and Events

Water Level Record Field Sheet for CSG Installation

Page _1_ of _1_

Stream Name	Stream Code	Date	Crew
WHITEMANS CREEK	WHM	2009/07/23	S. SALAR, S. TRUTTA

Site Code	CSG length (mm)	Reference rebar height[1] (mm)	Distance from bottom of CSG to water level (mm)	Distance from reference pt. to tape[2] (optional)	Comments: (justify negative numbers)
WHM1	1010	37	25	229	
WHM2	1225	-125	32	325	TOP OF CSG IS BELOW THE REFERENCE REBAR
WHM3	1001	78	-15	118	WATER LEVEL IS BELOW THE LEVEL OF THE CSG
WHM4	1500	226	0	-115	REBAR BELOW BANKFULL,WATER LEVEL AT CSG BASE
WHM5	1350	35	-99	195	DRY STREAM

Notes: 1 If CSG is lower than the rebar record as a negative number
2: If rebar is lower than the bankfull height (tape measure) record as a negative number.

Water Level Record Field sheet for CSG Event Data Sheet

Page 1 of 1

Stream Name: WHITEMANS CREEK

Stream Code: WHM

Date: 2009/07/31

Crew: S. SALAR, S. TRUTTA

Event Identification: RAINFALL ONE

Event Description: 65 MM HIGH INTENSITY THUNDER STORM

Site Code	Sample	Replicate	Time: (2400)	Height bottom of tube to response height (mm)	Height rebar to top of tube (mm)	Reset height bottom of tube to water level (mm)	Reset height rebar to top of tube[1] (mm)	Comments (readability, reliability, cap on, etc.)
WHM1	1	1	1030	59	37	35	37	
WHM2	1	1	1050	310	-123	45	-123	
WHM3	1	1	1100	1001	85	15	78	RESET PIPE AND TIGHTENED TIES, ADDED TWO NEW TIES
WHM4	1	1	0930	1500	226	750	-115	STREAM STILL HIGH, CONTINUE TO CHECK
WHM4	1	2	1110	1315	226	750	226	
WHM4	1	3	1230	916	226	750	226	
WHM4	1	4	1430	626	226	750	226	
WHM4	1	5	1700	108	226	750	226	
WHM4	1	6	1915	5	226	750	226	

Note: 1. if rebar higher than tube record as negative number.

Appendix II

Measuring Cross Sectional Profiles

In many situations study designs will dictate that the CSG data be converted to a measure of the wetted cross sectional area of channel occupied by water for each event. This requires a detailed profile of the channel that can be referenced back to the CSG stage measurements through the reference rebar or other mark. Details regarding these measurements are provided in S4.M3, Bankfull Profiles and Channel Entrenchment.

The cross sectional profile of the channel is carried out at right angles to the flow and at the location of the CSG (Figure 3) with the caveat that **the tape measure must be extended across the bank at a height equal to or greater than the highest anticipated flows during the study period** (often exceeds bankfull height). Ensure that the tape is kept level during the survey as deviations could introduce errors in measures of cross sectional area[3]. Measure the depth of the channel at every inflection point in the cross-sectional profile such that no more than a 5 cm change in stream bed elevation occurs without being captured. This represents the most detailed level of application of S4.M3, Bankfull Profiles and Channel Entrenchment. The data is used to determine the area of the channel that is wetted during each hydrologic event (Figure 4).

To tie the observations to the CSG readings, measure the distance to the tape from the reference rebar (TR in Figure 4). In making these measurements, it is important to note whether the reference rebar is above or below the tape height. In keeping with the convention mentioned earlier, record a **positive** number for the height of rebar if it is above the tape. If the rebar is below the tape record the distance to the tape as a **negative number**.

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[3] Use of a laser level provides an easy means of facilitating this task.

Figure 1: Conducting a bankfull profile at a crest stage gauge within a headwater stream

For each event, the dry channel height is determined as follows (Figure 4):

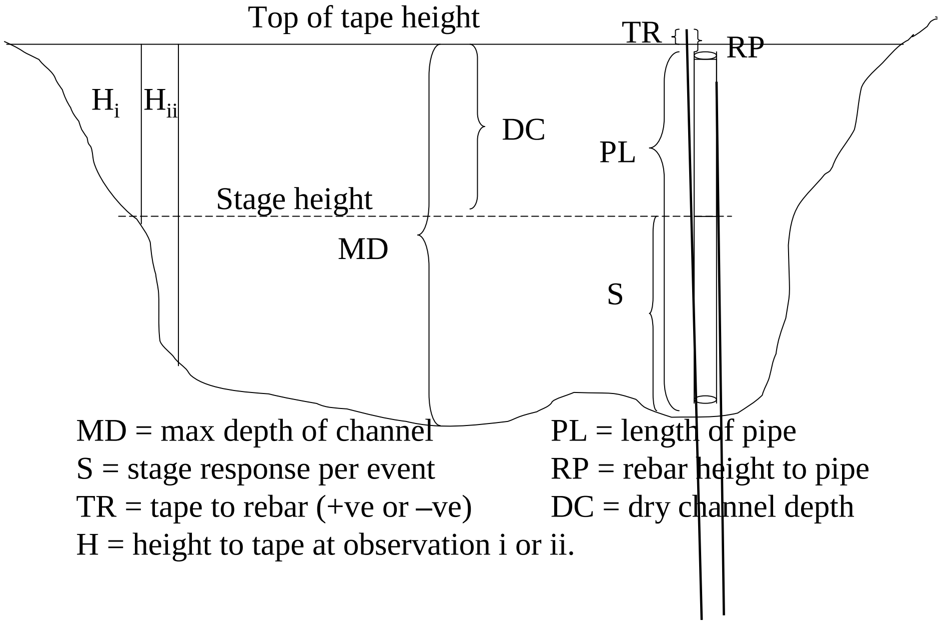
$$DC = PL - (S + RP + TR)$$

Equation 1

TR (distance between tape measure and reference point) must be adjusted for each event to account from movement between samples. To do this subtract the difference in the RP ($RP_{beginning}$ –RP_{event}) from the TR (i.e., (TR – ($RP_{beginning}$ –RP_{event}))).

TR Adjustment Example: If the initial TR was 230 mm and the reference heights were 205mm when the bankfull profile was measured and 207mm for a hydrologic event, the TR value used to calculate dry channel depth for the event would be 232 mm or (230mm-(205mm-207mm)).

The area of wetted channel for each event is calculated by subtracting the area of the stream that remains dry from the overall cross-sectional area. This should be calculated one “panel” at a time. For details of this approach and example algorithms for extracting the data using Excel see Stanfield (2009).



MD = max depth of channel
S = stage response per event
TR = tape to rebar (+ve or –ve)
H = height to tape at observation i or ii.

PL = length of pipe
RP = rebar height to pipe
DC = dry channel depth

Figure 4: Field measurements necessary for linking CSG measures to channel profiles. Ensure that all data are obtained upon installation of the CSG.

Appendix III

Quantifying Precipitation for an Event

If linking stream response to precipitation events is a study objective, a reliable measure of the amount and intensity of precipitation that fell in the upstream catchment of the site is necessary (at minimum). Storm events can be highly variable and localized and the amount of runoff reaching the stream varies with soil conditions, geology, land use, catchment size, time of year, etc.). Specific needs will vary depending on the desired precision of results however it is recommended that surveyors consider placing rain gauges in the study catchment area to augment weather station data and capture local variation in rainfall. Gauges should be placed at least 30 m from any tree or object likely to intercept precipitation. If the study objectives target more widespread events, precipitation data can be obtained from the Environment Canada web page (http://www.ns.ec.gc.ca/msc/em/land_climate.html).

Record the amount of precipitation (to the nearest mm) and the duration (to the nearest 0.25 hours) for the storm or drought event.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 7

Standardized Procedures for Measuring Site Slope[1]

TABLE OF CONTENTS

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[1] Authors: L. W. Stanfield,

1.0 INTRODUCTION

This module provides instructions for measuring changes in the elevation of the stream bed or water surface between two or more locations within a site. When combined with site length, the techniques are useful for measuring the average slope of the bed and the water surface in a site. The methods are also appropriate for characterizing the variation in bed elevation and water surface gradient within a site if differences in elevation between specific morphologic features (i.e., riffles versus pools) are recorded. These methods can be applied to diagnostic surveys that measure small changes in bed elevation, however there are more efficient, albeit expensive, approaches than those described here.[2]

Stream slope provides one measure of the erosive power and sediment transport capabilities of a stream. Changes in slope reflect both the natural physiography of a catchment and anthropogenic alterations to the channel. Variations in stream bed elevation provide a measure of habitat diversity, particularly water depth, and can provide insight into whether channels are aggrading or degrading (i.e., down cutting or depositing) over time. Measurement of the water surface slope is also necessary to convert measures of stage response (S4.M6) to a measure of estimated discharge using Manning's equation (see Harrelson et al 1994, Newbury and Gaboury 1993, Stanfield 2008).

If the study objective is to assess causes of stream instability, it is recommended that the bankfull profile (S4.M3, Bankfull Profiles and Channel Entrenchment) and at minimum the substrate component (3.6.6 Substrate Particle Size Distribution) of S4.M2, Point Transect Sampling for Channel Structure, Substrate and Bank Conditions or the rapid assessment module for substrate (S4.M8) also be evaluated.

The methods described in this module have been modified from Newbury and Gaboury (1993) to provide a balance between precision and efficiency and are suitable for any wadeable streams, although the specific tools used will vary with stream width.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people (a surveyor and a recorder). Survey time varies with the tools used and the sinuosity of the stream and density of vegetation but typically takes anywhere from 15 to 90 minutes to complete.

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[2] High resolution GPS units in tandem with a local base station can be used to generate a complete bed profile to cm accuracy. This approach will be described in further detail in future OSAP modules.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

The following equipment list is required:

1. Discharge and Slope Measurements Form: Non-Point Transect Methods
2. Pencils
3. Wooden metre sticks
4. Stadia rod[3]
5. Tape measures (30 m or longer)
6. Surveyor level: This can consist of either a traditional surveyor level (sometimes called a transit) with a telescope and spirit level mounted on a tripod or other technologies such as a laser level and tripod, an abney level, or even a laser level with a range finder[4]
7. Flagging tape
8. Calculator (waterproof, or in resealable bag)

Crews should adhere to safety precautions and requirements set forth by their employers /managers (e.g., first aid kit, first aid training, travel plan, buddy system, mobile phone etc) and should follow the manufacturer's instructions for safe use of laser devices.

3.0 FIELD PROCEDURES

The module should be completed in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M3, Assessment Procedures for Site Feature Documentation. At each site, fill out the site descriptors (i.e., 'Stream Name', 'Stream Code', 'Site Code', 'Sample #' and 'Date') and record the names of the 'Crew'. At a minimum, elevations should be measured at the bottom and top crossovers of a station. The number of times that the surveyor level needs to be moved will depend on the equipment used, site conditions, and survey goals. Therefore, several options are described for data collection and implementation is left to the crews. Tying all observations to a station benchmark, a large boulder, culvert etc., (see S1.M3) provides an

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[3] Stadia rods come in many forms including versions that can telescope to varying heights. These can also be constructed for use in the field by gluing tailors tapes to or marking boards that are linked with wing nuts. Stadia rods should have 0.5 cm accuracy.

[4] Laser levels work well for short distances between readings, although they are prone to the light being blocked by vegetation or by diffusion in bright sunlight. They also require the use of protective eyewear. Newer technologies are emerging rapidly and should be considered as cost saving approaches for large scale studies and to improve accuracy of field data.

optimal way of ensuring all observations are comparable and also enables comparisons to be made between sampling events.

3.1 Overview of Sampling Procedures

Step 1: Ensure that site boundaries (S1.M1, Defining Site Boundaries and Key Identifiers, Section 3.2, Identifying the Site Boundaries) have been established. It is recommended that a site sketch be completed and that all measurements be tied in to at least one station marker (refer to S1.M3 Assessment Procedures for Site Feature Documentation).

Step 2: Select an appropriate location to set up the survey level that provides a level and unobstructed view of the sample area.

Step 3: At the downstream crossover, place the stadia rod on the stream bed in the middle of the channel and measure the level location and the water depth on the stadia rod. Ideally, measurements will also be made to the station marker.

Step 4: Measure the distance up the middle of the channel to the next observation point, whether it is the top of the station or the next stream feature.

Step 5: Repeat step three at this location. The difference in readings from the upstream location and the downstream location indicate the change in bed elevation.

Step 6: To obtain the change in water surface elevation, subtract the water depth from the stadia readings. The difference in readings divided by the distance between locations is the slope used in Manning's velocity equation.

Step 7: If the stadia rod cannot be observed from a particular location, move the survey level to a new upstream location and repeat the process, ensuring that observations from both locations are made to one observation point to calibrate between observations.

Note: If measurements are to be tied in to a station marker, choose the feature that offers the most obvious and permanent location for measuring elevation (e.g. the top of an erratic, the base of a building, road bed) and record the measurements described below for each stadia location.

3.2 Setting up the Survey Level

Set up and level the tripod upstream of the first observation point. The location should offer an unobstructed view of the downstream crossover and at least one upstream observation point (Figure 1). In shallow systems, the best location for the tripod may be in the channel or on a bar mid-channel.

Position the survey level device on the tripod (see Harrelson et al 1994 or the instructions provided in the device manual). Level the survey device by adjusting the platform at the top of the tripod. If a laser level is being used, ensure that the unit is above the height of all vegetation in the pathway. Swing the level on the tripod base to ensure it is level in all positions and adjust if necessary.

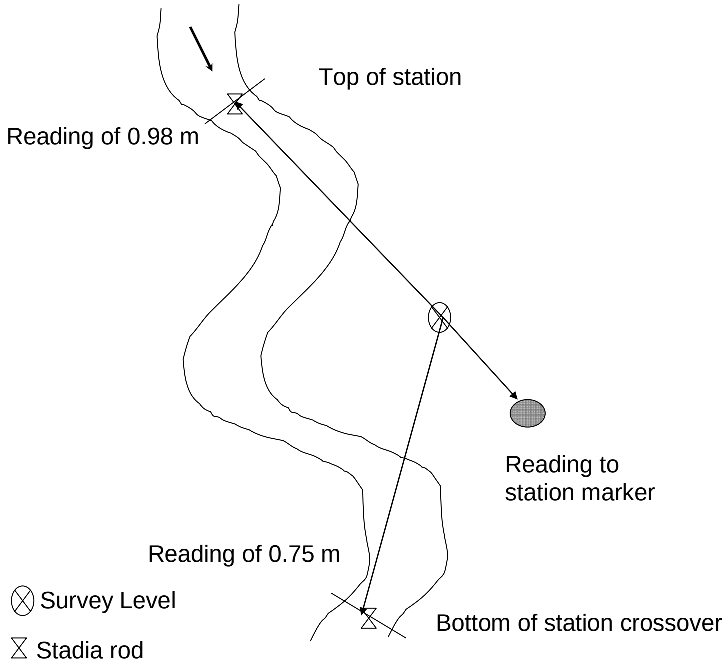

Figure 1: Obtaining site slope measurements from one observation point. Recording observations to the station marker is optional but recommended.

3.3 Measure the Difference in Elevation from Survey Level to Pavement Layer

Place the stadia rod on the pavement layer (Figure 2) of the stream bed in the center of the bottom crossover (ensure the rod is facing the survey level). Record the water depth (to the nearest 5mm) on the stadia rod and measure the height difference between the survey level and the pavement layer of the stream bed. If using a traditional survey level this value will be the intersection of the line in the view finder and the stadia rod. If a laser level is used read the height as the mid point of the beam on the stadia rod.

Pavement Boundary

The pavement boundary represents the bottom of the active flowing channel and is identified as the point where substrate particles form a fairly uniform layer across the bottom (Figure 2). This may be difficult to determine in areas dominated by coarse material. In these instances, put the ruler between the coarse material to the lowest layer of material that is visible.

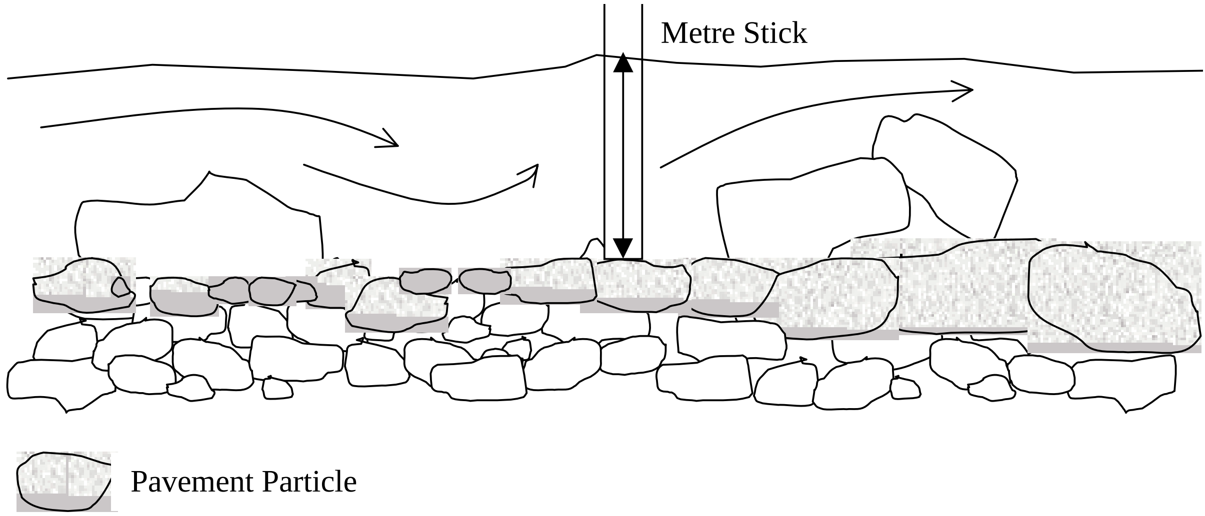

Figure 2: Placement of Stadia Rod on Pavement Layer.

3.4 Locating and Measuring Distance to the Next Observation Point

Identify the location for the next stream bed elevation measurement based on the objectives of the study. For example, a study to capture the longitudinal profile of the stream might locate observation points at specific thresholds for depth changes (e.g., > 0.1 m) or at the maximum depths of hydrologic features such as riffles and pools. The minimum measure is the elevation at the top and bottom of the station (i.e., crossovers) which provides a total drop in elevation through the site.

Measure the distance between the first and second observation points by chaining up the centre of the stream. To do this, one person stands at the bottom of the site in the middle of the stream to mark the starting point and a second person proceeds upstream until the stream changes direction or the next observation point is reached. If the stream changes direction before the observation point is reached, the second person should mark the location and the distance and call for the first person to move up to the new mark. This process continues until the observation point is reached. Record the distance between points to the nearest 0.1 m.

Note: If the next observation point cannot be observed from the current location of the survey level, procedures for tying in multiple survey level stations will need to be employed (see below).

3.5 Measure Stream Bed Elevation at Subsequent Observation Points

Place the stadia rod at the next observation point and turn the survey level so that a reading can be made. Be careful not to knock the tripod when using the level. Record the water depth on the stadia rod (to the nearest 5 mm) and measure the height difference between the survey level and the pavement layer.

If a level with a range finder is used, crews can record the distance from the tripod to the stadia rod for each observation and apply the cosine rule to calculate the straight line distance between observation points.

3.6 Tying in Measures from Multiple Survey Level Points

If the survey level must be moved to obtain additional bed elevation levels the observation from one location must be tied into or corrected to subsequent observations. This is achieved by making multiple observations of the same channel bed location from two different vantage points. In practice, the person holding the stadia rod remains in place while the survey level is relocated to an upstream location and a new reading of the same observation point is taken (Figure 3). The differences between the readings from the first and second readings of this observation point represent the difference in height of the survey level. This must be taken into account for subsequent observations[5]. The process is repeated each time the survey level is relocated, enabling all observations to be corrected to the first survey level height measurement.

Another option for tying in observations is to incorporate the use of the station benchmarks.

4.0 TIPS FOR APPLYING THIS MODULE

This technique can be applied to develop a profile of the site by taking measurements at each change in bed elevation and at about every one channel width along the site.

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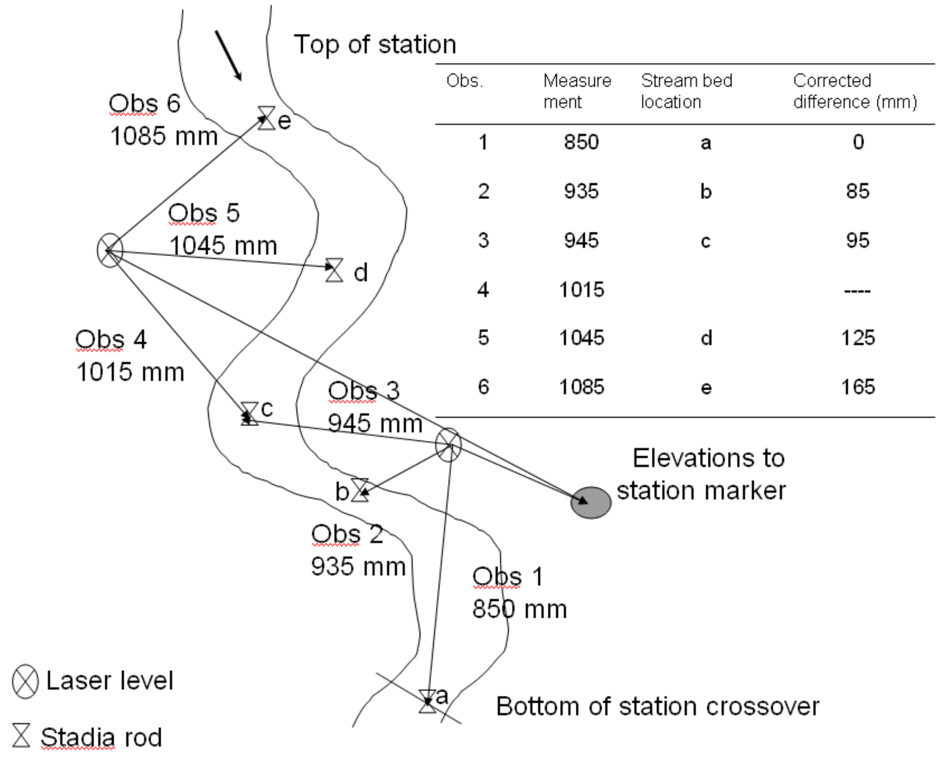
[5] The change in bed elevation at any two observation points is calculated as: elevation_x = survey obs_x-survey obs_0 where 0 is the downstream observation point. Once more than one sample location is included the survey observation must first be corrected by subtracting or adding differences in elevation between observations to subsequent records. In the figure 3 example, the second survey level was placed 70 mm higher on the land than the first one, as determined by subtracting observation 4 from 3 (1015-945 = 70). This would be repeated on subsequent moves of the survey level, if required.



Obs.	Measurement	Stream bed location	Corrected difference (mm)
1	850	a	0
2	935	b	85
3	945	c	95
4	1015		----
5	1045	d	125
6	1085	e	165

Figure 4: Obtaining measurements from multiple survey level locations. Note the difference in measurements between observation 3 and 4 provide the correction factor for subsequent observations.

If surveyors are using a laser and range finder, recording the bearing and distance to each observation point from the level enables the cosine rule to be used to calculate the straight line distance between observation points.

Remember higher points on the ground give lower readings on the stadia rod. If you are generating a stream profile from downstream to upstream outside the HabProgs database, don't forget to invert the observations, otherwise it appears as though the stream is flowing upslope. From the example, observation point 2 is actually plotted as -85 mm.

This technique can easily be linked to observations collected using other modules (for example S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions) by measuring differences in bed elevation between transects.

Mark all field equipment with bright paint or flagging tape to increase visibility and prevent loss.

Make sure that all fields have data recorded <u>before</u> taking down the tape measure.

Transport the laser level inside a waterproof container and consider placing the entire unit inside a clear plastic bag.

5.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

6.0 LITERATURE CITED

Harrelson, C.C., C.L. Rawlins and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Techniques. USDA Forest Service Report RM-245 (available on line)

Newbury R. W., and M. N. Gaboury. 1993. Stream analysis and fish habitat design: A Field Manual. Co-Published by Newbury Hydraulics Ltd., the Manitoba Habitat Heritage Corporation and Manitoba Natural Resources, Gibsons, British Columbia (available on line at www.newbury-hydraulics.com)

Stanfield, L. W. 2009. Understanding the factors that influence headwater stream flows in response to storm events. University of Toronto, Masters Thesis. 75 pp. + appendices.

Appendix 1

Example Site Slope Field Form

Site Slope Field Form

Page 1 of 1

Stream Name WILMOT CREEK	Site Code WM1	Site Code 3CDW	Date (yyyy/mm/dd) 2005/06/12

Crew Leader S. SALAR	Crew Members S. BYE, J. CODE	Equipment Used ☐Survey Level X ☐ Laser Level ☐ GPS ☐ Range Finder

Description of Station Marker or Benchmark (if used):
BASE OF WILMOT CREEK FISHING CLUB BUILDING, NORTHEAST CORNER (SEE SITE DESCRIPTION).

Comments

Obs. Num.	Unique Location Num.	Instream Observation Points				Station Markers (if used)			Comments
		Distance from Previous Obs. (m)	Water Depth (mm)	Stadia Rod Reading (mm)	Corrected Difference (mm)	Distance to Station Marker (m)	Stadia Rod Reading (mm)	Corrected Difference (mm)	
1	1	------	---	850	0	20.2	650	0	BOTTOM CROSSOVER
2	2	3.6	126	935	85	------	------	------	
3	3	10.2	300	945	95	------	------	------	
4	3	------	---	1015	------	32.8	815	95	MOVED TRIPOD TO SEE NEXT POINT
5	4	38.6	230	1045	125	------	------	------	
6	5	42.2	350	1085	165	------	------	------	UPSTREAM CROSSOVER
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 8

Rapid Assessment Methodology for Instream Substrate Sampling[1]

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APPENDICES

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[1] Authors: S.E. Hogg and L. W. Stanfield

1.0 INTRODUCTION

This module describes techniques for conducting screening level assessments of substrate composition throughout an entire site. The techniques used are a cross between a traditional Rapid Assessment Methodology (RAM) and a standard survey approach in that crews use rapid assessment approaches to locate sampling points and then apply a standard approach to measure substrate composition. As such, this approach can generate an accurate assessment of the proportion and sizes of substrate particles throughout a site.

The point-transect approach used in this module improves repeatability over conventional non-point transect visual assessments (Hawkins et al. 1993, Stanfield and Jones 1998). While this methodology is defensible and variance can be quantified, data collected using this tool vulnerable to sampler bias because the sample locations are selected visually. As such crews must be diligent about minimizing bias in both the location of observation points and in the selection of particles to be measured, if data are to be an accurate representation of the substrate composition of the site.

As these methods are vulnerable to sampler bias it is recommended that project leaders incorporate both a training strategy and a calibration exercise to quantify bias where sample sites are located in highly variable substrate conditions and/or where subtle biases have the potential to impact on study findings. Follow the procedures provided in S4.M1, Rapid Assessment Methodology for Channel Structure, if this is the case for your study. Finally, as most surveyors will also collect stream width and depth data while conducting these surveys, the methods described in other modules are also provided here and space is provided for these “optional” measurements on the field sheet.

This module is best applied in studies that have one of the following objectives:

- a study of fish habitat conditions for which substrate composition is a critical factor but resources are limited. In this instance crews will use the instream habitat measures described in S4.M1, Rapid Assessment Methodology for Channel Structure and supplement these measures with the more accurate evaluation of substrate composition provided by this module.
- to supplement other surveys of streams (e.g. geomorphology, hydrology, benthos) to provide accurate descriptions of substrate, but for which the minor bias associated with sample location is not considered important.

If more accurate results are required a full point-transect method should be considered (S4.M2, Point-Transect Sampling for Channel Structure, Substrate and Bank Conditions).

2.0 PRE-FIELD ACTIVITIES

A typical survey of a site should take between 10 to 20 minutes. A two-person crew is recommended for safety. Field surveys should follow a training program (see Appendix I).

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1, Site Identification and Documentation)
- Equipment check

The following equipment is required:

1. RAM Field Forms on waterproof paper
2. Pencils
3. Metre stick and small ruler
4. Tape measure or hip chain
5. Maps

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

This module assesses the substrate and sediment transport characteristics of the site, within the context of the type of parent material available to the stream. There are two types of channels, bedrock and alluvial. Bedrock streams can either be erodible (shale) or not (granite). Alluvial streams have parent material of either fine (sand), medium (gravel), or coarse (cobble) particulate materials. In order to understand the relationship of parent substrate materials and bedload transport, measurements and comparisons are made between **maximum particle** and **point particle** sizes.

Procedures outlined below include defining site boundaries, recording site information, and measurement of channel features, bank conditions and substrate.

3.1 Recording the Site Identification Information

The module should be done in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation. Additional information required depends on the objectives of the study and resources available.

3.2 Defining the Site Boundaries

The site boundaries are defined as per S1.M1. If no accurate data on site length are available, record the approximate length of the site (±3 m). This is accomplished by either chaining up the centre of the stream (most accurate) or by pacing up the channel or the banks, depending on site conditions. Record the site length on the Site Identification Form, mark with an asterisk (*), if anything other than chaining was used to obtain this measurement, and include an explanation in the ‘Comments’ section indicating that the site length was estimated. On the RAM Field Form (Appendix 3), record the appropriate unique identifiers for the site (see S1.M1).

3.3 Setting up Transects and Observation Points

The number of transects required and the number of observation points per transect is determined by the minimum width of the site. If the stream is greater than 3 m wide throughout the site, use 10 transects and six observation points per transect; otherwise estimate the stream width at the narrowest location and refer to Table 1. Transects should be evenly spaced along the site.

Beginning at the first downstream transect, visually locate the appropriate number of observation points along the transect (Figure 1). Point substrate measurements are made directly below the observation point and maximum particle size measurements are made within a visualized estimated 30 cm ring centered on the observation point (referred to as the ‘observation area’).

Table 1: Relationship Between the Minimum Stream Width and the Number of Observation Points Required per Transect

Minimum Stream Width (m)	Number of Transects	Number of Observation Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.5	15	3
< 1.0	20	2

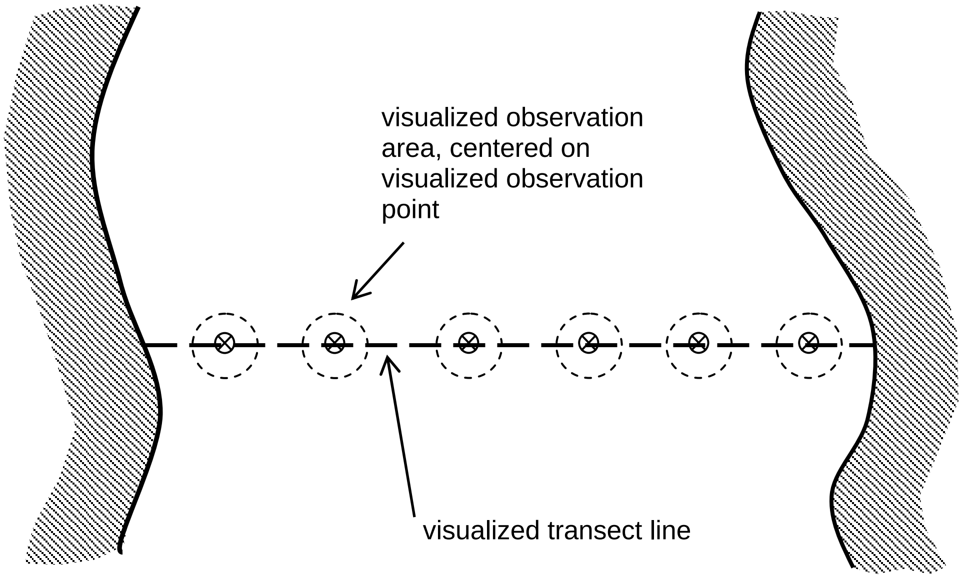

Figure 1: ‘Observation Areas’ (30 cm diameter) and Transect.

3.3.1 Substrate Measurements

At each observation point measure the size of the point particle and largest particle that is within or is touched by an imaginary circle that is centered on the observation point and has a diameter of 30 cm. If in doubt use your ruler to see if a particle is greater than 15 cm from the observation point.

3.3.1.1 Point Particle

At each of the visualized observation points, a substrate particle should be selected by looking away and extending an index finger until a substrate particle is touched. Measure the particle along its median axis (Figure 2); for very large particles measurements may be taken in the stream. If the median axis of the material is between 2 mm and 1000 mm, record this measurement on the Rapid Assessment Methodology for Instream Substrate Form; otherwise record standard sizes found in Table 2 in dot tally format. Remove undecomposed organic material (e.g. leaves, sticks), before making substrate measurements. Decomposed organic material should be classified as silt.

Median Axis

There are three axes to every particle. The median axis represents the intermediate width of any particle (Figure 2). Rocks will often lie with the median axis at right angles to the flow.

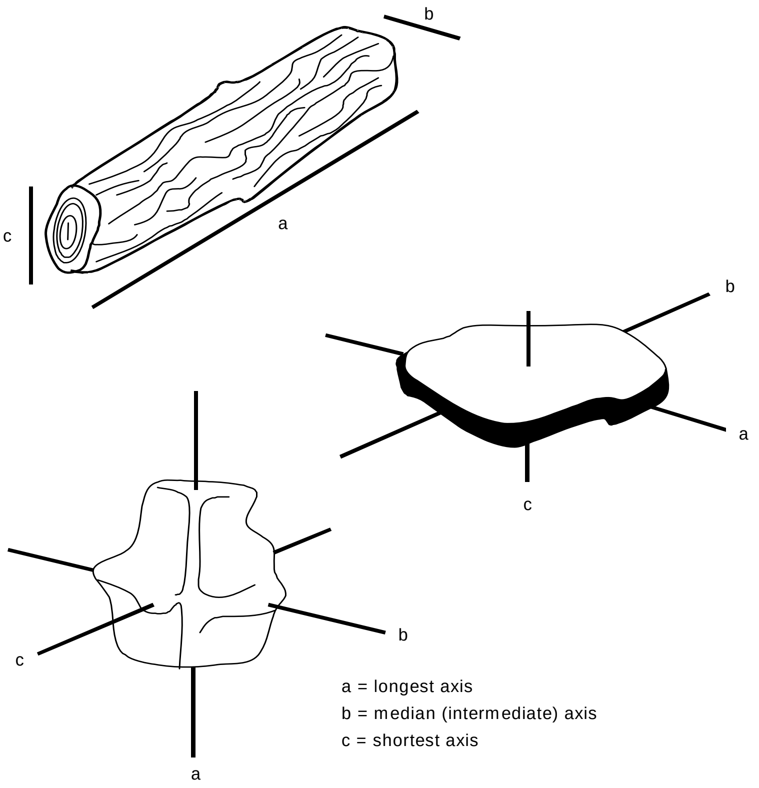

Figure 2: Measuring the Median Axis of Cover and Substrate.

Conducting a Dot Tally ('Box Ten')

Dot tallies are used as a convenient means of recording data when a number of categories are being counted simultaneously. One dot or line represents a single observation. **Four** dots are used to form the outside of a box. Then **four** lines are used to form the outside of the box and finally **two** lines are used to form a cross for a total of **ten** observations per filled box. Make sure the dots are large enough that they aren't mistaken for photocopy imperfections.

3.3.1.2 Maximum Particle

Select the largest particle within the visualized observation area (i.e., 30 cm circular sampling area) and measure its width along the median axis following the same procedures described above.

Note: In some situations large boulder can extend across several observation points, being counted each time that it is appropriate.

Hint: *If there is a mixture of smaller particles within the 30 cm ring, such as silt/sand or clay/silt, catalogue point particle size as the smaller particle size (e.g., silt (0.05)), and the maximum particle size as the largest particle size (e.g., sand (0.10)). This is to avoid biasing the sample.*

Table 2: Substrate Descriptions and Size Categories.

Material	Description	Size to be Recorded
'Unconsolidated Clay'	Very hard packed when dry and sticky when wet	'0.01'
'Consolidated Clay'	Hard even when wet, slippery, gray in colour, often laminated	'0.011'
'Silt'	Feels soft like a powder or flour	'0.05'
'Sand'	Gritty, sizes >0.05 and < 2 mm	'0.10'
'Bedrock'	Exposed bedrock	'1111'
Measured particles	Between 2 mm and 1000 mm.	Median axis
'Large Boulders'	> 1000 mm but not attached to bedrock	'1001'

3.3.2 Optional Stream Measurements

This section provides guidance on how to measure 'Wetted Width' and the 'Mean Depth at Crossover'.

At the bottom of the site (i.e., at crossover point), measure and record the wetted width of the stream in the box marked 'Wetted Width (m)'. Measure to the nearest tenth of a metre.

At the same crossover estimate the average water depth. Water depth at crossover points should be relatively uniform across the channel. The measurement can be taken using several techniques (e.g., measurement of several points across the transect with a metre stick, use of a wading rod). Record the water depth to the nearest 5 mm (e.g. a water depth of 17 mm should be recorded as 15 mm).

3.4 Tips for Applying this Module

Crews using this module should have experience with the point-transect methodology.
It is strongly recommended that crews be trained and have enough field experience to ensure repeatability.

Project managers should establish a training program for crews at the outset of the study and a follow-up assessment to ensure that data are acceptable (Appendices 2, 3).

Data should be recorded while proceeding up the stream and then summarized before leaving the site.

4.0 DATA MANAGEMENT

Upon returning from the field;
1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

If data has been collected at calibration sites use the procedures described in Appendix 3 to develop correction factors for the variables of interest to the project.

5.0 LITERATURE CITED

Hawkins, C. P., J. L. Kreshner, P.A. Bisson, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman and M.K. Young. 1993. A Hierarchical Approach to Classifying Stream Habitat Features. Fisheries. 18(6):3-12.

Stanfield, L. W. and M. L. Jones. 1998. A Comparison of Full-Station Visual and Transect-Based Methods of Conducting Habitat Surveys in Support of Habitat Suitability Index Models for Southern Ontario. North American Journal of Fisheries Management 18: 657-675.

Appendix 1

Example Rapid Assessment Methodology Field Form

Rapid Assessment Methodology for Instream Substrate Form

Stream Name WILMOT CREEK	Stream Code WM1	Site Code 3CDW	Sample 1	Date (yyyy/mm/dd) 2005/06/08

Wetted Width (m) 5.1	Mean Water Depth (mm) 55	Comments USED 12 TRANSECTS, 5 OBSERVATION POINTS EACH

Record standard substrate particles using a dot tally under the Standard Sizes section. Substrate particles ranging from 2mm – 100 mm must be measured along their median axis and recorded in the Measured Particles section.

Substrate Measurements

Standard Sizes

Material	**Description**	Count *(use box tally)*			
		Substrate Particles	Total	Maximum Particles	Total
Unconsolidated Clay	Very hard packed when dry and sticky when wet	☒ •	11	• •	2
Consolidated Clay	Hard even when wet, slippery, gray in colour, often laminated				
Silt	Feels soft like a powder or flour	☒	10		
Sand	Gritty, sizes >0.05 and less than <2mm	☒☒ • • • •	24	• •	2
Bedrock	Exposed Bedrock	•	1	• • •	3
Large Boulders	> 1000 mm but not attached to bedrock			•	1
Measured Particles	*Between 2mm and 1000 mm*	*Measure median axis and record under 'Measured Particles'*			

Measured Particles

Substrate Particles						Maximum Particles					
24	68	16	35	3	12	48	160	182	212	60	78
98	140	12	32	56	21	65	200	306	82	205	86
24	64					204	314	104	256	214	524
						54	68	251	356	125	137
						217	421	123	323	421	57
						98	84	76	124	185	201
						162	213	79	142	136	215
						46	82	304	145	62	97
						104	186	245	211		

Crew Leader S. SALAR	Crew J.J, S.B, H.K	Recorder H.K	Entered H.K.	Verified S.S.	Corrected H.K.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 4: MODULE 9

Check Your Watershed Day Protocol for Stream Discharges and Perched Culverts [1]

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[1] Author: Stanfield, L. W., J. Chau and S. Hogg

1.0 INTRODUCTION

This module describes a methodology for evaluating the flow condition of all stream crossings within a watershed. This protocol is designed to be applied within a single watershed, at a time when the stream is approaching its summer low flow discharge[2]. During these conditions the flow in the stream originates mainly from groundwater discharge. These surveys provide a measure of the contribution of flow from headwater systems[3] and, if carried out in conjunction with strategically placed surveys on larger streams, can be used to generate coarse level water budgets that identify relative gains and losses throughout the basin. The techniques and field sheets provided in this module can also support sampling conducted as part of broader reconnaissance surveys in small streams (S4.M4, Reconnaissance Surveys for Stream Discharge).

Small streams are the life blood of rivers and their flow condition is variable. The variability is a consequence of differences in local geology, depth of the water table, aquifer pathways and land/water use. As a result, existing information and planning tools cannot adequately identify stream condition in headwater systems. This information is required to ensure that planning protects critical habitats for fish and identifies areas of lesser concern.

With this tool, headwater systems will be evaluated for flow status on a date that generally falls within the period summer low flow discharge. This tool is best applied through a collaborative effort, involving enough surveyors to ensure that the entire watershed can be surveyed in one day.

This technique is an extension of the reconnaissance survey techniques and follows the Site Documentation procedures described in S1.M2, Screening Level Site Documentation (access route/site description optional).

This protocol is best applied on small streams (less than 3 meters in wetted width) at stream crossings. A stream crossing is defined as a location where a drainage feature[4] with clearly defined banks crosses a road (generally at right angles). Crews should use their best judgment to ensure that all small streams are surveyed (e.g. if a crew is assigned a site and finds the wetted width to be 3.4 m upon arrival, the site should still be surveyed).

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[2] The methods are equally applicable for surveys conducted at any time of year or conditions that characterize relative conditions of flow in the watershed.

[3] Headwater streams are those from small catchments (< approx. 10 km^2) that provide the source water to the main stream systems.

[4] A drainage feature is a depression in the ground that serves to drain water off the land. Examples of drainage features are streams, wetlands and swales, etc.

The techniques described herein should not be applied on drainage features that run parallel to a road. Where two or more stream crossings occur in close proximity to each other (e.g. less than 200 apart) only one crossing should be surveyed. Refer to Figure 1 for further detail regarding crossings that should be assessed as part of this protocol.

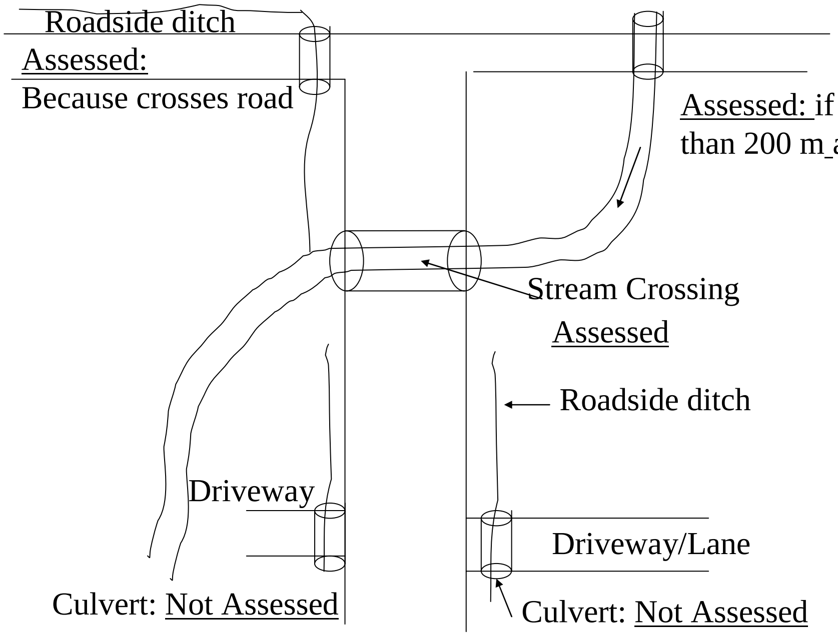

Figure 1. Illustration of stream crossings to be assessed during a survey.

In some areas, drainage features other than streams with cross roads (i.e., wetlands, swales etc.). Where this occurs, crews should document the type of feature at the crossing and move to the next site.

Ideally, this protocol will be applied in conjunction with sampling that evaluates stream flow at the larger stream crossings in the watershed. This allows for an inventory of the flow conditions across an entire watershed and ensures all measures are relative as they are collected within the same day.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of at least two people per 8-10 sites to be surveyed. Data collection requires about 5-10 minutes of time per site/stream crossing. If the project is being implemented over a single day and involves minimally trained crews or volunteers a project implementation plan will be required (see Appendix III).

Pre-field activities should include:

- Documentation of site access and appropriate stream identifiers (S1.M2 Screening Level Site Documentation)
- Equipment check

For this protocol, the following equipment is required:

1. Meter stick (wooden)
2. Stopwatch or watch, with seconds indicator
3. Rubber boots or waders
4. Buckets and or funnels
5. Tape measure (meters)
6. Field sheets and HB pencils

Additional equipment for site location documentation:

7. GPS unit
8. Maps
9. Camera

Crews should adhere to safety precautions and requirements set forth by their project managers, i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

We recommend that project managers provide crews with maps that “cover” the watershed (Figure 2). Mapping should include all roads and stream crossings from the most accurate water layer available. Site codes from previous surveys should also be included as well as the route to be covered by each crew. Note that most municipalities have identifiers for stream crossings and inclusion/use of this information will enable further sharing of data.

Each crew will be provided with field sheets (Appendix I). Project managers should ensure that these field sheets (called Reconnaissance Survey Forms) contain the key stream identifier information (stream name, stream code, watershed code), the sample

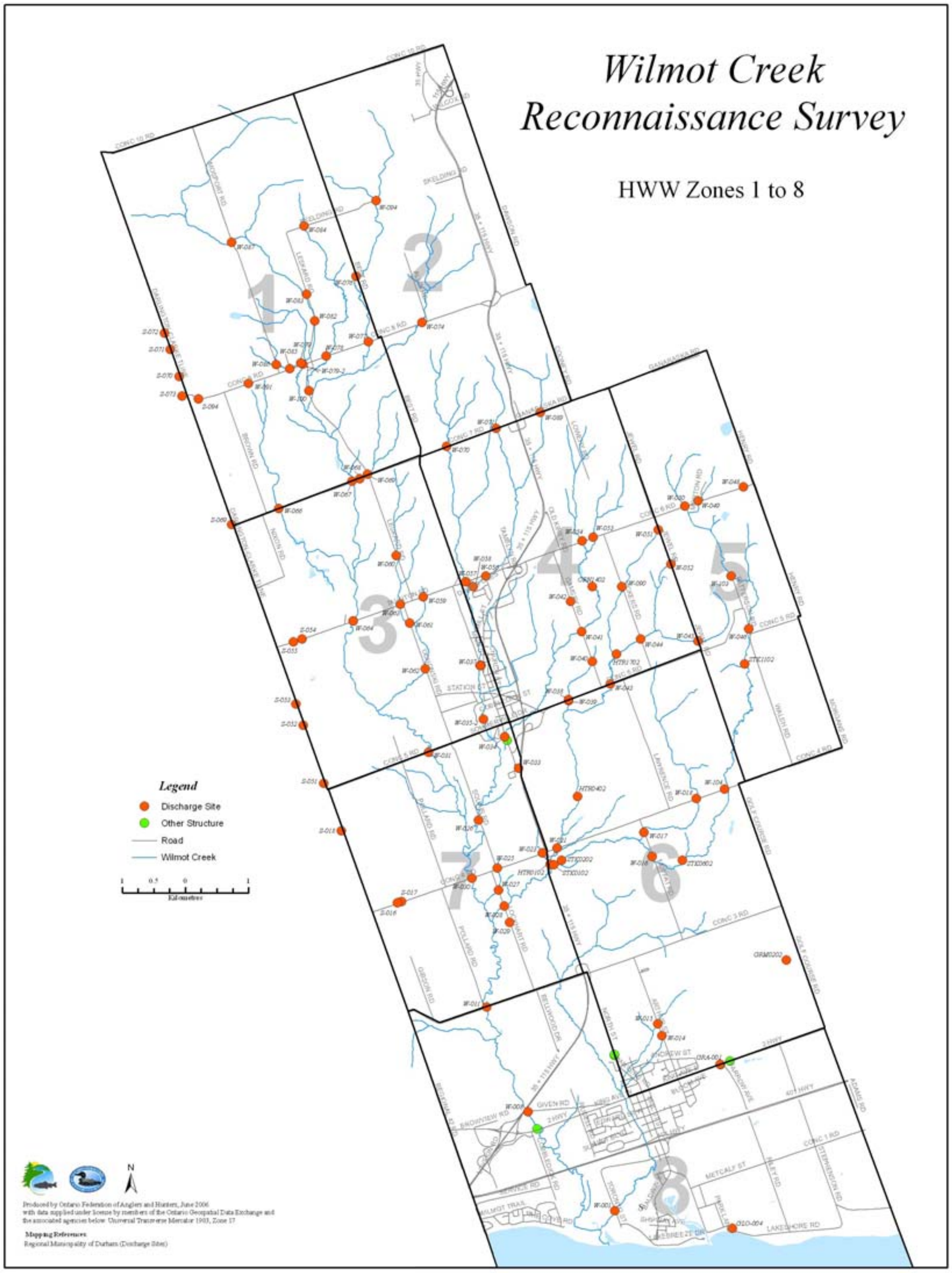

Figure 2. Example map for identifying sampling locations and zones.

number, the sampling zone, the UTM grid number, and either a list of pre-identified sites or a process for identifying unique site codes to be used in the survey.

2.1 Tips for Good Data Collection

Before leaving each site, check over the field sheet and make sure all the boxes have been filled out. If a field is not measured at a site, put a line through that box. Remember that zero (“0”) is a value that must be recorded. If there is a blank space where a “0” should be, there is no way to determine whether there truly was no flow (for example) or whether flow was measured but not recorded. All information should be clearly and legibly recorded using a sharp pencil, if you must erase data, make sure the correction is legible. Use capital letters for text records as this will improve legibility. Use only the measurement units on the field forms (e.g., mm and m) and make sure they are consistently applied by all crew members. At the end of the day, have someone else check the field sheet for legibility, accuracy and completeness.

Finally, crews need to be familiar with the objectives of the module and the techniques used such that they will be able to obtain data when suboptimal conditions are encountered at a site. In these situations, crews may deviate from the standard procedures to obtain measurements provided data quality is not affected. For example:

- if a site is braided (e.g. an island is present in the middle of the channel) methods may be applied on both sides of the braid. Discharge calculations can then be added together to obtain a total value
- if a site is too shallow to obtain measurements, crews may move to another area that is more appropriate, or temporarily modify the channel to enable data collection (e.g. concentrate flow)

3.0 FIELD PROCEDURES

On the sample day, crews will need to develop a travel route to ensure all the sites assigned for sampling are visited in the most efficient manner[5]. Upon reaching each stream crossing the following information will be documented:

- Stream crossing identifiers and location (including marking location on map)
- Width and depth of wetted stream (0’s indicate dry conditions)
- Stream discharge using the most appropriate method for each site
- Channel width and maximum depth
- Height of the drop from perched culverts

- Jumping height for fish

2.2 Filling Out the Form Header

The form header provides survey information relevant to all sampling locations included on that page. In order to facilitate efficient data collection it is recommended that the form header by filled out prior to the event by the project manager. Please record the ‘Stream Name’, ‘Stream Code’ and ‘Watershed Code’ and ‘Zone’ the crew will sample. Also record the ‘Surveyor Name(s)’, ‘Date’, ‘Source of Coordinates’ and ‘UTM Grid’.

Under ‘Sample’ record a “1” if the crew is comprised of volunteers, a “2” for sites identified for quality assurance and control, and a “3” if the site is to be sampled by agency staff. For crews with both agency and volunteer staff, list as agency staff if the agency member will be leading the crew.

2.3 Documenting the Sample Site Location

Each sample location is documented in four ways:

- Site Code and Map Notation
- Address Description
- UTM Coordinates
- Photograph (optional)

2.3.1 Site Code and Map Notation

For existing sites, record the existing site code (if available) on the data sheet and cross off the site on the field map. For new sites, record a new site code on the data sheet and mark and label the site location on the map.

Establish a process to ensure that new site codes are unique for each watershed. For example, crews will use the area or zone number as the first identifier and then a crossing number (e.g., A1C1) where the last number increases sequentially with each new site visited (e.g., A1C2). Two sites within a watershed cannot have the same identifiers.

2.3.2 Address Description

In rural areas, record the 911 address. In urban areas, record the street address for the closest unit to the stream crossing. Record this information in the “Description” section for each site (e.g., 24 inch culvert 40 m S of 1356 Ochonski Rd).

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[5] Project managers may wish to check with municipalities for road closures and construction

2.3.3 UTM Coordinates

Record the source of your UTM coordinates on the field sheet (e.g., GPS or GIS). Record the UTM coordinates for each site visited.

2.3.4 Photograph

If possible, use a camera to record the site access from the road and the sampling section of the stream. Be sure to include important nearby features. Include a sign with the site code in the picture for easy site identification after the sampling day.

2.4 Determining the Sampling Section of the Stream

Sites should be accessed from the downstream side of the road wherever possible. If access on the downstream side is not feasible, the crossing should be assessed visually to determine whether the culvert is perched before moving to the upstream side. Note that sampling is being conducted on the upstream side of the site, as well as whether a perched culvert is present, in the 'Description' section of the field sheet.

Upon reaching the stream, look for a section that is easy to access and includes an area of uniform depth and smaller substrate (sand to fine gravel), such that flows will be relatively uniform. This will typically be located either at or close to a crossover (i.e., flow is in the centre of the channel, the banks are of equal height and stream bed is of uniform depth). Ideally, no obstructions to flow (e.g. logs, large rocks, grass, etc.,) will be present at or within 2 m of the measurement location.

If a channel with clearly defined banks is not present, record the drainage feature type in the 'Comments' section. Strike a line through the remaining boxes in the field sheet for that site and move to the next site. Drainage feature types are available in Table 1.

2.5 Recording the Wetted Width and Depth of the Stream

For each stream site where water is present, stretch a tape measure across the stream at the crossover and measure and record the width of the wetted stream to the nearest 0.1 m. If the stream is dry record a “0” under ‘Wetted Width’ (m).

Choose three approximately equal spaced locations across the stream and measure and record water depth (Figure 3) at each. Record depths to the nearest 2 mm on the field sheet.

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activities to ensure all sampling areas are reachable.

Table 1. Drainage Feature Types.

Drainage Feature Type	Description
Wetland	contains obvious water tolerant or dependent plants (e.g. cattails) and/or water observed
Swale	a shallow trough-like depression that carries water mainly during rainstorms or snow melts
Agricultural area	areas where there is no evidence of flow under summer conditions and lands are available for agricultural use
Stream	channel with clearly defined banks present

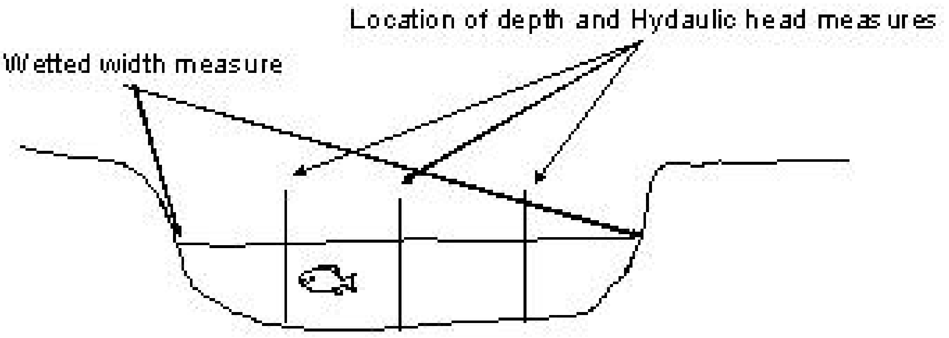


Figure 3. Location of measurements for wetted width and water depth.

2.6 Measuring Stream Discharge

If visible flow is present at the site, measure the amount of discharge (or the amount of water flowing through the stream) using one the following techniques described below. Techniques are described in order of preference as each technique provides a different level of accuracy. The technique used should be applied three times to improve the accuracy of the measurement. If there is no flow at the site, record a “0” in the ‘Depth’ box of the field sheet.

In very small streams, you may need to temporarily modify the channel to create a uniform sampling area. This may require moving objects that interfere with flow (e.g. rocks, sticks or grass) to provide uniform width and depth. Be sure to replace any objects moved after measurements are complete.

2.6.1 Technique 1: Volume / Time

For locations where the stream is small and flowing through a drop structure (e.g., perched culvert or weir) or has sufficient flow to enable a drop structure to be temporarily installed, a bucket and a stopwatch can be used to directly measure discharge. In some situations, a funnel can be used to direct the water into a measuring device.

Measure the time it takes to collect a known volume of water (e.g., volume of the bucket). Record the volume (litres) and the time (seconds) to fill on the field sheet. Three separate volume/time measurements should be recorded on the field sheet. If flows are divided, or there is more than one culvert, do the measurements for each part of the flow and add the values together for recording on the field sheet. Note in the comments field when this occurs.

2.6.2 Technique 2: Area / Velocity, Hydraulic Head

For locations without a drop structure where depth is 20 mm or greater and water is moving with reasonable speed (> 10 cm/s), use hydraulic head to measure velocity. This technique should only be applied where the velocity of water at the site generates more than 2 mm of hydraulic head, if less than 2mm of hydraulic head is greater use Technique 3. A formula can be applied to convert velocity into a measure of discharge (Appendix II).

Hydraulic head (HH) is measured at the same location as water depth and is measured in millimetres. Hold the wooden ruler vertically in the stream with the **wide side facing downstream** (Figure 4). Measure the maximum height difference observed over a 3-5 second period (more time may be required in faster water) between the front and back of the ruler. For example, if the upstream reading is measured as 35 mm, the downstream as 16 mm, the hydraulic head is 19 mm (35 mm minus 16 mm). Record the hydraulic head to the nearest mm in the box marked 'Hydraulic Head (mm)' on the field sheet. Three separate HH measurements should be recorded on the field sheet.

Avoid standing in front or too close behind the ruler as this can obstruct the flow. It may be easier to use a pencil or finger to mark the locations on the ruler and then measure the difference out of the water. At higher velocities, there will be greater variability in the height differential (i.e., the hydraulic head will pulse up and down). The formula is based on the maximum velocity observed (e.g. we assume it overestimates velocity). Therefore record the maximum pulse observed over 3-5 s observation time.

Background on Hydraulic Head

Flowing water is “pushed up” against any object that it comes into contact with. The magnitude of the head varies with velocity. We use a ruler to measure the Hydraulic Head such that the height the water climbs is used as a measure of velocity.

Figure 4. A point measurement of hydraulic head.

2.6.3 Technique 3: Distance / Time, Floating Objects

Where the stream velocity creates less than 2 mm of hydraulic head floating objects may be used to estimate velocity. A formula can be applied to convert velocity into a measure of discharge (Appendix II).

Water velocity is determined by timing the movement of a floating object such as a small leaf or twig over a fixed distance. The measurements are made over a length of river that has relatively laminar (smooth and unobstructed) flow and similar width and depth across the channel. This is typically located close to the crossover points where the maximum depth of the stream is in the middle of the channel.

The distance (in meters) over which velocity is measured must allow the object to float for at least 3 seconds. This ensures the accuracy of the velocity data. The object should be floated over the location where width and depth measurements were taken.

To begin the velocity measurement, drop the object at the beginning (upstream end) of the distance to be measured and use a watch to measure the amount of time it takes the object to reach the end of the measured distance. Record the distance used (length of stream over which the object was floated) and the time required for the object to successfully pass through the area. A successful pass is one in which the object is able to pass from the start to the finish without being delayed by contact with any objects. This process should be repeated until three successful passes have occurred and been recorded on the field sheet.

2.7 Documenting Channel Dimensions

At each site stretch a tape measure from the top of the bank on the left side to the top of bank on the right side of the stream (Figure 5). The tape should be placed at the point where the stream would begin to spill onto the banks under high flow conditions. This location can be identified by observing changes in the bank angle; from steep to a flatter more gradual angle. The measuring tape should be placed at the point where the angle changes, called the "inflection point". Record this measurement (in meters) on the field sheet under 'Bankfull Width'.

Leaving the tape in the same location, locate the deepest part of the channel (generally the center of the stream) and measure the distance from the stream bed to the tape measure (Figure 5). Record this measurement (in meters) on the field sheet under 'Bankfull Depth'.

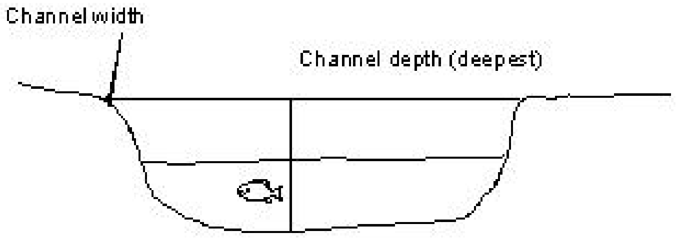


Figure 5. Measuring bankfull width and depth.

2.8 Documenting Perched Culverts

A perched culvert occurs when the bottom of the culvert is raised above the stream bed and results either from improper installation (rare) or stream erosion. Perched culverts may prevent fish from accessing upstream waters.

For sites where perched culverts exist, measure the distance from the bottom of the culvert to the stream bed and record as the 'Perched Height' (m) on the field sheet. Also measure the distance from the lowest part of the culvert (its center) to the water surface and record this as the 'Jumping Height' (m) (Figure 6).

Figure 6. Measuring depth to bed of perched culvert and jumping height for fish.

3.0 DATA MANAGEMENT

Upon returning from the field, have a member of another crew (or event staff) check over your field sheet to ensure all information is legibly and accurately recorded. Provide the data sheet to the project manager who should:

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies in a separate location from the master copy.

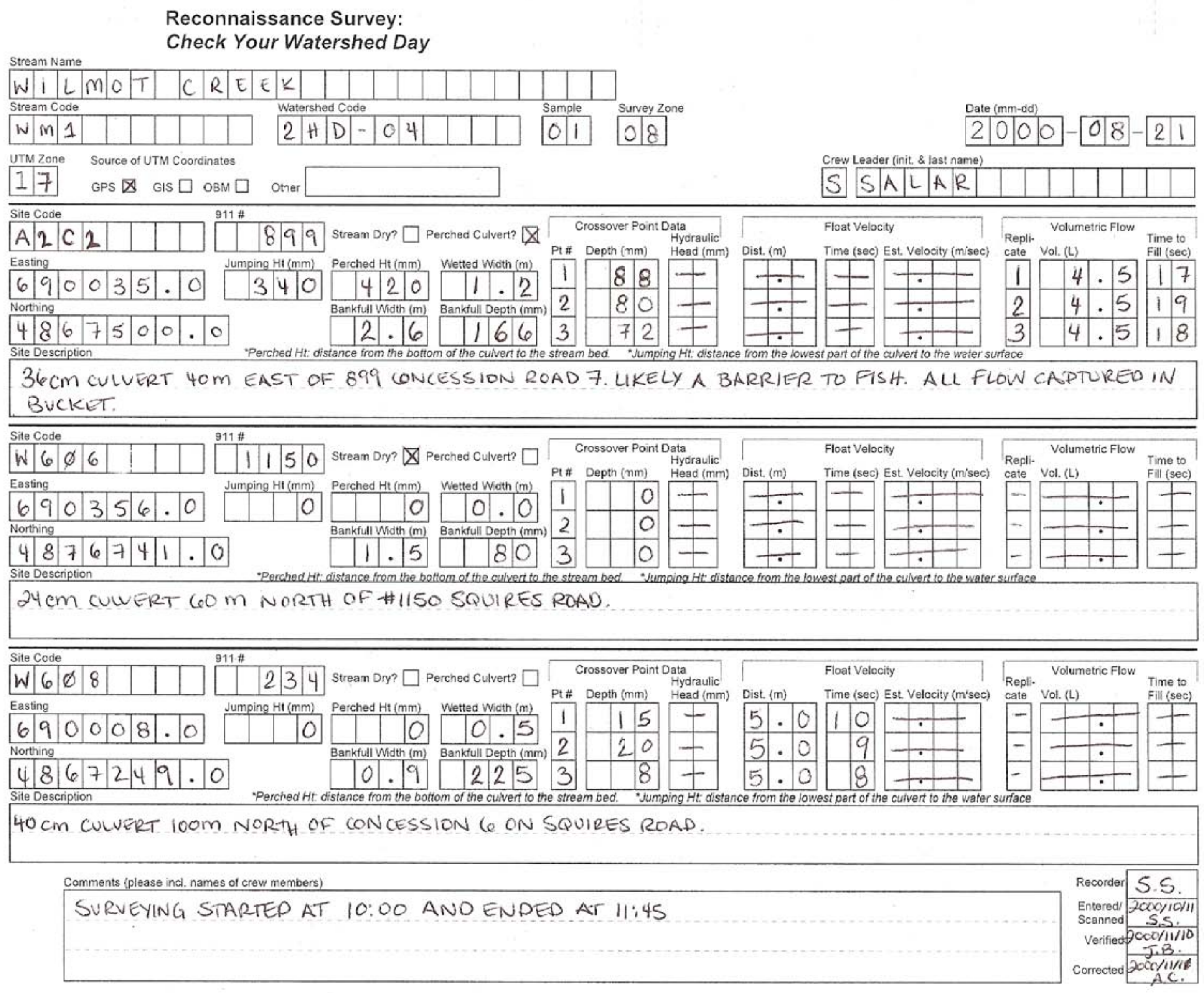
By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

4.0 REFERENCES

Stanfield, L. (Editor). 2005. Ontario Stream Assessment Protocol for. Version 7, Fish and Wildlife Branch. Ontario Ministry of Natural Resources, Peterborough, Ontario.

Appendix 1.

Example of a Reconnaissance Survey Form



Reconnaissance Survey:
Check Your Watershed Day

Stream Name: WILMOT CREEK
Stream Code: WM1
Watershed Code: 2HD-04
Sample: 01
Survey Zone: 08
Date (mm-dd): 2000-08-21
UTM Zone: 17
Source of UTM Coordinates: GPS ☒ GIS ☐ OBM ☐ Other
Crew Leader (init. & last name): S SALAR

Site Code: A2C2
911 #: 899
Stream Dry? ☐ Perched Culvert? ☒
Easting: 690035.0
Jumping Ht (mm): 340
Perched Ht (mm): 420
Wetted Width (m): 1.2
Northing: 4867500.0
Bankfull Width (m): 2.6
Bankfull Depth (mm): 166

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	88	—	—	—	—	1	4.5	17
2	80	—	—	—	—	2	4.5	19
3	72	—	—	—	—	3	4.5	18

*Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface

Site Description: 36cm CULVERT 40m EAST OF 899 CONCESSION ROAD 7. LIKELY A BARRIER TO FISH. ALL FLOW CAPTURED IN BUCKET.

Site Code: W606
911 #: 1150
Stream Dry? ☒ Perched Culvert? ☐
Easting: 690356.0
Jumping Ht (mm): 0
Perched Ht (mm): 0
Wetted Width (m): 0.0
Northing: 4876741.0
Bankfull Width (m): 1.5
Bankfull Depth (mm): 80

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	0	—	—	—	—	—	—	—
2	0	—	—	—	—	—	—	—
3	0	—	—	—	—	—	—	—

*Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface

Site Description: 24cm CULVERT 60 m NORTH OF #1150 SQUIRES ROAD.

Site Code: W608
911 #: 234
Stream Dry? ☐ Perched Culvert? ☐
Easting: 690008.0
Jumping Ht (mm): 0
Perched Ht (mm): 0
Wetted Width (m): 0.5
Northing: 4867249.0
Bankfull Width (m): 0.9
Bankfull Depth (mm): 225

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Replicate	Vol. (L)	Time to Fill (sec)
1	15	—	5.0	10	—	—	—	—
2	20	—	5.0	9	—	—	—	—
3	8	—	5.0	8	—	—	—	—

*Perched Ht: distance from the bottom of the culvert to the stream bed. *Jumping Ht: distance from the lowest part of the culvert to the water surface

Site Description: 40cm CULVERT 100m NORTH OF CONCESSION 6 ON SQUIRES ROAD.

Comments (please incl. names of crew members): SURVEYING STARTED AT 10:00 AND ENDED AT 11:45

Recorder: S.S.
Entered/Scanned: 2000/10/11 S.S.
Verified: 2000/11/10 J.B.
Corrected: 2000/11/1[illegible] A.C.

Appendix 2. Converting Data to Measures of Discharge

While it is not necessary for surveyors to convert the field observations to standardized measures of discharge, they may wish to know how the data is used to generate this information. A different algorithm is used for each technique.

Technique 1: Volume/Time

The volume measured is divided by the time taken to fill the container. For example, a 4.5 litre container took 25 seconds to fill to provide a discharge of 0.18 litres/second (4.5litres/25second).

Technique 2: Area/Velocity, Hydraulic Head

When hydraulic head is used, it must first be converted to velocity using the formula[6]:

$$\text{Velocity (m/s)} = 0.625\sqrt{(0.02*HH)}$$

Then velocity is multiplied by the wetted width and the depth to obtain the measure of discharge.

$$\text{Discharge } (m^3/s) = (\text{velocity})(\text{wetted width})(\text{depth})$$

However, both the hydraulic head and depth measurements have to be corrected for the edge effects (i.e. while we make 3 observations we do so in 4 panels).

So for the example at site W-060, the measurements are as follows:

hydraulic head = 6 mm, 8 mm and 5 mm
depths at the hydraulic head = 40 mm, 60 mm and 50 mm
wetted width = 0.8 m

The mean hydraulic head measurement across the stream channel is 4.75mm.

$$HH = (6mm + 8mm + 5mm)/4 = 19mm/4 = 4.75mm$$

---

[6] This formula accommodates the differences in measurements, such that the observed hydraulic head measurements are entered as is, and recognizes that HH tends to overestimate velocity by this factor. This was determined from some as yet unpublished work by Stanfield (Ontario Ministry of Natural Resources, 2007), which compared HH and velocity measurements taken at the same location.

The velocity is 0.19m/s.

Velocity = 0.625√(0.02*HH) = 0.625√(0.02*4.75mm) = 0.625√0.095m = 0.19m/s

The standardized depth measurement is 0.0375m.

Depth = (40mm + 60mm + 50mm)/4 = 150mm/4 = 37.5mm = 0.0375m

The discharge is therefore 0.0061 m^3/s or 6.1 L/s.

Discharge = (Velocity)(wetted width)(depth) = (0.203m/s)(0.8m)(0.0375m) = 0.0061m^3/s or 6.1 L/s.

Technique 3: Time / Distance

Where velocity is measured by a time interval over a distance the velocity must first be converted to m/s. So if it takes 5 seconds for an object to travel 0.5 m, the velocity is 0.1 m/s (0.5m/5s). This value is then used in the same formula as above to convert the measure to a discharge.

Appendix 3. Developing an Implementation Plan

Implementing a “Check Your Watershed Day[7]” type survey requires considerable up-front planning, particularly if volunteers are used. The following summarizes the main tasks required:

1. Choose a “home-base”; a location where crews will meet for training and equipment dispersal and where data submission and follow up activities will occur. Criteria that should be considered in choosing a home-base includes:
    - Accommodation for all of your intended participants (e.g. parking, training, lunch)
    - Close proximity to a stream suitable for crew training
    - Availability of a landline phone and/or good cellular phone reception

2. Create survey maps to identify the “zones” to be sampled by each crew as well as known sample sites (i.e. road crossings) and their site codes. This step requires:
    - Determining each location where small stream intersect roads (road crossings)
    - Assigning site codes to each road crossing (using existing ones if available)
    - Determining the location and size of sampling zones (~8-10 sites/zone)
    - Preparing maps with stream and road layers (underlaying orthophotos is helpful)

3. Prepare equipment for each crew:
    - Ensure you have the required equipment for each crew; including any QA/QC crews and crews who will be using velocity meters
    - Ensure each crew has the proper safety equipment (e.g. first aid kit, phone, etc.)
    - Set up an equipment station for distribution and return of materials on event day
    - **Note**: it is recommended that event organizers contact other groups to borrow equipment in order to reduce costs

4. Data management:
    - Set up a data quality station on the event day and have field sheets verified as crews return from the field. If data recording errors are observed contact the crew immediately to rectify the error if possible.
    - Data should be re-verified after the event and entered into Habprogs

5. Securing adequate human resources:

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[7] For more information contact Citizens’ Environment Watch: www.CitizensEnvironmentWatch.org or Email: info@citizensenvironmentwatch.org

- Choose an overall Coordinator to be the lead on the day of the event
- Choose a Volunteer Coordinator to recruit and manage volunteers
- Choose a staff member to man a 'Data Quality Station' and check the datasheets as the crews return to home base
- Choose a staff member or volunteer to man the 'Equipment Station' and ensure crews return all of the equipment

6. Training program:
    - Implement a training program on the morning of the event for as many volunteers as possible. Be sure to emphasize that improvisation may be necessary to obtain measurements but should not impact data quality.
    - Training videos for CYWD are available from OMNR: contact Les.Stanfield@ontario.ca or online at www.trca.on.ca/osap.

7. QA/QC Sampling:
    Additional sampling by a QA/QC crew and/or a trained crew using a velocity meter team is useful for validating survey results and helps to obtain maximum benefit from the survey results.
    - QA/QC team - survey the same sites as crews such that data can be compared
    - Crew with Velocity Meter – depending on the size of the watershed, 1 to 3 staff/agency team(s) should be established. These crews measure discharge at strategic locations within the larger tributaries of the watershed in order to provide a total discharge for each tributary (e.g. to determine water budget)

8. Communications and Other Considerations:
    - Develop a communications strategy to assist with volunteer recruitment
    - Inform local media and decision makers about the event
    - Arrange insurance coverage for event participants
    - Work with a local group (e.g. local fishing club) to help promote the event and gain volunteer support
    - You may wish to provide crews with several copies of a letter explaining the event and its purpose, these letters can be provided to any interested landowners or members of the public

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 5

Water Temperature Assessment

TABLE OF CONTENTS

INTRODUCTION

This section describes techniques for assessing water temperature and estimating summer maximum water temperatures. Water temperature strongly influences the composition of aquatic communities. Knowledge of aquatic thermal regimes is important for predicting species composition, activity level, behaviours and life cycle events.

The modules in this section are suitable for use on wadeable streams with flowing water.

Although this section provides very restrictive advice on how to collect temperature data, it should be noted that temperature measurements taken at any time of the year are of value. Field technicians are encouraged to record stream temperatures, regardless of weather and time constraints.

S5.M1: Estimating Summer Maximum Temperatures Under Baseflow Conditions

This module describes a technique for determining the summer maximum water temperature of a site. Results can be used to assess the suitability of a stream for fish communities and for classifying thermal regimes (Barton et al. 1985, Stoneman and Jones 1996, Wehrly et al. 1999). This technique can be used for determining standardized summer maximum temperature. The methods for calculating the standardized summer maximum temperature are described in Stanfield and Kilgour (in press). This module must be applied within the weather and time constraints described.

S5.M2: Characterizing Stream Temperature Variability Using Digital Recorders

This module describes a method for characterizing stream temperature variability at a site using a digital recording thermometer. The data can be used for determining daily and seasonal fluctuations in water temperature (e.g., daily temperature pattern, diurnal fluctuations, maximum and minimum temperatures, growing degree days) and comparing thermal properties among sites.

LITERATURE CITED

Barton, D.R., W.D. Taylor and R.M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management. 5:364-378.

Stanfield, L. W., and B. W. Kilgour. 2006. Effects of percent impervious cover on fish and benthos assemblages and in-stream habitats in Lake Ontario Tributaries. Pages 577-599 i*n* R. M. Hughes, L. Wang, and P.Seelbach. Landscape influences on stream habitats and biological assemblages. American Fisheries Society, Symposium 48, Bethesda Maryland.

Stoneman, C.L. and M.L. Jones. 1996. A simple methodology to evaluate the thermal stability of trout streams. North American Journal of Fisheries Management. 16:728-737.

Wehrly, K.E., M.J. Wiley and P.W. Seelbach. 1999. A thermal habitat classification for Lower Michigan Rivers. State of Michigan, Department of Natural Resources, Fisheries Division, Research Report Number 2038.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 5: MODULE 1

Estimating Summer Maximum Temperatures Under Baseflow Conditions[1]

TABLE OF CONTENTS

APPENDICES

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes a method for estimating the maximum summer water temperature of a site based upon a one-day measurement of air and water temperatures. This module has been developed through research conducted by the Great Lakes Salmonid Unit, Ontario Ministry of Natural Resources (Stoneman and Jones 1996) that demonstrated a relationship between stream maximum temperatures and weather conditions. Results can be used to assess the suitability of a stream for fish communities and for classifying thermal regimes (Barton et al. 1985, Stoneman and Jones 1996, Wehrly et al. 1999). This technique can be used for determining standardized summer maximum temperature. The methods for calculating the standardized summer maximum temperature are described in Stanfield and Kilgour (in press).

This module must be applied within the weather and time constraints described.

The methods described in this module may not provide the actual summer maximum temperature, as summer maximum may occur in conjunction with point discharges of storm runoff or industrial runoff. Those interested in this measure should use a digital recording device (see S5.M2, Characterizing Stream Temperature Variability Using Digital Recorders).

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people. Maximum air temperature data can be obtained from the Environment Canada website (http://www.weatheroffice.ec.gc.ca/canada_e.html) or The Weather Network (http://www.farmzone.com).

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment list is required:

1. Site Features Form (preferably on waterproof paper)
2. Pencils
3. Thermometer (calibrated and accurate to ± 0.5°C)[2] or

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[2] Equipment must be calibrated and this should be regularly verified. It should also be noted that maximum-minimum thermometers often produce inconsistent data.

4. Digital recording thermometer (calibrated and accurate to ± 0.5°C)[2], with chain, lock and porous anchor (cement block, clay pipe etc).

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

3.0 FIELD PROCEDURES

This module should be done in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3, Assessment Procedures for Site Feature Documentation.

Data must be collected under the following conditions:

- from any well-mixed section of the stream,
- between July 1st and September 10th,
- between 4:00 pm and 4:30 pm[3],
- on days when the maximum air temperatures exceed 24.5°C, and
- **during a heat wave** (i.e., the sampling day must be preceded by at least two days with maximum air temperatures exceeding 24.5°C) during which there has been no rainfall that affected baseflow.

Water temperature can be determined using either a thermometer or a digital recording thermometer. Digital recording thermometers can be used to monitor temperature over a longer period of time and the data retrieved from the day/time using the above criteria.

If several sites will be sampled within a short period of time, temperatures may be measured at accessible locations (e.g., a road crossing near the site). If this approach is used, the water temperatures from within the site and at the accessible location must be compared prior to the actual sampling day. Temperatures should be the same indicating the absence of groundwater upwellings or other features that can affect stream temperature.

3.1.1 Obtaining the Stream Temperature

Place a thermometer in the main flow of the stream (i.e., a run or scour pool), avoiding deep pools as they may be sources of groundwater upwellings. After 30 seconds have elapsed,

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[3] Although the predictability is best if temperatures are taken between 4:00 and 4:30 pm, it is recognized this may be logistically difficult, therefore it is acceptable to take temperatures between 3:45 and 4:45 pm.

record the water temperature to the nearest degree (‘Water Temperature (°C)’). Also record the time (‘Time:’) that the water temperature was taken.

3.1.2 Obtaining the Air Temperature

Measure and record the air temperature at the time of sampling (‘Air Temperature at Same Time (°C)’). The air temperature should be measured in the shade using a dry thermometer.

Record the ‘Maximum Air Temperature (°C)’ using data from Environment Canada or The Weather Network for the closest monitoring station to the stream. Record the ‘Source of Maximum Air Temp’.

3.1.3 Obtaining Daily Maximum Air Temperature Data

Daily maximum air temperatures are required from July 1st to September 10th. These data can be obtained using either of the following methods:

- placing a digital recording thermometer in a shaded area away from the cooling influence of the stream, or
- obtaining the data from Environment Canada or The Weather Network for the closest monitoring station to the stream.

3.2 Measuring Temperature Using a Digital Recording Thermometer

Secure the digital recording thermometer to an anchor. To protect the digital recording thermometer it can be placed inside a cement block or section of pipe. The device and anchor should be placed in a well-mixed but protected area in the stream. Record the location and the identification number on the digital recording thermometer (if more than one is deployed) in the ‘Comments:’ area on the Site Features Form. Record the ‘Time:’ and ‘Date:’ of deployment.

After at least one weather event that meets the criteria described above, retrieve the digital recording thermometer. Download the data, and sort and extract the stream temperature on the date/time that meets the requirements as stated above. Record this as the ‘Maximum Water Temperature (°C)’ on the Site Features Form. Record the ‘Maximum Air Temperature (°C)’ for that date and how it was determined.

3.3 Tips for Applying this Module

If multiple sites are being assessed using a thermometer, a customized spreadsheet field sheet can be created for recording data. Data should be transferred to the Site Features Form after they are collected.

Do not delay getting the water temperature data on days that satisfy the criteria.

Ensure that the temperature data are transferred to the Site Features Form described in Section 1 soon after they are collected as these data often get misplaced.

Summer maximum water temperatures should not be used from periods where there has been heavy rainfall that changes baseflow.

If digital recorders are used, ensure that all water temperature data are archived as they can be used to characterize stream temperature variability (see S5.M2, Characterizing Stream Temperature Variability Using Digital Recorders).

Digital recording thermometers should not be placed in the open where they will be prone to theft.

Digital recording thermometers are prone to battery failure; therefore batteries should be checked prior to deployment.

Ensure that anchors are heavy enough to prevent digital recording thermometers from being washed downstream during storm events.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Enter the data into a digital storage system, such as HabProgs, and save backup copies that are stored in a separate location from the master copy.

By storing the data digitally in HabProgs, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

5.0 LITERATURE CITED

Barton, D.R., W.D. Taylor and R.M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management. 5:364-378.

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Wehrly, K.E., M.J. Wiley and P.W. Seelbach. 1999. A thermal habitat classification for Lower Michigan Rivers. State of Michigan, Department of Natural Resources, Fisheries Division, Research Report Number 2038.

Appendix 1

Example Site Features Form

Note that this example also shows data that was collected in conjunction with S1.M3, Assessment Procedures for Site Feature Documentation.

Site Features

Stream Name: WILMOT CREEK

Date (mm-dd): 2000-08-01

Stream Code: WM1

Site Code: 3COW

Sample: 01

For each landuse, check all boxes that apply. Be sure to include comments explaining the particulars, including names and numbers of contacts

Site Features	Ongoing & Active	Historical Evidence	No Evidence but Reported	No Evidence	Unknown	Comments
Potential Point or Non-point Source Contaminant Sources	☐	☐	☐	☒	☐	
Major Nutrient Sources Upstream	☒	☐	☐	☐	☐	VILLAGE OF ORONO SEPTIC BED LEACHATE
Channel Hardening or Straightening	☐	☐	☐	☒	☐	
Adjacent Landuses that Destabilize Banks	☒	☐	☐	☐	☐	TRAMPLING BY ANGLERS
Sediment Loading or Deprivation	☐	☒	☐	☐	☐	BASE OF BRIDGE ABUTMENT AT BANK HEIGHT
Instream Habitat Modifications	☐	☒	☐	☐	☐	HALF LOG STRUCTURES BURIED IN STREAM
Barriers and/or Dams in the Vicinity of the Site	☐	☐	☐	☒	☐	
High Fishing Pressure	☒	☐	☐	☐	☐	WORLD FAMOUS TROUT FISHERY
Log Jam Deflectors	☒	☐	☐	☐	☐	4 CROSSLOGS AND 2 LOG JAMS
Springs or Seeps at the Site	☐	☐	☐	☒	☐	
Impervious Substrate Limiting Burrowing Depth of Fish	☒	☐	☐	☐	☐	CLAY BED EXPOSED AT SEVERAL LOCATIONS
Fish Stocked Near Sample Site	☐	☒	☐	☐	☐	STOCKING RECORDS INDICATE HISTORIC STOCKING OF ATLANTIC SALMON
Other Activities that Could Influence Biota or Habitat	☐	☐	☐	☐	☒	

Sources of Information

Visual Immediate ☒ Visual Extended ☒ Interview ☐ Maps & Photos ☒

Temperatures

Time (24hr): 16:10

Air Temp (°C): 22

Water Temp (°C): 19

Max Air Temp (°C): 27

Max. Water Temp (°C): 22

Source of Max. Air Temp: ENV CAN

Riparian Vegetation Community

Only check one box for each bank and zone.

Dominant Vegetation Type

	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest
1.5-10m	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☒	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☒
30-100m	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☑	☐

Comments

OLD STUMPS IN RIPARIAN AREA INDICATE LOGGING IN PAST (~20 YEARS AGO)

Crew Leader (initial & last name): S BYE

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected
J.B., S.S.	S.S.	2000/10/11 S.S.	2000/11/10 J.B.	2000/11/11 A.C.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 5: MODULE 2

Characterizing Stream Temperature Variability Using Digital Recorders[1]

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[1] Author: L.W. Stanfield

1.0 INTRODUCTION

This module describes a method for characterizing stream temperature variability using a digital recording thermometer. The data can be used for determining daily and seasonal fluctuations in stream temperature at a site (e.g., daily temperature pattern, diurnal fluctuations, maximum and minimum temperatures, growing degree days), or to document changes due to spike events such as point source discharges of unusually warm or cold water. Data can be extracted and summarized to enable comparisons between sites.

2.0 PRE-FIELD ACTIVITIES

This module requires a crew of two people.

Pre-field activities should include:

- Landowner contact
- Documentation of site access and appropriate stream identifiers (see Section 1)
- Equipment check

For this protocol, the following equipment list is recommended:

1. Site Features Form (preferably on waterproof paper)
2. Pencils
3. Digital recording thermometer (calibrated and accurate to ± 0.5°C) [2],
4. Porous anchor (cement block, clay pipe etc.)
5. chain and lock for securing object

Each digital recorder requires initiation at the office prior to deployment. Follow the operational instructions the unit prior to leaving for initial placement.

Crews should adhere to safety precautions and requirements set forth by their employers /managers i.e., first aid kit, first aid training, travel plan, buddy system, mobile phone etc.

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[2] Equipment must be calibrated and this should be regularly verified.

3.0 FIELD PROCEDURES

This module should be done in conjunction with S1.M1, Defining Site Boundaries and Key Identifiers and S1.M2, Screening Level Site Documentation or S1.M3 Assessment Procedures for Site Feature Documentation.

3.1 Measuring Temperature

Secure the digital recording thermometer to an anchor. To protect the digital recording thermometer it can be placed inside a cement block or section of pipe. The device and anchor should be placed in a well-mixed and preferably shaded and protected area in the stream. Record the location and the identification number on the digital recording thermometer (if more than one is deployed) in the 'Comments:' area on the Site Features Form. Record the 'Time:' and 'Date:' of deployment.

The study design will determine the duration that the digital recording thermometer will be in the stream. If the study design requires comparisons between the water and air temperatures, the latter can be obtained from the Environment Canada website (http://www.weatheroffice.ec.gc.ca/canada_e.html) or The Weather Network (http://www.farmzone.com) or can be measured by placing a digital recording thermometer in a shaded area away from the cooling influence of the stream.

3.2 Tips for Applying this Module

Digital recording thermometers should not be placed in the open where they will be prone to theft.

Digital recording thermometers are prone to battery failure; therefore batteries should be checked prior to deployment.

Ensure that anchors are heavy enough to prevent digital recording thermometers from being washed downstream during storm events.

4.0 DATA MANAGEMENT

Upon returning from the field;

1. Create a backup hard copy (i.e., photocopy) of field forms, and store in a place separate from the original.

2. Download the data as appropriate for each specific product. Data from multiple sites can be combined into a relational database[3]. Ensure that the data are linked with other digital storage systems, such as HabProgs, and save backup copies stored in a separate location from the master copy.

By storing the data digitally and sharing it with the HabProgs database manager, the data can be shared with a large number of users province-wide. Data sharing will facilitate the refinement and development of habitat suitability models, and this will improve habitat management practices and policies.

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[3] A new application to house this data will be a component of the Flowing Waters Information System Phase II. In the interim, data should be stored in a stable repository. Notifications of progress on this development will be posted on both the FWIS (www.comap.ca\fwis) and TRCA (trca.ca\osap) websites.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 6: MODULE 1

Using the HabProgs Database[1]

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[1] Authors: M. Stoneman, L. W. Stanfield, S. Hogg, B.A. Harlow

1.0 INTRODUCTION

HabProgs is the current data repository for OSAP data and should be used for entering and storing data collected using the OSAP protocols. It is a relational database that has been specifically developed for use with the modules described in this manual. This module is designed to guide users through the HabProgs data entry process and provide an introduction to a new Flowing Waters Information System (FWIS) that is being phased in to replace HabProgs.

FWIS is being designed as a web-based portal to help manage site location information and as an information management system for storing and sharing data on flowing waters in Ontario. The site location component of FWIS is operational and is the most reliable way to verify site locations to the provincial water layer, and to discover and access data contained within Habprogs (www.comap.ca/fwis/).

OSAP data stored in HabProgs will be transitioned to FWIS when the application development is completed. The goal is to make this transition as smooth as possible and efforts will be made to communicate progress to the stream monitoring partners throughout the process. To accommodate this, periodic progress updates will be produced and distributed to partners by the database custodian. Updates will also be posted on the Toronto Region Conservation Authority (www.trca.on.ca/osap) and FWIS websites.

The following sections will provide users with a guide on how to use the existing HabProgs database, and provide advice on how to edit site location information (from Section 1) and extract data from FWIS in its current condition.

1.1 Background on HabProgs

The field forms used in this manual have been designed to facilitate efficiency and accuracy of data entry, and the data entry screens in HabProgs are comparable to the forms. HabProgs provides a single, fully integrated electronic repository for data recorded at all of the sites included in a project. In addition, the database includes the programs (SQL queries and VBA code) that transform the raw data into a set of site-level summary statistics that can be used to score the habitat suitability of the site. Further, it provides a standardized means of processing and summarizing the data.

It is recognized that surveyors who collect stream data have proprietary rights on the use of the data, and a 'proprietary rights' function can be initiated in the HabProgs database by the project manager. This function flags project data and indicates to database users that permission to use the data must be obtained from the project manager. If proprietary rights are applied to data, the database will reflect this restriction on its use for a period of five years from when the data were collected. Data belonging to projects where no proprietary rights are identified are considered to be public domain and are available for use by partners.

2.0 TIME AND "RESOURCES" REQUIRED

It will generally take 10-20 minutes to set up a project in HabProgs and initiate the data entry procedures for a sample. The amount of time required to enter field data is dependent on the amount and type of data collected and the proficiency of the data entry technician.

HabProgs requires a computer with Microsoft Access 2000, 2002 or 2003 (for Windows or Windows Vista) installed on it. Access "borrows" files from the Windows application which may be been included in newer version of Windows (e.g. Windows Vista). If this occurs the user will get an error that indicates that the system cannot find a specific file. One routine error that Habprogs users have identified is a failure to find the file utility.mda in the main directory. To date this has occurred only for users with Vista as their operating system. It is possible to correct this error by removing the file from the database references however, backwards compatibility between operating systems has not been yet been tested and running and saving Habprogs in a newer version of Access may create issues in the append process.

As with all computer programs, the speed at which HabProgs will run is dependent on the microprocessor speed of the computer and available RAM. The database screens are optimally displayed at a screen resolution of 800 x 600 pixels. If the monitor resolution is set to less than this, the database screens will be truncated (i.e., the entire database screen will not be visible).

All dates must be entered into the database using a four-digit year format, which may require that the default Windows date setting be changed. Different operating systems will vary in where this field is located, but in general it is found in the Windows 'Control Panel', under the 'Regional Options' icon. Locate the 'Date' tab (it may be under the 'Customize' tab for XP users) and then click on the button next to 'Short Date Style'. Select the choice that says 'yyyy/MM/dd'. This ensures that all dates entered into HabProgs follow this format. Note that this may affect other programs running and relying on a specific date format.

3.0 DETAILED PROCEDURES

If Microsoft Access has not already been installed on the computer that will be used for data processing, obtain a copy and follow the installation instructions.

The standard version of the database is distributed as a compressed Zip file, which is available from the Toronto Region Conservation Authority website: (www.trca.on.ca/osap). The Zip file contains two files, ***HabProgsFXV09_18_2009.mdb*** (or more recent date stamp) and

Habitat.mdb. The two files should be extracted to a directory set up by the user (i.e., the user can name the directory) using a Zip-compatible archive program.

Open Microsoft Access and load ***HabProgsFXV09_18_2009.mdb*** using ‘File’, ‘Open’. Alternatively, double-click on ***HabProgsFXV09_18_2009.mdb*** in the ‘Windows Explorer’ or ‘My Computer’ windows to start Access and automatically open HabProgs. The best method, however, is to make a shortcut for HabProgs by right-clicking on ***HabProgsFXV09_18_2009.mdb*** in ‘Windows Explorer’, and dragging it to the desktop. When the mouse button is released, a menu will pop up. Select ‘Create Shortcut(s) Here’ and an icon will appear. Double-click on the icon to start the habitat database.

Once Access opens and loads the application, the opening screen appears. A message box may appear, requesting the location of ***Habitat.mdb***. Browse to the directory and select the file. Next, the ‘Main Switchboard’ screen (Figure 1) will be displayed.

The ***Habitat.mdb*** file should be renamed to more appropriately reflect the user’s project (e.g., ***Lake Erie Inventory.mdb***). Be sure to avoid the use of spaces or special characters when renaming the project.

3.1 Background to the Database System

The database system consists of many linked tables which are stored in two different database files. Some of the tables contain the raw field data while others contain summary outputs and parameters. All of the tables are linked by the common fields: stream name, stream code, site code, sample number, and year. **In order for the database system to operate effectively, it is essential that no field, table, form, report, macro, or query names are altered**. For example, if a table name is changed, database queries will not be able to locate the information held in the table. A list and brief description of the data tables is provided in Stanfield et al. (2003)[2] . Note that in the future FWIS metadata fields that are currently optional may become mandatory. Two of these fields are the project code and project organization. To ease the transition to the new system, the database managers will be validating data to make sure that all current datasets contain this information as well.

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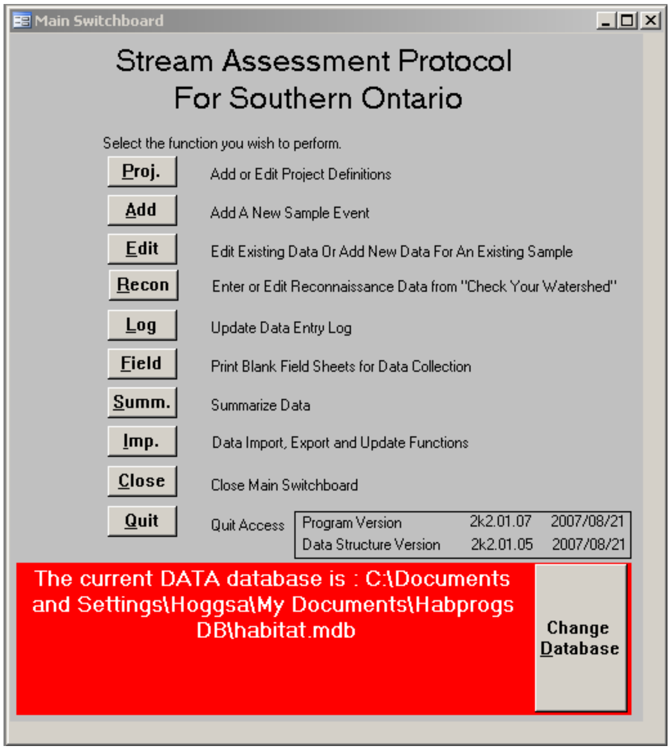
[2] Available from: www.trca.on.ca/osap



Stream Assessment Protocol
For Southern Ontario

Select the function you wish to perform.

Proj.	Add or Edit Project Definitions
Add	Add A New Sample Event
Edit	Edit Existing Data Or Add New Data For An Existing Sample
Recon	Enter or Edit Reconnaissance Data from "Check Your Watershed"
Log	Update Data Entry Log
Field	Print Blank Field Sheets for Data Collection
Summ.	Summarize Data
Imp.	Data Import, Export and Update Functions
Close	Close Main Switchboard
Quit	Quit Access

Program Version	2k2.01.07	2007/08/21
Data Structure Version	2k2.01.05	2007/08/21

The current DATA database is : C:\Documents and Settings\Hoggsa\My Documents\Habprogs DB\habitat.mdb

Figure 1: Main Switchboard for the Standard Version of the Database System.

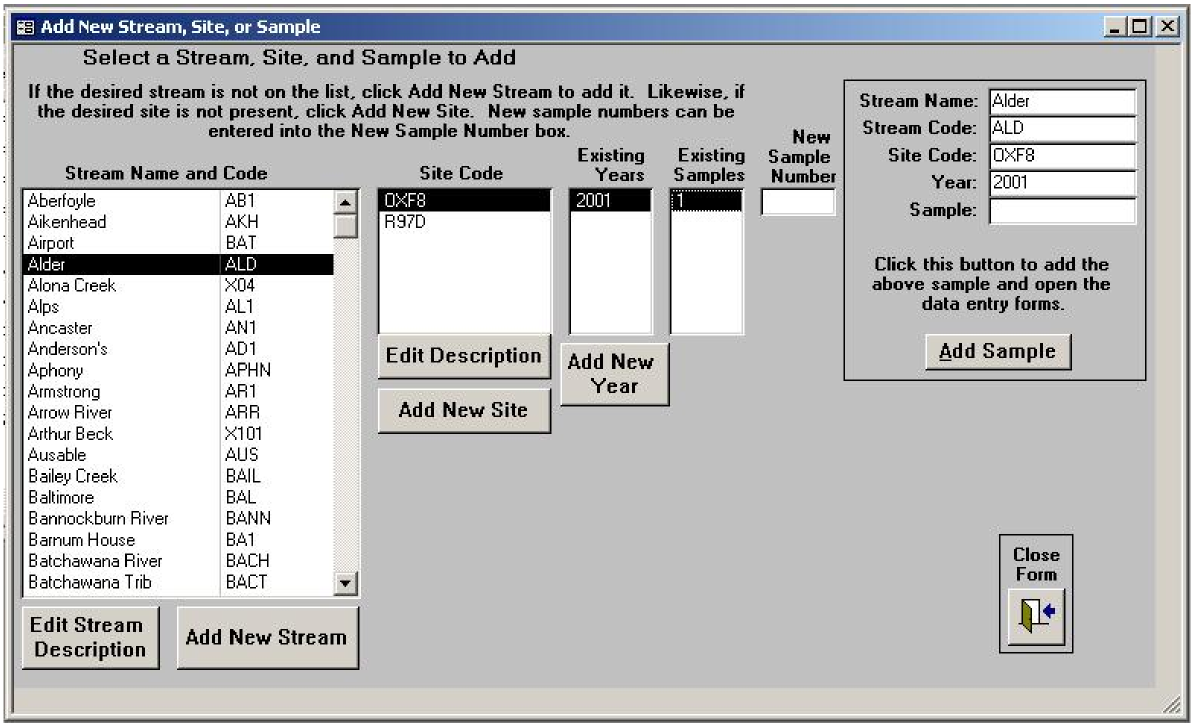
The ‘Main Switchboard’ screen offers several options that may be accessed at different stages of data management. The options are discussed in a sequence typically applicable to a first-time operator.

3.2 Proj. “Add or Edit Project Definitions”

Field data is collected as part of a project. In this section, project managers or their designates identify the lead project organization and key contact, and describe the background and objectives associated with the study. Also, project managers wishing to exercise proprietary rights over data associated with a project (see Introduction, i.e., indicating that database users must first obtain permission before using their data), should toggle the appropriate box to initiate this function. A unique acronym is assigned to each project which will be assigned to each sample associated with the project. This information is used to sort or export data. Data may be collected for more than one purpose; therefore more than one project code may be assigned to a sample. Project managers are encouraged to update project definitions once a project is complete so that information about reports generated, et cetera, can be relayed to future users of the data.

3.3 Add “Add a New Sample Event”

Before new data can be entered, the unique codes that will be assigned to the sampling event must be established. The ‘Add New Stream, Site or Sample’ window (Figure 2) allows access to a hierarchy of stream names and codes, site codes, year and sample numbers that are associated with existing data. Data entry personnel should work through the hierarchy to ensure that the data to be entered are matched to the correct unique stream and codes. If any of the unique codes are not already in the database (i.e., it is a new site), follow the directions provided to add the new information. For new locations, provide a description of the location in the appropriate box so that others can navigate to these identifiers. Duplicate information should not be added to the database. For example, a data entry technician trying to enter information from Silver Creek (AG1) who discovers it has already been entered under another stream code (e.g. as Credit River (stream code CR1) or Silver Creek with stream code SV2) should not re-enter the data. If this situation is encountered, the database custodian should be contacted for advice. Efforts are underway to generate a standard stream naming and coding convention for the province that will provide a solution to the long standing issue of generating unique tabular identifiers for each sample site. If a new stream name and code must be entered, the data entry technician should contact the database manager to ensure that the code has not been assigned previously.



If the desired stream is not on the list, click Add New Stream to add it. Likewise, if the desired site is not present, click Add New Site. New sample numbers can be entered into the New Sample Number box.

Stream Name and Code	
Aberfoyle	AB1
Aikenhead	AKH
Airport	BAT
Alder	ALD
Alona Creek	X04
Alps	AL1
Ancaster	AN1
Anderson's	AD1
Aphony	APHN
Armstrong	AR1
Arrow River	ARR
Arthur Beck	X101
Ausable	AUS
Bailey Creek	BAIL
Baltimore	BAL
Bannockburn River	BANN
Barnum House	BA1
Batchawana River	BACH
Batchawana Trib	BACT

Site Code	Existing Years	Existing Samples	New Sample Number
OXF8	2001	1	
R97D			

Stream Name: Alder
Stream Code: ALD
Site Code: OXF8
Year: 2001
Sample:

Click this button to add the above sample and open the data entry forms.

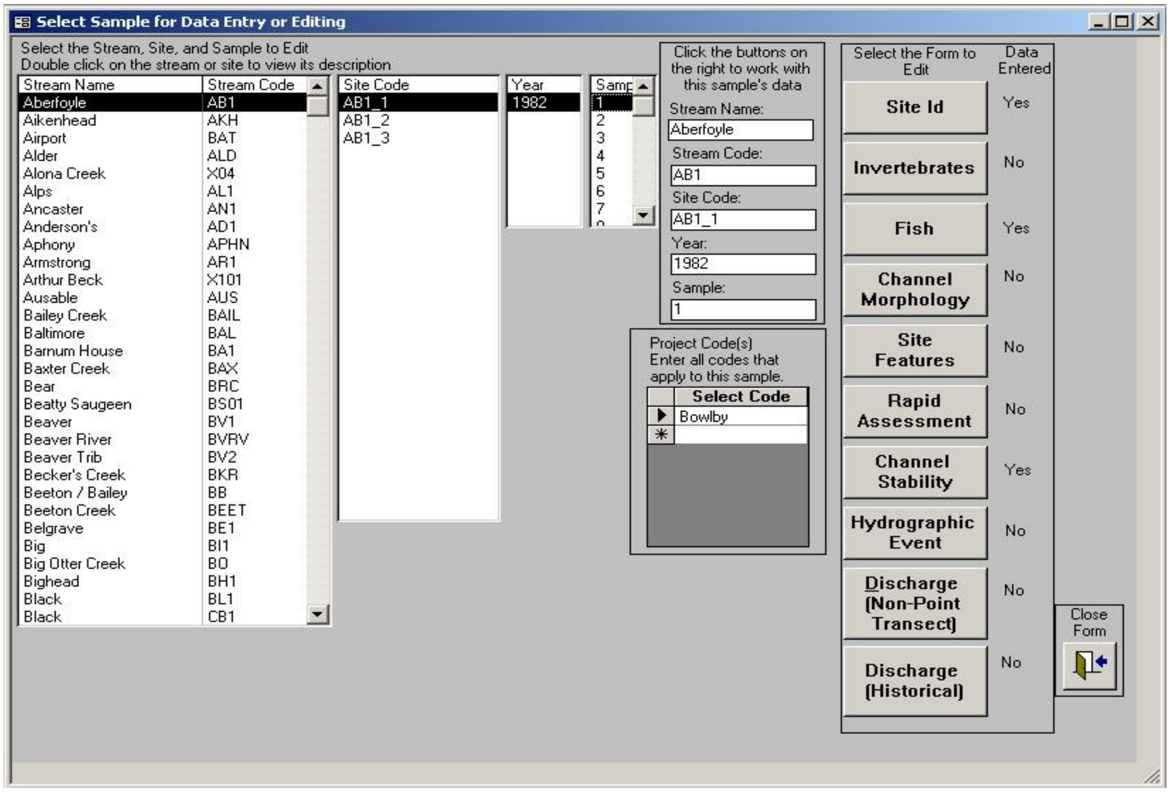
Figure 2: Screen for Adding New Streams, Sites or Samples.

A unique sample includes the year and sample number. Both must be filled in before the sample is established and data entry can continue. Assign the appropriate project code(s) to each new sample.

Note: Data collected using S4.M4, Reconnaissance Surveys for Stream Discharge must be entered from the main switchboard screen and follows a slightly different process, that will be harmonized with the process described here in the new operating system. See Section 3.4.

3.4 Edit "Edit Existing Data Or Add New Data For An Existing Sample"

To enter new records (field data) or edit/access existing records, the 'Main Switchboard' must be open, and the Edit button should be selected (refer to Figure1). The screen which pops up (Figure 3) is also organized in a hierarchy to assist with locating the sample of interest. Scroll to the appropriate sample (note that typing the first letter of the stream name jumps the cursor to the first stream with that letter) and open the window that contains the data of interest or for which data are to be entered. If data are recorded for any of the field forms (i.e., 'Site Id', 'Invertebrates', 'Fish', 'Channel Morphology', 'Site Features', 'Rapid Assessment', 'Channel Stability', 'Hydrographic Event', 'Discharge (Non-Point Transect)', or 'Discharge (Historical)'), 'Yes' will be displayed under the 'Data Entered' column.



Select the Stream, Site, and Sample to Edit
Double click on the stream or site to view its description

Stream Name	Stream Code
Aberfoyle	AB1
Aikenhead	AKH
Airport	BAT
Alder	ALD
Alona Creek	X04
Alps	AL1
Ancaster	AN1
Anderson's	AD1
Aphony	APHN
Armstrong	AR1
Arthur Beck	X101
Ausable	AUS
Bailey Creek	BAIL
Baltimore	BAL
Barnum House	BA1
Baxter Creek	BAX
Bear	BRC
Beatty Saugeen	BS01
Beaver	BV1
Beaver River	BVRV
Beaver Trib	BV2
Becker's Creek	BKR
Beeton / Bailey	BB
Beeton Creek	BEET
Belgrave	BE1
Big	BI1
Big Otter Creek	BO
Bighead	BH1
Black	BL1
Black	CB1

Site Code
AB1_1
AB1_2
AB1_3

Year
1982

Samp
1
2
3
4
5
6
7

Click the buttons on the right to work with this sample's data

Stream Name: Aberfoyle
Stream Code: AB1
Site Code: AB1_1
Year: 1982
Sample: 1

Project Code(s)
Enter all codes that apply to this sample.

Select Code
Bowlby

Select the Form to Edit	Data Entered
Site Id	Yes
Invertebrates	No
Fish	Yes
Channel Morphology	No
Site Features	No
Rapid Assessment	No
Channel Stability	Yes
Hydrographic Event	No
Discharge (Non-Point Transect)	No
Discharge (Historical)	No

Figure 3: Screen to Select Modules for Data Entry and Editing.

If data are entered that are beyond the conditions set for a parameter within OSAP the user will receive an “invalid entry” error. This simply means that either an error occurred in recording the information (typically a decimal place is missing) or a data entry error has occurred. In either event, correct the error (including the field sheet) and continue.

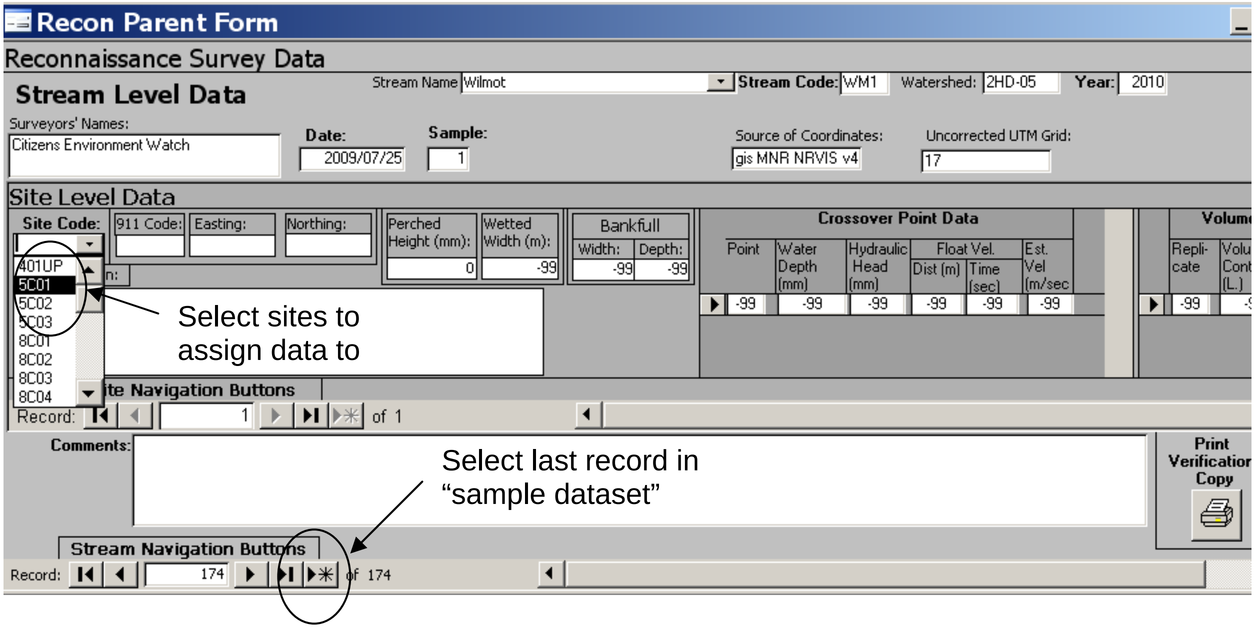
For each new sample, the ‘Site Identification’ field form must be filled out before data can be entered and stored in other field forms. The sample date is used as the key field for the ‘Site Identification’ form and must be filled out prior to future data entry. Once this data entry field has been filled out, and the ‘Site Identification’ form data has been stored, the appropriate window(s) for other field forms may be opened and data may be entered.

It is recommended that the boxes at the bottom of each field sheet be used to keep track of data entry status for each sheet. With this the data entry person initials the appropriate box after each step in the process: entered; verified and corrected. In some instances data will be missing from a form and the form should be marked as being incomplete and the information should be obtained and entered prior to the form being marked off as being verified (see next section). This is particularly important in the case of the ‘Site Identification’ form, which requires some research to get all the information (i.e., validated UTM coordinates etc.).

3.5 Recon “Enter or Edit Reconnaissance Data for “Check Your Watershed”

The Recon data entry system for S4.M4, Reconnaissance Surveys for Stream Discharge (a.k.a. Check Your Watershed Day) is organized slightly differently than the rest of the data collection options. A separate data entry screen enables the users to set up a sample event for a single date of sampling in a single watershed (stream code) and expedites data entry by populating the sample data into each subsequent table of data associated with the site sampled.

To enter records for this module select the Recon button from the ‘Main Switchboard’. The ‘Recon Parent Form’ will appear on screen (Figure 4). Click on the “add new record” Stream Navigation Button (indicated by an arrow and asterisk) at the bottom of the screen. Once you have created a new empty record, set up the sample by selecting the appropriate stream from the drop down list at the top of the form and filling in the ’Date’, ‘Source of GIS Coordinates’, ‘UTM Grid’ and ‘Sample’ number for the dataset.



Stream Name: Wilmot
Stream Code: WM1
Watershed: 2HD-05
Year: 2010
Surveyors' Names: Citizens Environment Watch
Date: 2009/07/25
Sample: 1
Source of Coordinates: gis MNR NRVIS v4
Uncorrected UTM Grid: 17
Site Code: 5C01
Perched Height (mm): 0
Wetted Width (m): -99
Bankfull Width: -99
Bankfull Depth: -99
Record: 1 of 1
Record: 174 of 174

Select sites to assign data to

Select last record in "sample dataset"

Figure 4: Setting up a reconnaissance survey sampling event. Once set up, use these settings to select sites for entering data.

Once the sample data is established choose the site for which data was collected using the 'Site Code' drop-down list. Site codes must exist in the list of available sample sites (entered from the initial 'Add New Sample Event' option on the Main Switchboard. If a site code is not present in the drop-down list then return to this screen and populate the sample location information.

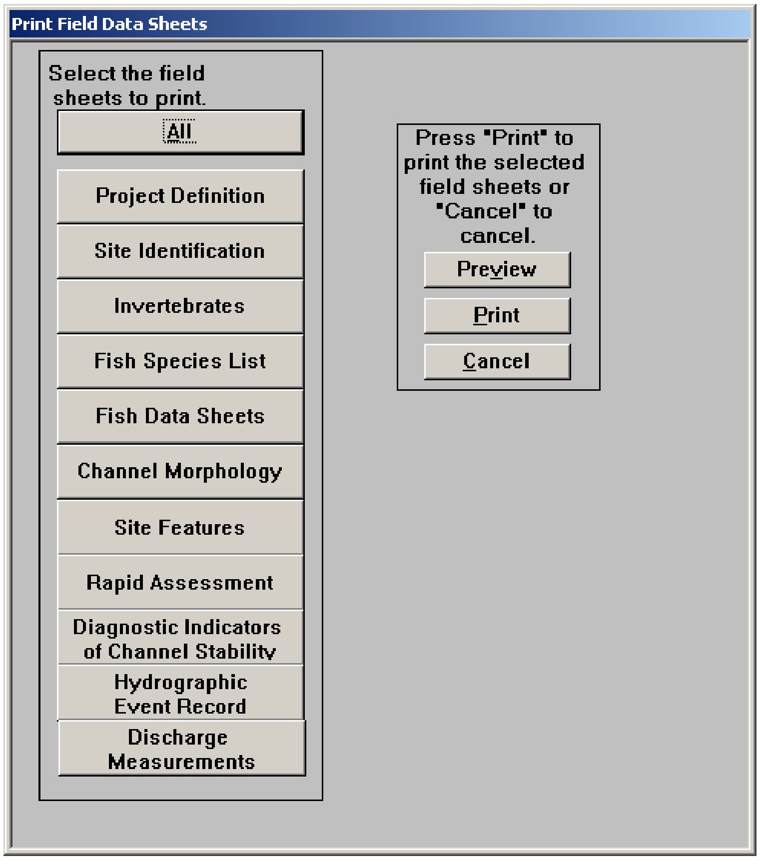
Project leads for reconnaissance surveys often establish quality assurance and control (QA/QC) crews to collect a second sample from a site on the same day as the initial data collection. Data from these crews should be identified as a separate sample. Finally, in some instances projects will also apply more detailed measures of discharge to validate volunteer collected data (e.g., S4.M4 and S4.M5). If more detailed measures are taken crews should enter this information following the standard approaches described above.

3.6 Data Verification

All field form data entry screens contain a tab button that can be used to print a verification copy. The printout will look like a reduced version of the data entry screen and is used for comparison with the field form containing the raw data. Even if a high level of care is applied to data entry, there will usually be data entry errors that require correction. This means that it is essential to verify the accuracy of all data in the database by comparing the electronic forms to the raw data sheets. Any errors should be marked on the verification copy (using a red pen) and then the corrections should be made in the database. A complete audit of the data should be performed - it is not acceptable to simply check a sample of data points to gauge the probability of errors. If possible, someone other than the data entry technician should conduct the verification process. When the data have been completely ‘Verified’ and ‘Corrected’, fill out the date(s) and initial the boxes under these columns on the field form that contains the raw data. During the verification process, it is equally important to make sure the type of data entered is valid, i.e., that codes are correct, data is recorded in the correct units (i.e., 100 mm not 10 cm), all unique fields are filled in on every field sheet, etc.

3.7 Field “Print Blank Field Sheets for Data Collection”

This window (Figure 5) is used to print blank field sheets, either individually or all at once. Note that other options for generating field sheets that are compatible with HabProgs are also being explored, including the use of scannable forms. Advice on accessing the most current field sheets is available on the TRCA website (www.trca.on/osap) and in the HabProgs database.

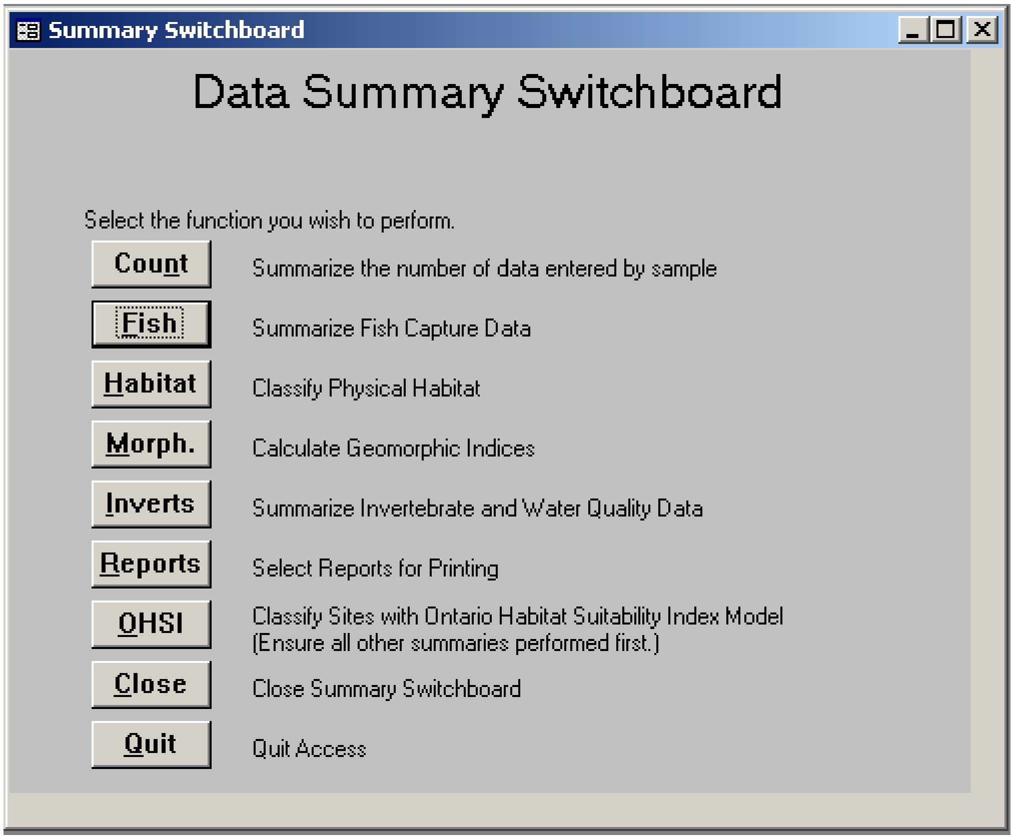


Print Field Data Sheets

Select the field sheets to print.

Press "Print" to print the selected field sheets or "Cancel" to cancel.

Figure 5. Printing Blank Field Sheets Form.



Data Summary Switchboard

Select the function you wish to perform.

Count	Summarize the number of data entered by sample
Fish	Summarize Fish Capture Data
Habitat	Classify Physical Habitat
Morph.	Calculate Geomorphic Indices
Inverts	Summarize Invertebrate and Water Quality Data
Reports	Select Reports for Printing
OHSI	Classify Sites with Ontario Habitat Suitability Index Model (Ensure all other summaries performed first.)
Close	Close Summary Switchboard
Quit	Quit Access

Figure 6: Summarize Data and Creating Reports Screen.

3.8 Summ. "Summarize Data" (Optional)

Within HabProgs, a number of summary queries and reports can be produced. Initiating the summary procedures contained in the 'Summary Switchboard' (Figure 6) will populate a number of tables within the database, enabling reports to be generated. A synopsis of each summary function is described below, while details of the rationale for and the criteria applied for each of these reports are described in the compendium manual for OSAP (Stanfield, 2003).

Count: Summarizes the data entered for each sample and is used to evaluate whether all data that should have been entered were entered and stored.

Fish: Generates a summary (by taxa) of the numbers and weights of fish caught and the biomass reported in g/100 m^2. It also generates the estimated catches for salmonids based on the regression formula of Jones and Stockwell (1995) and can generate a DeLury population estimate for three pass surveys. Finally, where no weight data are available for individual fish, correction factors for weight can be generated for certain taxa.

Habitat: A number of queries summarize the instream habitat data in order to generate distributions of morphologic units, substrate amount and distribution of cover and width/depth ratios.

Morph.: A number of queries that summarize the instream habitat data in order to generate distributions of morphologic units, substrate amount and distribution of cover and width/depth ratios.

Inverts: This provides the proportion of the total made up by each taxon after combining data from observation areas within a site. Additionally a Hilsenhoff biotic index score is generated for each sample.

Reports: A summary sheet that provides a synopsis of the data described above can be prepared and printed for each site.

Additional summary queries and reports are routinely generated for this program as needs arise.

3.9 Linkages with FWIS for Data Validation and Access

A transition phase between Habprogs and the development of the Flowing Waters Information System (FWIS) will be necessary. Some portions of FWIS are functional and a process has been put in place to enhance data management in general and to address some of the most important gaps in HabProgs. FWIS can be used as a tool for validating/correcting site locations for field samples. Sites can be viewed against the most up to date digital imagery and water layers available and locations of sites, “dots”, can be easily made. These changes are tracked and verified and incorporated into the master so that this historic data is continually improved. It also provides a window into the availability of data based on either spatial or tabular queries. Both types of queries are available because at present spatial locations are not accurate for all records that have been stored in Habprogs. Secondly, tabular queries enable sites to be identified that are either not accurately represented spatially, or to enable specific datasets to be explored that are associated with organizations, projects, or jurisdictions. The two approaches ensure that data explorations are comprehensive.

Data are organized by projects and descriptions are provided to assist users in understanding why data were collected, how site locations were selected and any specific biases that might be associated with the data. Any practitioner with a passcode can propose editorial changes, but these must be reviewed by both the database custodian and the project custodian prior to inclusion in the master database. Access to FWIS is available to any member of the OGDE or to other partners that sign a data sharing agreement. To obtain a pass code to the system contact Les.Stanfield@ontario.ca, or the database administrator, through the FWIS portal.

Instructions in the use of FWIS are available from the website (www.comap.ca\fwis) and through periodic training sessions. Eventually, FWIS will provide controlled access to raw datasets, but in the interim, practitioners can select and save selected datasets as a CSV file and forward this to the database custodian for extraction of the appropriate data (see below).

3.10 Imp. "Data Import, Export and Update Functions" (Optional)

A complete copy of a dataset can be made by clicking the 'All' button. This function is provided so that project managers (or their designate(s)) can export larger datasets or subsets of them. This is useful for sharing partial datasets and for assisting with analysis. The import and update functions are mainly used by the database manager. If the Export tab is activated a tabbed dialog box (Figure 7) appears that provides a number of options for selecting samples to export. Click on the 'Select Destination' button to select a name and location for the dataset that is to be extracted. A dataset containing empty tables (e.g., in order to start entering new data), can be created by clicking on the button that is labelled 'None'. The 'counters' at the right side of the screen keep track of how many samples are contained in the database and how many are currently selected for export. Clicking on the tabs across the top enables samples to be selected from a variety of options, including project and watershed codes. It should be noted that data that have not been assigned to a project (i.e., a project code is not associated with the data) will not be exported when a project code is selected, and must be flagged and exported in another manner (e.g., by using the 'Site' tab).

The database custodian may also extract data based on key fields obtained from FWIS. In cases where proprietary rights have been requested or where sensitive data exists (e.g., location of species at risk) the data custodian may request that permission be obtained from the original data user prior to providing the data to another user. A query is available to generate a subset of the master for distribution to all members of the OGDE and other users who have signed a data sharing agreement with the province.

4.0 MAINTAINING BACKUP COPIES OF THE DATA

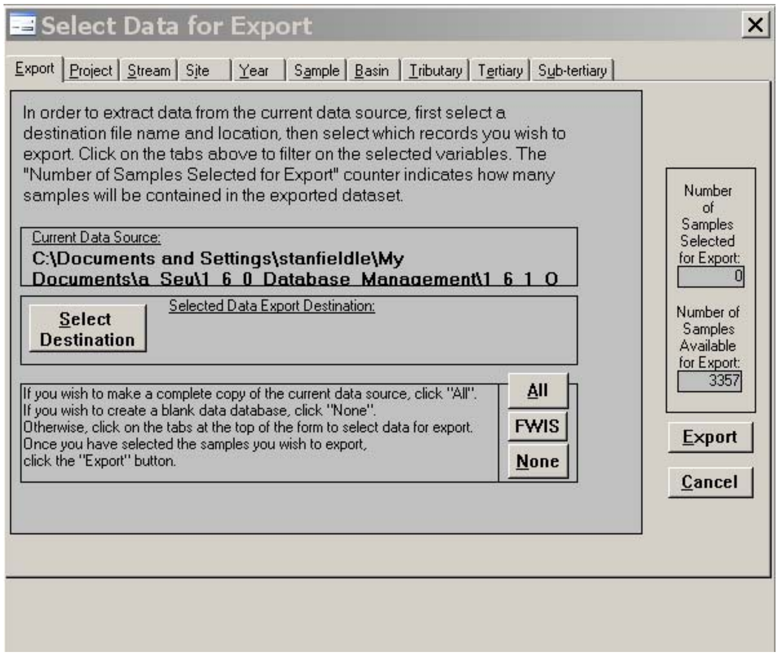
The data are stored in the data side of the application (i.e., ***Habitat.mdb*** file), and 'backup' copies of this file should be made on a regular basis. There is no need to back up the ***HabProgs*** file, as it can be re-installed at any time.

It is extremely important to generate backup copies of the data files. A single hard disk, compact disk or mass storage device should not be relied on as the sole repository for data.

Backup to a server (rather than a hard disk) is recommended. Some offices have backup systems in place; the backup schedule should include data files from the HabProgs application. In addition to routine backups, it is recommended that an archive copy of the raw data for each site (or collection of sites in a project) is made as soon as data entry and verification are completed. Unverified data should not be archived as it is likely to be mistakenly treated as verified data at later dates.

Frequent (**at least daily**) incremental backups of the data files are strongly recommended. For organizations with existing records retention policies and backup procedures, organizational guidelines should be followed. Alternative recommendations are detailed below.

A set of five rotating incremental backup files, i.e., Monday to Friday, should be maintained. Data files are then backed up on a daily basis to the server or disk corresponding to the appropriate day of the week. These files should be labelled as ‘Incremental backup Monday disc __ of __ (i.e., 1 of 5)’. The name of the directory where the data are stored should also be recorded, e.g., (d:\data\habitat). A separate, full backup should be performed every Friday, and this version should be kept for a month before being copied over. Again, record the name of the directory where the data are stored. This scenario provides a backup system for any file that is a month old.



In order to extract data from the current data source, first select a destination file name and location, then select which records you wish to export. Click on the tabs above to filter on the selected variables. The "Number of Samples Selected for Export" counter indicates how many samples will be contained in the exported dataset.

Current Data Source:
C:\Documents and Settings\stanfieldle\My Documents\a_Seu\1_6_0_Database_Management\1_6_1_O

If you wish to make a complete copy of the current data source, click "All".
If you wish to create a blank data database, click "None".
Otherwise, click on the tabs at the top of the form to select data for export.
Once you have selected the samples you wish to export,
click the "Export" button.

Number of Samples Selected for Export: 0

Number of Samples Available for Export: 3357

Figure 7: Options for Data Export

5.0 STORING DATASETS IN A CENTRAL REPOSITORY

After all data have been entered and verified, two copies of the data should be made. One copy should be stored in a fire-proof location.

Another copy of the data should be sent to the database manager (currently located at: Glenora Fisheries Station, RR 4, Picton Ontario, K0K 2T0, email les.stanfield@ontario.ca). Sending a copy of the data to the database manager will ensure that data are stored safely in another location and will make the data available to other researchers, managers, and private organizations. Note that project data that have been flagged with the proprietary rights functions will prompt the database manager to contact the appropriate project manager for authority to share the data with other partners.

5.1 Tips for Improving Data Quality

Take frequent breaks while entering and verifying data, to relieve eyestrain and mental fatigue.

Have someone other than the person who entered the data perform the data verification, or wait at least three days after entering the data before verifying it.

Check that all codes, values in fields, etc., are appropriate when doing data verification.

Make sure that all data fields have been completely filled in before marking the field form as being verified. If data are missing (usually information about the site location) it will likely be a long time before someone notices and it will not only jeopardize the value of the data but will reflect poorly on the technicians who entered and verified the data.

Be careful not to mix up data forms from different samples.

Original data sheets should never be sent out of their permanent repository; only photocopies should be shared!

If validating data on-screen, a person other than the data entry technician should review the data using the printed version to ensure that all errors are corrected.

In Access, pressing the control key and the apostrophe key (`- at the top left corner of your keyboard) repeats the previous record into any field. It is very useful for entering fish data, comments and other repetitive entries however, this method is more likely to introduce error, so be sure to verify your data.

If problems entering the date are encountered, check that the computer's internal date format is set up as yyyy/MM/dd.

Access provides transect navigation and record selector buttons that enable scrolling through records of data within a set of data or to add new record pages (i.e., a new transect page). These buttons have arrows and asterisks and are generally located at the top of the page. The Record Selector buttons (grey buttons with black VCR like arrows) allow you to move from one record to another in the same sample.

New records may be inadvertently initiated when data are entered causing the program to stop functioning (the computer will beep). To clear the record/sample being created and return to data entry, the 'Esc' key should be pressed.

If field crews have only recorded their initials and not their full names on the field forms, the data entry technician should ensure that at least a last name and a first name initial is recorded for the crew members associated with every record.

6.0 LITERATURE CITED

Jones M. L. and J. D. Stockwell. 1995. A Rapid Assessment Procedure for the Enumeration of Salmonine Populations in Streams. N. Amer. J. Fish. Man. 15:551 -562.

Stanfield, L. W. (Ed.). 2003. Guidelines for Designing and Interpreting Stream Surveys: A Compendium Manual to the Ontario Stream Assessment Protocol. Ontario Ministry of Natural Resources, Aquatic Research and Development Section, Picton. Internal Publication.

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 7

Glossary and List of Acronyms

active channel	the active channel boundaries mark the area between the two outside banks which includes all connected water at the time of the survey. This includes actively flowing as well as stagnant areas provided there is no land barrier that separates it from the main channel
aggradation	Readjustment of the stream profile where the stream channel is raised by the deposition of bed load
aquatic macrophytes	includes many different species of aquatic plants; all are rooted in the stream bottom and have obvious stems or leaves or filaments (e. g,, *Veronica* spp., pondweed, tape grass, arrowhead, bulrush and cattail)
armouring	rip rap, gabion, concrete, etc., placed on the banks
backwater pools	wet areas adjacent to the active channel that are fed by intergravel flow
bank angle	a measure of the slope of the bank which can be used in determining stream bank stability
bankfull stage	in alluvial streams, defined as the point at which the channel is completely full just prior to flows overtopping the banks and occupying the floodplain; the flows at bankfull stage are typically considered the channel forming flows
bank grid	used to record the amount of living bank vegetation, measures 100 cm long by 5 cm wide, and is comprised of 16 (6.25 cm) blocks
benthic macroinvertebrates	animals without backbones that live on the bottom of lakes, rivers, and streams and are visible with the naked eye
assessment surveys	these methods require more effort than screening surveys; they are recommended for monitoring or impact assessment studies
baseflow	the portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not

	include direct runoff or flow from stream regulation, water diversion or other human activities
benthos	benthic macroinvertebrates
bottom	when referring to the site, pertains to the downstream end
bulk weights	obtained by sorting a sample of fish by species or like groups, counting the individuals, and measuring the combined weight of each species or group to the nearest gram
cobble areas	exist where at least 10 particles with a median axis > 100 mm occur within the riffle
cover particle	any object that touches the water within the sample area, is at least 100 mm wide along the median axis and of sufficient density to block >75 % of sunlight from reaching the stream bottom; it can consist of a mat of materials such as twigs, macrophytes, or the bank
crossover point	the location where the thalweg (main concentration of flow, normally the deepest part of the channel) is in the centre of the channel during bankfull discharge
diagnostic surveys	these methods provide detailed data and a higher degree of interpretative power than the screening or assessment surveys, but require more effort to conduct
degradation	Readjustment of the stream profile where the stream channel is lowered by the erosion of the stream bed
DFO	Department of Fisheries and Oceans
dot tally	a convenient means of recording data when a number of categories are being counted simultaneously; one dot or line represents a single observation, four dots are used to form the outside of a box, then four lines are used to form the outside of the box and finally two lines are used to form a cross for a total of ten observations per filled box
drop structures	perched culvert, weir, flume etc.
embedded cover	provides only a velocity refuge and has less than a 4 cm overhang (e.g., the interstitial spaces around the cover object are filled with material)
entrenchment	the degree to which the stream is restricted from accessing the flood plain, or how incised the stream is within the valley (i.e., the valley width/bankfull width)

entrenchment width	the width of the flood-prone area of a channel at twice the height of its maximum bankfull depth from the channel bed
filamentous algae	have hair-like filaments, are slimy to the touch, and are often attached to rocks
flat rock	the longitudinal axis is at least twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis > 2
FWIS	Flowing Waters Information System
GIS	Geographic Information Systems
GPS	Global Positioning System
grass	terrestrial grasses (as opposed to tape grass or eelgrass) which are growing in the stream; terrestrial grasses tend to be found at the margins of the stream
heat wave	three consecutive days where maximum air temperatures exceed 24.5°C and during which there has been no rainfall that affected baseflow of the stream
hydraulic head	a surrogate measurement of velocity measured as the difference in height of water between the front and back of a vertically held ruler that is placed at right angles to the flow of water
imbrication	refers to stream condition where larger substrate particles are stacked in ways that mimic fallen dominoes
inflection points	a change in the slope along the bank, perpendicular to the stream flow
inlets	presence of tributaries that provide sufficient discharge to produce a plume or delta, or major outfalls emptying into the channel
inorganic deflectors	mid-channel islands, large rocks (erratics), etc., that are sufficiently large to cause erosion on either bank
knickpoints in streams	a point along a river's length at which it suddenly begins to flow in a steeper course in the downstream waters. These represent high points in bed elevation
left	when referring to the site, refers to the left side while facing upstream
macroinvertebrates	aquatic invertebrates retained by a sieve of 500 μm
macrophytes	include many different species, all are rooted in the stream bottom

	and have obvious stems or leaves or filaments (examples: *Veronica* spp., pondweed, tape grass, arrowhead, bulrush and cattail)
Manning's equation	estimates water velocity using measures of stream slope, roughness, hydraulic radius and constants for channel types
median axis	there are three axes to every particle; the median axis represents the intermediate width of any particle
mid-channel island	any solid object with a median diameter greater than 30 cm (located within the active channel) which protrudes above the water
moss	small plants (2-20 cm) found in a matted colony on coarse substrate and wood; they are distinguished from plants by the absence of a distinctive stem or true leaves
non-filamentous algae	are slimy to the touch with no hair-like filaments
NHIC	Natural Heritage Information Centre
NRVIS	Natural Resource Value Information System
OBBN	Ontario Benthic Biomonitoring Network
OBM	Ontario Base Map
OMNR	Ontario Ministry of Natural Resources
OSAP	Ontario Stream Assessment Protocol
pavement boundary	the bottom of the active flowing channel and is identified as the point where substrate particles form a fairly uniform layer across the bottom
'press' disturbance	permanent landuse changes that typically have long lasting (i.e. centuries rather than decades) effects on the biophysical features of a stream
'pulse' disturbance	catastrophic changes to stream processes, including weather events such as hurricanes, tornadoes, extreme floods, fire etc.
RAM	Rapid Assessment Methodology
RCA	Reference Condition Approach, as per OBBN protocol
riffles	areas of relatively fast, turbulent flow, where the water's surface is typically broken and has an obvious slope
right	when referring to the site, refers to the right side while facing upstream

ROM	Royal Ontario Museum
round rock	the longitudinal axis is less than twice as long as the shortest axis, i.e., ratio of longitudinal axis/shortest axis < 2
sand and gravel areas	have less than 10 particles with a median axis > 100 mm
sample	one completion of the protocol (i.e., a module) , regardless of how many days it takes to finish it; a second sample would be a repeat assessment or a sample carried out in a different year
sampling site	represents at least one riffle-pool sequence, is at least 40 m long, and begins and ends at a crossover point
SAR	Species At Risk
screening surveys	these methods are used to perform rapid inventories tend to be visually based; they are useful for the collection of information for ‘state of the resource’ reports and for identifying future collection efforts
site length	the longitudinal length of the site (measured to the nearest metre) as measured down the centre of the stream
stratification	dividing the study design into equal or representative groupings of various factors
stream width	the wetted width of the stream (i.e., subtract the width of islands and include undercuts), to the nearest tenth of a metre
terrestrial plants	firm stemmed plants that occasionally grow on the margins of streams, such as jewelweed, stinging nettles, poison ivy, willow, dogwood, etc.
thalweg	main concentration of flow, normally the deepest part of the channel
top	when referring to the site, pertains to the upstream end
trim line depth	an equivalent to the bankfull stage in streams flowing through channels that are affected by bedrock, roots and woody material, large glacial deposits etc., identified as the upper limit of a regularly scoured zone and a distinct change in vegetation
watercress	plants that have dark green, non-woody stems with flat, broad, opposite compound leaves with 3 to 9 leaflets per stem; often found in large clusters along margins of stream, they are indicators of groundwater inputs and are also nitrate fixers

wetted width	the average width of the stream at the edges of the wetted channel, taken at right angles to the stream flow
unembedded cover	provides overhead and velocity protection for small fish and has at least a 4 cm overhang
UTM	Universal Transverse Mercator
wood deflectors	large logs or trees which impede the flow causing bank erosion on either side of the deflector
WRIP	Water Resources Information Project

ONTARIO STREAM ASSESSMENT PROTOCOL

SECTION 8

Blank Field Forms

Site Identification:
without Site Markers

Organization

Stream Name

Date (mm-dd)
20 – –

Stream Code

Site Code

Sample

Site Length (m)
.

**** Record using NAD83 datum*

Uncorr. UTM
Zone 1
Easting .
Northing .

Corr. UTM
Zone 1
Easting .
Northing .

OR →

Long.
DD
MM
SS.sss .

Lat.
DD
MM
SS.sss .

Source of Uncorrected UTM Coord.
- GPS/DGPS ☐
- GIS ☐
- OBM ☐

Other

Source of CorrectedUTM Coordinates
- FWIS ☐
- Ortho-photos ☐
- GIS ☐

Other

Name of Layer Used for Correction

Site Description & Access Route

Sketches

Site/Access Route Sketch

Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Photo No.

Photo Name

Photo Description

Comments

Crew Leader (init. & last name)

Crew

Recorder

Ent/Scanned

Verified

Corrected

Site Identification

Organization

Stream Name

Date (mm-dd) 20__ – __ – __

Stream Code

Site Code

Sample

Site Length (m) .

Site Sketches Included? Yes ☐ No ☐

*** *Record using NAD83 datum*

Uncorr. UTM — Zone 1_ — Easting . — Northing .

Corr. UTM — Zone 1_ — Easting . — Northing .

→ *OR*

	DD	MM	SS.sss
Long.			.
Lat.			.

Source of Uncorrected UTM Coord.

GPS/DGPS ☐

GIS ☐

OBM ☐

Other

Source of CorrectedUTM Coordinates

FWIS ☐

Ortho-photos ☐

GIS ☐

Other

Name of Layer Used for Correction

Township/Municipality

Lot

MNR District

Watershed Code

Concession

Access Route

Site Description

Site Marker Description

Upstream Marker (measure from stake to site)

Bearing (D)

Distance (m) .

	Photo No.	Photo Name
Upstream		
Dwnstream		

Upstream Description

Downstream Marker (measure from stake to site)

Bearing (D)

Distance (m) .

	Photo No.	Photo Name
Upstream		
Dwnstream		

Downstream Description

Additional Photos & Description

Photo No.	Photo Name

Comments

Crew Leader (initials & last name)

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected

Site Identification: Sketches

Site Sketch

Access Route

Be sure to include enough detail in sketches to ensure that someone could find the site again; include a north arrow and the locations of all markers and noted features. The artist should also sign the sketches.

Site Features

Stream Name

Date (mm-dd) 20__ – __ – __

Stream Code

Site Code

Sample

For each landuse, check all boxes that apply. Be sure to include comments explaining the particulars, including names and numbers of contacts

Site Features	Ongoing & Active	Historical Evidence	No Evidence but Reported	No Evidence	Unknown	Comments
Potential Point or Non-point Source Contaminant Sources	☐	☐	☐	☐	☐	
Major Nutrient Sources Upstream	☐	☐	☐	☐	☐	
Channel Hardening or Straightening	☐	☐	☐	☐	☐	
Adjacent Landuses that Destabilize Banks	☐	☐	☐	☐	☐	
Sediment Loading or Deprivation	☐	☐	☐	☐	☐	
Instream Habitat Modifications	☐	☐	☐	☐	☐	
Barriers and/or Dams in the Vicinity of the Site	☐	☐	☐	☐	☐	
High Fishing Pressure	☐	☐	☐	☐	☐	
Log Jam Deflectors	☐	☐	☐	☐	☐	
Springs or Seeps at the Site	☐	☐	☐	☐	☐	
Impervious Substrate Limiting Burrowing Depth of Fish	☐	☐	☐	☐	☐	
Fish Stocked Near Sample Site	☐	☐	☐	☐	☐	
Other Activities that Could Influence Biota or Habitat	☐	☐	☐	☐	☐	

Sources of Information

Visual Immediate ☐ Visual Extended ☐ Interview ☐ Maps & Photos ☐

Temperatures

Time (24hr) __ : __

Air Temp (°C)

Water Temp (°C)

Max Air Temp (°C)

Max. Water Temp (°C)

Source of Max. Air Temp

Riparian Vegetation Community

Only check one box for each bank and zone.

	Dominant Vegetation Type													
	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Past-ure	Crop-land	Mea-dow	Scrub-land	Forest	None	Lawn	Past-ure	Crop-land	Mea-dow	Scrub-land	Forest
1.5-10m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
30-100m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Comments

Crew Leader (initial & last name)

Crew Initials	Recorder	Ent/Scanned	Verified	Corrected

Benthic Survey Sheet

Stream Name

Stream Code

Site Code

Sample

NOTE:
For all measurements, right and left banks defined facing upstream.

Date (mm-dd) 20 – –

Time (24hr) :

Water Quality

Water Temp (°C)

Conductivity (uS/cm)

pH

DO (mg/L)

Alkalinity (mg/L as CaCO3)

Substrate

Enter dominant substrate class and second dominant class for each sub-sample.

	Collect. Area 1	Collect. Area 2	Collect. Area 3
Dominant			
2nd Dominant			

Class	Description
1	Clay (hard pan)
2	Silt (floury, <0.06 mm particle diameter)
3	Sand (grainy, 0.06 - 2mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (>250 mm)
7	Bed Rock

Bankfull Width (m)

Gear Type

☐ Poled Seine ☐ Ponar

☐ D-Net ☐ Ekman

☐ Surber ☐ Other :

Collection Method

☐ Rapid Survey

☐ Stationary Kick Survey

☐ Transect Kick & Sweep

☐ Grab

MeshSize (microns)

☐ 250 ☐ 600

☐ 500 ☐ 1000

(Select the box that most closely represents the mesh size used.)

% Canopy Cover

☐ 0 - 24 ☐ 50 - 74

☐ 25 - 49 ☐ 75 - 100

If instrument used, record type:

River Characterization

☐ Perennial

☐ Intermittent

☐ Unknown

Candidate Reference Site?
(ie. minimally impacted)

☐ Yes

☐ No

Comments

Crew Leader (initial & last name)

Aquatic Macrophytes & Algae

Enter appropriate abundance class for each type and sub-sample.

Class	Description
0	Absent
1	Present
2	Abundant

Macrophytes	Collect. Area 1	Collect. Area 2	Collect. Area 3
Emergent			
Rooted Floating			
Submergent			
Free Floating			

Algae	Collect. Area 1	Collect. Area 2	Collect. Area 3
Floating Algae			
Filamentous			
Attached Algae			

Riparian Vegetation Community

Only check one box for each bank and zone.

Dominant Vegetation Type

	Left Bank							Right Bank						
Riparian Zone	None	Lawn	Pasture	Crop-land	Mea-dow	Scrub-land	Forest	None	Lawn	Pasture	Crop-land	Mea-dow	Scrub-land	Forest
1.5-10m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10-30m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
30-100m	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Pool or Riffle (P/R)	Sampling Dist.(m)	Sampling Time (min : sec)	Max. Depth (mm)	Hydraulic Head (mm)	Wetted Width (m)	Grabs/ Area
Collection Area 1:		.	:			.	
Collection Area 2:		.	:			.	
Collection Area 3:		.	:			.	

Enter a P or an R to indicate whether the collection was a riffle or pool.

1, 2, or 3 grabs can be collected within each collection area.

Crew Names

Recorder Init.	Entered	Verified	Corrected

Benthic Macroinvertebrate Sample Form

Survey Type: ☐ Rapid Survey ☐ Stationary Kick Survey

Stream Name

Date (YYYY/MM/DD)

Identified in (circle): Field Lab

Microscope Used? Yes No

Sample Preserved? Yes No

No. of Vials:

Mesh Size (microns): 251-500 501-1000

Median sizes of 10 substrate particles randomly chosen from collection area (mm)

Stream Code

Sample #

Water Depth (mm.)

Stream width(m):

Habitat Sampled (circle) Riffle Pool

Sorting Method (circle) Unsorted Marchant Box Splitter

Site Code

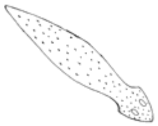
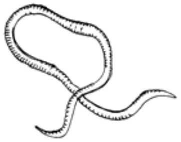
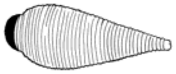
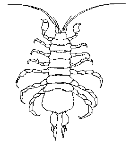
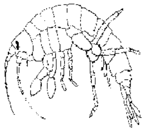
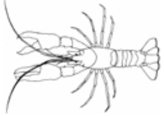
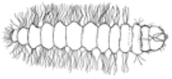
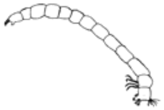
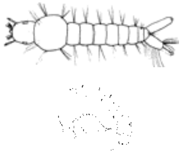
Collection Area

Hydraulic Head (mm.)

Sampling Time(sec):

Size of Kick Sample Collected (ml or gm) Total: Portion not picked:

Net Type(circle): Square Surber D-net

 2 – 5 mm Hydra (Coelenterates)	 2 – 10 mm Flatworms (Platyhelminthes)	 1 – 100 mm Nematoda (Roundworms)	 1 – 100 mm Oligochaeta (Aquatic Earthworms)	 5 – 100 mm Hirudinea (Leeches)	 5– 300 mm Isopoda (Aquatic Sowbugs)	 2 – 250 mm Pelecypoda (Clams)	 5 – 20 mm Amphipoda (Scuds)	 0 – 150 mm Decapoda (Crayfish)
 0.4 – 3.0 mm Acarina (Water Mites)	 3 – 28 mm Ephemeroptera (Mayflies)	 15 – 45 mm Anisoptera (Dragonflies)	 10 – 26 mm Zygoptera (Damselflies)	 5 – 50mm Plecoptera (Stoneflies)	 15 – 40 mm Hemiptera (True Bugs)	 25 – 90 mm Megaloptera (Helgrammites)	 2-50 mm Trichoptera ('Caddisflies)	 10 – 25 mm Lepidoptera (Aquatic Moths)
 2 - 40 mm Coleoptera (Beetles)	 2– 70 mm Gastropoda (Snails)	 2 – 20 mm Chironomidae (Blood Worms)	 15 – 40 mm Tabanidae (Horse and Deer Flies)	 2 – 50 mm Culicidae (Mosquitos)	 3 – 13 mm Ceratopogonidae (No-see-ums)	 10 – 45 mm Tipulidae (Crane Files)	 3 – 15 mm Simuliidae (Black Flies)	 Misc. Dipteras (Misc. True Flies)

Dot Tally, keep track of total number sampled

Crew Members:

Comments, check box if more on back:

	Ent.	Ver.	Corr.
Date			
Init.			

Benthic Tally Sheet

Date (mm-dd) 20

Stream Name

Stream Code

Site Code

Sample

Collection Area

Sorting Method
☐ Unsorted
☐ Marchant Box
☐ Splitter

Sample Size ☐ mL ☐ g

Total Vol/Wt

Vol/Wt not Picked

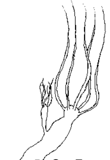
Sample Preserved? ☐ Yes ☐ No

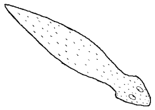
No. of Vials

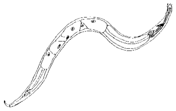
Identification
☐ in Field
☐ in Lab
☐ Microscope
☐ no Microscope

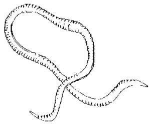
Unknown Species

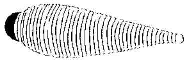
Comments

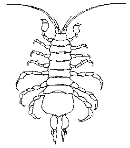

2 - 5 mm
Coelenterates
(Hydra)

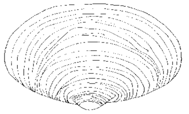

2 - 10 mm
Platyhelminthes
(Flatworms)

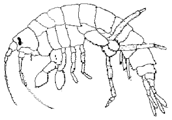

1 - 100 mm
Nematoda
(Roundworms)

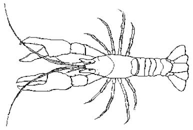

1 - 100 mm
Oligochaeta
(Aquatic Earthworms)

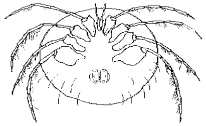

5 - 10 mm
Hirudinea
(Leeches)

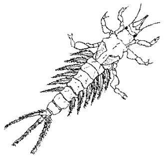

5 - 300 mm
Isopoda
(Aquatic Sowbugs)


2 - 250 mm
Pelecypoda
(Clams)

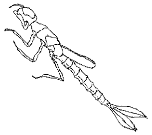

5 - 20 mm
Amphipoda
(Scuds)

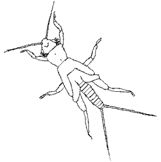

10 - 150 mm
Decapoda
(Crayfish)


0.4 - 3 mm
Acarina
(Water Mites)

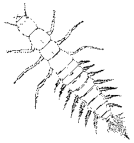

3 - 28 mm
Ephemeroptera
(Mayflies)

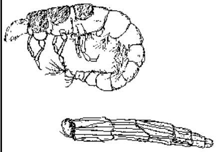

15 - 45 mm
Anisoptera
(Dragonflies)

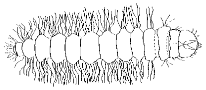

10 - 26 mm
Zygoptera
(Damselflies)


5 - 50 mm
Plecoptera
(Stoneflies)

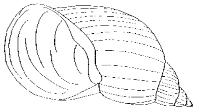

15 - 40 mm
Hemiptera
(True Bugs)

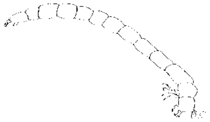

25 - 90 mm
Megaloptera
(Helgrammites)

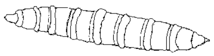

2 - 50 mm
Trichoptera
(Caddisflies)

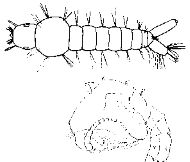

10 - 25 mm
Lepidoptera
(Aquatic Moths)

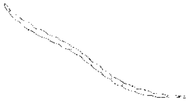

2 - 40 mm
Coleoptera
(Beetles)

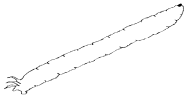

2 - 70 mm
Gastropoda
(Snails)


2 - 20 mm
Chironomidae
(Blood Worms)

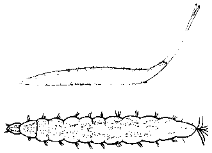

15 - 40 mm
Tabanidae
(Horse & Deer Flies)


2 - 50 mm
Culicidae
(Mosquitos)


3 - 13 mm
Ceratopogonidae
(No-see-ums)


10 - 45 mm
Tipulidae
(Crane Flies)


3 - 15 mm
Simuliidae
(Black Flies)


Misc. Diptera
(Misc. True Flies)

Dot Tally (track total no. sampled)

Crew Leader (init. & last name)

Crew Init.

Recorder Init.

Verified

Corrected

Fish Sampling

Page No. ☐☐ of ☐☐

Stream Name

Date (mm-dd) 20__ – __ – __

Stream Code

Sample

Run No. ☐☐ of ☐☐

Start Time (24hr) __ : __

Elapsed Min.

Shocker Sec.

Site Code

Science Collect. No.

Stop Time (24hr) __ : __

Model No.

Anod.

Voltage

Frequency

Pulse

Channel Morphology Available?

☐ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m) ___ . _

Widths (m)

1	__ . _	6	__ . _
2	__ . _	7	__ . _
3	__ . _	8	__ . _
4	__ . _	9	__ . _
5	__ . _	10	__ . _

Individual Fish

☐ Total Length

☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

ID	Species	Length (mm)	Weight (g)	B / O	P / S	Sp Name/Remarks
1				☐ ☐	☐ ☐	
2				☐ ☐	☐ ☐	
3				☐ ☐	☐ ☐	
4				☐ ☐	☐ ☐	
5				☐ ☐	☐ ☐	
6				☐ ☐	☐ ☐	
7				☐ ☐	☐ ☐	
8				☐ ☐	☐ ☐	
9				☐ ☐	☐ ☐	
10				☐ ☐	☐ ☐	
11				☐ ☐	☐ ☐	
12				☐ ☐	☐ ☐	
13				☐ ☐	☐ ☐	
14				☐ ☐	☐ ☐	
15				☐ ☐	☐ ☐	
16				☐ ☐	☐ ☐	
17				☐ ☐	☐ ☐	
18				☐ ☐	☐ ☐	
19				☐ ☐	☐ ☐	
20				☐ ☐	☐ ☐	

Comments

Bulk Fish

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Crew Leader (initial & last name)

Crew Initials

Recorder

Field ID (initial & last name)

Cert. Level

Entered/ Scanned

Verified

Lab ID (initial & last name)

Cert. Level

Corrected

Fish Sampling: Additional Samples

Page No. ☐☐ of ☐☐

Individual Fish Data

ID	Species	Length (mm)	Weight (g)	B O	P S	Sp Name/Remarks
				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	
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				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	
				☐ ☐	☐ ☐	

Comments

Bulk Fish Data

Batch	Species	Grp #	Fish Total	Bulk Weight (g)	Presvd	Bag #	Sp Name/Remarks

B = Bulk P = Preserved O = Otolith S = Scale

Grp #: 0 = unsorted or mixed sizes/ages 1 = YOY salmonines with total length < 100mm 2 = salmonines with total length > 100mm

** For individual and bulk records > 100, record ID and/or Batch numbers in the 'Remarks' field'.*

Rapid Assessment Methodology Field Form

Stream Name	Stream Code	Site Code	Year	Sample	Date (YYYY/MM/DD) Site Type (C – Calibration, S – Survey)

Crew

Channel Structure

Depth (mm)	Pools (Hydraulic Head = 0 – 3 mm)		Glides (Hydraulic Head = 4 – 7 mm)		Slow Riffles (Hydraulic Head = 8 – 17 mm)		Fast Riffles (Hydraulic Head >17 mm)	
	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present	No Cover	Cover Present
0 – 100 mm								
101 – 600 mm								
601 – 1000 mm								
> 1000 mm								
Total # Points								

Instream Cover

Cover Types	Flat Rock	Round Rock	Wood	Macrophytes	Bank	Other
Number of Points						

Substrate Types

	Fines (<2 mm)	Gravel (2 – 100 mm)	Cobble (101 mm – 1000nn)	Bedrock (>1000m)
Maximum Particle				
Point Particle				

Bank Stability

Mean Stream Width (m)	Mean Depth at Crossover (mm)	Maximum Particle Size (mm)

Eroding Bank		Angle > 45°, erodible soil, undercut or bare soil
Vulnerable Bank		Angle > 45°, erodible soil, no sign of recent erosion
Protected Bank		Angle > 45°, non-erodible material / soil
Deposition Zone		Angle < 45°, (gradual slope from river), fine grained sediments

Enter dates and initials when data entered in computer.

	Date	Init.
Entered		
Verified		
Corrected		

Channel Morphology

Stream Name

Date (mm-dd) 20 – –

Stream Code

Min. Width (m) .

Site Length (m) .

Active Channel Width (m) .

Site Code

No. of Transects

Transect Spacing (m) .

Point Spacing (m) .

Sample

Transect No. of

Bearing (D)

Points per Transect

Transect & Point Layout

Use this table to determine the number of transects & points required, given the minimum stream width.

Minimum Width (m)	No.Transects at Site	Points per Transect
> 3.0	10	6
1.5 - 3.0	12	5
1.0 - 1.49	15	3
< 1.0	20	2

Calculations:

$$\text{Transect Spacing} = \frac{\text{Site Length}}{(\text{No. of Transects } - 1)}$$

$$\text{Point Spacing} = \frac{\text{Active Channel Width}}{\text{Points per Transect}}$$

1st Point = Point Spacing / 2 (from left bank)

		Measure depth & hydraulic head to nearest 5 mm		Particle Sizes (mm)		Cover								Aquatic Vegetation Types Present						
Point No.	Location (m)	Depth (mm)	Hydraulic Head (mm)	Point	Max. in Ring	Unmeasurable	Quality	Wood	Round Rock	Flat Rock	Macrophyte	Bank	Other	FL	AL	SS	MC	WC	GR	TR
1	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6	.					☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Bank Angle & Particle Median Diameters

(Bank to tape height; if a height is >2m use check box, else enter values in proper observation points)

Dominant Vegetation Type

(Check box of the dominant type within the 1 x 2 m area)

		> 2 m	0 mm	250 mm	750 mm	1500 mm	Amount of Undercut (mm)	No. of Veg. Squares on Bank	None	Lawn	Pasture	Cropland	Meadow	Scrubland	Forest
Left Bank	Height	☐							☐	☐	☐	☐	☐	☐	☐
	Substrate Diameters														
Right Bank	Height	☐							☐	☐	☐	☐	☐	☐	☐
	Substrate Diameters														

Table Codes

Particle Sizes:

Measure all particles between 2.00mm and 1000mm

Material	Size
Unconsolidated Clay	0.01
Consolidated Clay	0.011
Silt	0.05
Sand	0.10
Large Boulders	1001
Bedrock	1111

Cover Quality:

0 = No Cover

1 = Embedded Cover

2 = Unembedded Cover

Aquatic Vegetation Types:

FL = Filamentous Algae

AL = Non-Filamentous

SS = Moss

MC = Macrophytes

WC = Watercress

GR = Grass

TR = Terrestrial Plants

Comments

Crew Leader (initial & last name)

Crew	Recorder	Ent/Scanned	Verified	Corrected

Diagnostic Indicators of Channel Stability Form

Transect No. ______ of _______

<table>
<tr><td colspan="2">Stream Name</td><td>Stream Code</td><td>Site Code</td><td>Sample</td><td>Date (yyyy/mm/dd)</td></tr>
<tr><td>Crew Leader</td><td colspan="2">Crew</td><td colspan="3">Recorder</td></tr>
<tr><td colspan="6">Comments</td></tr>
</table>

Transect and Point Layout

Use this table to determine the number of measured points per transect, given the minimum stream width

Min. Width (m)	Low Variance in Velocity or Depth	High Variance in Velocity or Depth
>3.0	8 + 1 every 2m	10 +1 every 2m
1.5-3.0	5	8
1.0-1.49	3	6
<1.0	2	4

Point Spacing = Active Channel Width / Points Per Transect

1st Point = Point Spacing / 2 (from left bank)

Site and Transect Measurements

Site Length (m)*	
Transect Spacing (m)*	
Active Channel Width (m)	
Point Spacing (m)	

*Record only on 1st transect

Discharge Approximates Baseflow?

☐Yes ☐No

Obstructions to Flow
(check all applicable)

- ☐ None
- ☐ Trampled Banks
- ☐ Wood Deflectors
- ☐ Inorganic Deflectors
- ☐ Armouring
- ☐ Inlets
- ☐ Other: _________

Indicators of Bankfull Level

Left Bank	Right Bank	
☐	☐	Inflection Point
☐	☐	Bank Material
☐	☐	Top of Point Bar
☐	☐	Vegetation
☐	☐	Min. Width:Depth
☐	☐	Other:___________
☐	☐	____________

Measures of Channel Entrenchment*

**Record either left, right, or total width*

Left Entrenchment Width (m)	
Right Entrenchment Width (m)	
Total Entrenchment Width (m)	

Entrenchment Height = 2 x Max. Channel Depth

Entrenchment Width = horizontal distance from location of max. channel depth to bank at entrenchment height

<table>
<tr><td></td><td>Horiz. Loc (m)</td><td>Vert. Ht. (mm)</td><td colspan="2">Ht. Represents Bankfull?</td><td colspan="2">Velocity Meter Type</td><td>Depth Ratio Used</td></tr>
<tr><td>Left BFD</td><td></td><td></td><td colspan="2">☐Yes ☐No</td><td colspan="2">_______________</td><td>☐ 0.4 ☐ 0.2/0.8</td></tr>
<tr><td>Right BFD</td><td></td><td></td><td colspan="5">Velocity Measurements</td></tr>
<tr><td>Max. Chann. Depth</td><td></td><td></td><td>Water Depth (mm)</td><td>Observ. Depth (mm)</td><td>Turns/Min</td><td>Calc.</td><td>Velocity (m/s)</td></tr>
<tr><td>Left Active Chann.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Right Active Chann.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Obs.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td colspan="5">Velocity Measurements</td></tr>
<tr><td>Obs.</td><td>Horiz. Loc (m)</td><td>Vert. Ht. (mm)</td><td>Water Depth (mm)</td><td>Observ. Depth (mm)</td><td>Turns/Min</td><td>Calc.</td><td>Velocity (m/s)</td></tr>
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</table>

Entered	Verified	Corrected

Discharge Measurements Form: Non-Point Transect Methods (discharge obtained without use of velocity metre)

Stream Name:

Site Code:

Stream Code:

Sample #:

Date: (YYYY/MM/DD)

DISCHARGE APPROXIMATES BASEFLOW? ☐ Check box if discharge approximates baseflow

Area X Estimated Velocity Method *

stream width (m):		mean depth (m):		area (m^2):		velocity (m/s):		discharge (m^3/s):
	X		=		X		=	
☐ measured		☐ measured		(optional calculation)		☐ measured		(optional calculation)

For stream width, depth, and velocity variables, check box to indicate that the variable was 'measured'. Leave the box blank if the variable was 'estimated'.

Comparative Discharge Estimate Method *

discharge (m^3/s):

Discharge estimated by comparison to sites (with similar site conditions) where discharge values are known.

Working Area:

value: ________ / second

unit of measurement

(Alternate scales of measurement useful for making the conversion to discharge in cubic metres per second).

10 litres/second = 0.01 m^3/second

10 cubic feet/second ~ 0.3 m^3/second

Volume/Time Method *

volume of container (L):

	replicate 1	replicate 2	replicate 3
time to fill container (seconds):			

estimate % of flow not captured by container:

Comments

Crew

Enter dates and initials when data is entered in computer.		
	Date	Init.
Entered		
Verified		
Corrected		

* Only one discharge method is required (e.g. Area X Est. Vel., Comparative, OR Vol/Time).

Water Level Record Field Sheet for CSG Installation

Page of

Stream Name	Stream Code	Date	Crew

Site Code	CSG length (mm)	Reference rebar height[1] (mm)	Distance from bottom of CSG to water level (mm)	Distance from reference pt. to tape[2] (optional)	Comments: (justify negative numbers)

Notes: 1 If CSG is lower than the rebar record as a negative number
2: If rebar is lower than the bankfull height (tape measure) record as a negative number.

Water Level Record Field sheet for CSG Event Data Sheet

Stream Name	Stream Code	Date	Crew

of

Page

Event Identification	Event Description

Site Code	Sample	Replicate	Time: (2400)	Height bottom of tube to response height (mm)	Height rebar to top of tube (mm)	Reset height bottom of tube to water level (mm)	Reset height rebar to top of tube[1] (mm)	Comments (readability, reliability, cap on, etc.)

Note: 1. if rebar higher than tube record as negative number.

Site Slope Field Form

Page of

Stream Name	Site Code	Site Code	Date (yyyy/mm/dd)

Crew Leader	Crew Members	Equipment Used ☐Survey Level ☐ Laser Level ☐ GPS ☐ Range Finder

Description of Station Marker or Benchmark (if used):

Comments

Obs. Num.	Unique Location Num.	Instream Observation Points				Station Markers (if used)			Comments
		Distance from Previous Obs. (m)	Water Depth (mm)	Stadia Rod Reading (mm)	Corrected Difference (mm)	Distance to Station Marker (m)	Stadia Rod Reading (mm)	Corrected Difference (mm)	
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									

Rapid Assessment Methodology for Instream Substrate Form

Stream Name	Stream Code	Site Code	Sample	Date (yyyy/mm/dd)

Wetted Width (m)	Mean Water Depth (mm)	Comments

Record standard substrate particles using a dot tally under the Standard Sizes section. Substrate particles ranging from 2mm – 100 mm must be measured along their median axis and recorded in the Measured Particles section.

Substrate Measurements

Standard Sizes

Material	**Description**	Count *(use box tally)*			
		Substrate Particles	Total	Maximum Particles	Total
Unconsolidated Clay	Very hard packed when dry and sticky when wet				
Consolidated Clay	Hard even when wet, slippery, gray in colour, often laminated				
Silt	Feels soft like a powder or flour				
Sand	Gritty, sizes >0.05 and less than <2mm				
Bedrock	Exposed Bedrock				
Large Boulders	> 1000 mm but not attached to bedrock				
Measured Particles	*Between 2mm and 1000 mm*	*Measure median axis and record under 'Measured Particles'*			

Measured Particles

Substrate Particles						Maximum Particles					

Crew Leader	Crew	Recorder	Entered	Verified	Corrected

Reconnaissance Survey:
Check Your Watershed Day

Stream Name

Stream Code

Watershed Code

Sample

Survey Zone

Date (mm-dd) 20 – –

UTM Zone 1

Source of UTM Coordinates

GPS ☐ GIS ☐ OBM ☐ Other

Crew Leader (init. & last name)

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m)

Northing

Bankfull Width (m)

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)

Site Description

Perched Ht: distance from the bottom of the culvert to the stream bed. **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m)

Northing

Bankfull Width (m)

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)

Site Description

Perched Ht: distance from the bottom of the culvert to the stream bed. **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m)

Northing

Bankfull Width (m)

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)

Site Description

Perched Ht: distance from the bottom of the culvert to the stream bed. **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Comments (please incl. names of crew members)

Recorder

Entered/ Scanned

Verified

Corrected

Reconnaissance Survey:
Check Your Watershed Day

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)
1			.		.	1	.	
2			.		.	2	.	
3			.		.	3	.	

Site Description

**Perched Ht: distance from the bottom of the culvert to the stream bed.* **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)
1			.		.	1	.	
2			.		.	2	.	
3			.		.	3	.	

Site Description

**Perched Ht: distance from the bottom of the culvert to the stream bed.* **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Site Code

911 #

Stream Dry? ☐ Perched Culvert? ☐

Easting .

Jumping Ht (mm)

Perched Ht (mm)

Wetted Width (m) .

Northing .

Bankfull Width (m) .

Bankfull Depth (mm)

Crossover Point Data			Float Velocity			Volumetric Flow		
Pt #	Depth (mm)	Hydraulic Head (mm)	Dist. (m)	Time (sec)	Est. Velocity (m/sec)	Repli-cate	Vol. (L)	Time to Fill (sec)
1			.		.	1	.	
2			.		.	2	.	
3			.		.	3	.	

Site Description

**Perched Ht: distance from the bottom of the culvert to the stream bed.* **Jumping Ht: distance from the lowest part of the culvert to the water surface*

Additional Comments