Part D3
Sediment Sampling
## Table of Contents

1 Introduction 1
   1.1 General Considerations 1
      1.1.1 Sample Layout and Design 2
         1.1.1.1 Sampling to Evaluate Background Conditions 2
         1.1.1.2 Discrete Sampling 2
         1.1.1.3 Probability-Based Sampling 3
            1.1.1.3.1 Gridded Sampling 3
            1.1.1.3.2 Incremental Sampling Method 3
            1.1.1.3.3 Composite Sampling 4
   1.2 Preparing to go to the Field 5
   1.3 Locating Sampling Locations in the Field 6
   1.4 Field Notes and Observations 6

2 Quality Assurance/Quality Control 8
   2.1 Field Quality Assurance 8
   2.2 Decontamination Techniques 9
   2.3 Field Quality Control 9
      2.3.1 Replicate Samples 9
      2.3.2 Reference Samples 9

3 Sampling Equipment 11
   3.1 Sampling by Hand: Scoop, Spoon or Trowel 11
   3.2 Grab Samplers 11
      3.2.1 Ekman Grab 12
      3.2.2 Petersen Grab 12
      3.2.3 Ponar Grab 13
      3.2.4 Van Veen Grab 13
   3.3 Core Samplers 15
      3.3.1 Hand Core Samplers 15
      3.3.2 Gravity Core Samplers 16
         3.3.2.1 Box Core Samplers 16
      3.3.3 Piston Core Samplers 17
3.3.4 Vibracore Samplers 17
3.4 Other Sediment Sampling Equipment 19
3.4.1 Bilge Pump: The “Guzzler” Method 19
3.5 Sediment Particle Size Samplers 19

4 Sediment Sampling Methods 20
4.1 Sampling by Hand: Scoop, Spoon or Trowel 21
4.2 Grab Sampling 21
4.3 Core Sampling 23
4.4 Sampling Methods for Special Conditions 25
4.4.1 Stream and River Sediment Sampling 25
4.4.2 Lake Sediment Sampling 25
4.4.3 Marine Sediment Sampling 26
4.4.4 Sediment Sampling from a Boat 26
4.4.1 Winter Sampling and Sampling through Ice 27
4.5 Other Sediment Sampling Methods 28
4.5.1 The Guzzler Method 28
4.6 Sampling for Sediment Particle Size 29
4.6.1 McNeil Sampler 29
4.6.2 Sediment Traps 29
4.7 Sampling for Parameters Requiring Special Handling 30
4.7.1 Volatile Organic Compounds 30

5 Shipping 31

6 Sources of Further Information 32

7 Revision History 34
Part D3
Sediment Sampling

In-Text Figures
Figure 1.1: Examples of Grid Sampling Designs 3
Figure 1.2: ISM Sampling Design Overview 4
Figure 1.3: Examples of Composite Sampling Designs 5
Figure 3.1: Schematic diagram of an Ekman Grab Sampler 12
Figure 3.2: Schematic Diagram of a Peterson Grab Sampler 12
Figure 3.3: Petite and Standard Ponar Grab Samplers 13
Figure 3.4: Schematic Diagram of a Van Veen Grab Sampler 13
Figure 3.5: Schematic Diagram of a Russian Peat Borer 15
Figure 3.6: Schematic Diagram of a Kajak-Brinkhurst Core Sampler 16
Figure 3.7: Schematic Diagram of a Reineck designed Box Core Sampler 16
Figure 3.8: Vibracore Sampler 17
Figure 3.9: McNeil Particle Size Sampler 19
Figure 4.1: Sample Homogenization 21
Figure 4.2: Ponar Grab Sampler Configurations 23
Figure 4.3: Photos of Vibracore Sampling and resultant Core 25

In-Text Tables
Table 3.1: Sediment Grab Sampler Comparison Chart 14
Table 3.2: Sediment Core Sampler Comparison Chart 18

Appendices
› I: Generic Field Checklist
1 Introduction

This Part of the British Columbia Field Sampling Manual (BCFSM) contains information and instruction provided to ensure that the quality and consistency of the field aspects of sediment data and sample collection meet acceptable quality objectives. Part D3 of the BCFSM focuses on methods for sediment sampling in freshwater aquatic environments (i.e., stream, river and lake), with methods that are also applicable to sediments in shallow and near-shore marine environments. Sediment collected using the techniques outlined herein provides samples that are suitable for sediment chemistry analysis and physical characteristics such as particle size distribution. Some of the information provided in this section of the BCFSM may also be helpful in the collection of samples for benthic invertebrate monitoring.

As with all environmental sampling a primary objective is to collect representative, minimally disturbed samples that meet the requirements of the monitoring program, and to prevent deterioration and contamination of the samples before they are analysed. The procedures outlined in this manual have been developed to provide guidance to persons required by the Ministry of Environment and Climate Change Strategy (ENV) to undertake sediment sampling, as well as ENV personnel and environmental professionals/consultants responsible for sediment sampling and monitoring.

The information and guidance provided in the BCFSM has been developed with reference to industry standards and research materials available at the time of writing. The BC Field Sampling Manual is a living document that will be updated periodically to reflect technological advancements which will be incorporated into new or revised sampling methodologies.

The sampling procedures described in this manual reflect those most widely used by ENV. Shipping procedures and safety measures are also outlined in this document. This section does not address laboratory quality assurance or data interpretation. The ENV provides a summary of required sample containers, storage temperatures, preservation requirements and holding times for analyses online (ENV, 2015). In addition to referencing the summary of requirements it is strongly recommended that practitioners consult with their analytical laboratory to ensure that the proper equipment and sample handling procedures are understood and included in their sediment sampling program.

This section does not address the collection of samples for the purpose of providing legal evidence. For information regarding legal sampling, refer to Guidelines for the Collection and Analyses of Water and Wastewater Samples for Legal Evidence (Lynch and van Aggelen, 1993).

It should be acknowledged that funding for the initial manuscript upon which this section is based was provided by the Aquatic Inventory Task Group of the Resource Inventory Committee.

1.1 General Considerations

Many factors will need to be considered when designing and planning a sediment sampling program. Sediment sampling programs can be used to evaluate the distribution of sediment types within a water body, for geological or geotechnical surveys, to identify and quantify contamination in sediments, and to evaluate the effects of sediment contamination on a water body and/or aquatic life (e.g., through benthic invertebrate sampling). The objectives for sediment sampling must be defined within the objectives and scope of the sampling program, which in turn will inform the planning process. Sediment monitoring and or sampling plans include identifying strategic sampling locations, appropriate methods for sample collection, analyses to be completed and commensurate quality control measures. Depending on the sampling program’s scope and objectives, programs can range from highly localized gridded sampling to regional scale sampling.
The scope and objectives of a sampling program should be well defined before the sample program is designed, and the sampling methods selected. As part of determining the program scope, considerations defining the intended outcome and purpose for the sediment sample results should be used as a guiding framework. Considerations include the purpose for sampling, regulatory requirements if applicable, how the sediment analytical (or other) data will be used, the number and locations of samples to be collected (for statistical analyses, if applicable), and whether or not reference/background samples are required. An effective way to communicate the scope and goals of a proposed sediment sampling program is through the creation of a detailed sampling plan, which should include a site plan with proposed sampling locations.

Once the objectives and scope of the sediment sampling program are well understood and defined, the next step is to decide on the sample layout and design. Considerations for the sampling program design include defining the spatial coverage of the targeted areas of investigation, sample density required to obtain samples representative of the site's conditions, the sample size required to accommodate planned or future statistical analyses, and monitoring for temporal changes in sediment conditions if applicable. In addition to these considerations the sampling design must accommodate the site's field conditions. Aspects such as access to sampling locations (e.g. shoreline or boat access), tides, high/low flow conditions, potential seasonal fluctuations in parameters, substrate type (e.g., fine- or coarse-grained sediments), overlying water depth, and potential hazards such as underwater utilities must be considered and planned for.

1.1.1 Sample Layout and Design

Sediments across a given area are inherently variable, and so the sample layout and design should consider the objectives of the sampling program to determine the most appropriate approach to obtain representative samples for the area under investigation. This includes consideration of the potential need for comparison of site-specific sediment results to background (or “reference”) samples, and selection of an appropriate sampling program design for the area of investigation.

1.1.1.1 Sampling to Evaluate Background Conditions

A sampling program may require a comparison of site-specific sediment results or analytical data to those of sediments collected from outside of the investigation area; an area considered to be representative of local background conditions. Site-specific background sediment quality may be established by comparison to sediment from a local reference location with similar characteristics to those of the site. Careful selection of an appropriate background site (or “reference site”) will ensure that the material and/or concentrations of parameters are attributable solely to natural conditions, and that the background site itself is not contaminated. The background site should be proximal and adequately representative of the investigation site’s conditions. Optimal background sites include locations along the same stream, or an area with similar sediment depositional mechanisms. Additionally, the sediment substrate type at the background site should, as closely as possible, reflect the substrate type at the investigation site. Whenever possible, the sediment sampling method used at the investigation site should be the same as that used at the background site.

Background conditions can be established through statistical evaluations of background sediment data provided in *Technical Guidance 16; Soil Sampling Guide for Local Background Reference Sites* (ENV, 2017).
1.1.1.2 Discrete Sampling

Traditional sediment sampling plans are often based on discrete sampling for sediment characterization. In this sampling method, one discrete sample is collected from each of the given sampling locations. This sampling design is effective when many sediment samples are being collected from the same general area, where larger-scale evaluation of sediment heterogeneity is not necessary. Advantages of this technique are that sampling is easy to implement, is relatively cost effective, and can be efficient when knowledge of the site, including areas of potential concern, are well understood. A disadvantage of discrete sample collection is that it generally cannot be reliably replicated, as the sample design relies on professional judgement, which can introduce bias in the selection of sampling locations.

1.1.1.3 Probability-Based Sampling

The alternative to discrete sampling is probability-based sampling, including gridded, incremental and composite sampling. These approaches are better suited for sediment characterization that requires consideration of sediment heterogeneity such as a regional-scale sampling program, a detailed investigation of a given site, or reduced uncertainty in reproducible results. Statistical inferences can be made from probability-based sample collection, and estimates of uncertainty can be calculated. Overall disadvantages are that the sample design and collection can be time consuming, random sample locations may be difficult to locate, and the design may be impeded by site conditions such as built structures, physical barriers, or unsuitable substrates.

1.1.1.3.1 Gridded Sampling

Gridded sampling is a systematic approach to sampling, in which samples are collected at regularly spaced intervals, often at the intersection of the grid lines overlaid on a site plan. The first sample location is chosen, and then all remaining sample locations are arranged systematically at regular intervals over a given area defined by sampling objectives. Examples of grid sampling are shown in Figure 1.1 below. Grid designs can include square, rectangular, triangular, or radial. Grid sampling applications can include sampling to identify contamination gradients or hot spots; for statistical approaches to infer means or percentiles; and for estimating spatial patterns or trends with time.

![Figure 1.1: Examples of Grid Sampling Designs](image-url)
1.1.1.3.2 Incremental Sampling Method

The incremental sampling method (ISM) is a structured composite sampling and processing protocol, designed to reduce data variability and increase the representativeness of the sample, yielding a more reproducible sample. The incremental sampling method produces a single sample that is representative of a given area within a site referred to as the decision unit or DU.

In the ISM method, the sample area is a subset of the site, referred to as the decision unit (DU), which should be of limited size to prevent sample dilution. As illustrated in Figure 1.2 the DU is divided into increments, typically between 30-50 divisions for sufficient spatial representation. Starting at a random point in the first grid cell, one sample is collected from each increment per grid cell. All increments are collected from the same relative location within the grid cell and the same volume of sediment is collected at each increment. Each aliquot of sediment is combined in an intermediate container. The sample is then subdivided based on a grid, with between 30 and 50 sections. Equal volumes of sediment are collected from each grid section. The combined sample material is further subdivided into equal portions that are placed in sample jars.

![Figure 1.2: ISM Sampling Design Overview](image)

One specific application of the ISM, as indicated by the US EPA, is utilization for risk assessments, to identify maximum concentrations or to determine upper confidence levels for sediment concentrations at a given site. Additional applications include meeting specific data requirements for statistical evaluations, and obtaining representative samples with adequate coverage when sampling heterogeneous sites. This method may not be suitable for sites where a grid design cannot be established, or where fewer than 30 increments can be collected.

1.1.1.3.3 Composite Sampling

Composite sampling is a form of systematic sampling in which sediment from several sampling units within a sampling area are mixed to form a single homogeneous sample for analysis. The approach is
dependent on sampling objectives. Examples of sampling plans which incorporate composite sampling are shown in Figure 3. Composite sampling is often combined with other sample designs (e.g., as part of a gridded sample) when the objective is to estimate statistical characteristics, or when evaluation of data pertaining to spatial or temporal variability is not an objective. Composite sampling is not suitable if there are potential biases, such as the potential loss of volatiles during the necessary homogenization of composite samples, or sediment dilution which would occur if contaminated sediment is mixed with non-contaminated sediment.

![Figure 1.3: Examples of Composite Sampling Designs](image)

1.2 Preparing to go to the Field

Dependable preparation protocols will save time, money and resources as oversights are not usually noticed until sample collectors have arrived at their first sampling location. The most effective way to prepare for a sampling trip is with a checklist designed specifically to meet the requirements of the project. In addition to site-specific instructions, a pre-trip checklist will prompt the field team to ensure that the following equipment, materials and logistics are ready in advance of the scheduled sampling event:

- Permission, gate keys and maps as necessary to access the site;
- Field equipment:
  - field screening instruments such as meters (with spare batteries, calibration equipment and adequate trouble-shooting equipment for small repairs);
  - sampling tools (i.e. grab sampler, core sampler) and equipment for homogenizing the sediment samples (mixing bowl, spoon);
  - decontamination supplies;
  - nitrile gloves;
  - tools for measuring/locating sample locations (GPS, tape measure, surveyor’s wheel), etc.;
Part D3
Sediment Sampling

› Sample containers (pre-labeled) and preservatives – include types and quantities (include extras);
› Appropriate quantity of ice packs and coolers;
› Field notebooks and/or log books;
› Personal gear for all possible weather conditions (e.g., raincoats, protective footwear, etc.);
› Health and safety documentation, first aid kit and appropriate safety equipment for working in/around water (e.g., cell/satellite phones, survival suit, life jacket);
› Camera or video equipment as required (waterproof equipment is preferable); and,
› Laboratory requisition forms (partially filled out).

A general operating procedure is to have the key equipment in a box or plastic “tote” which is dedicated to this activity. See Appendix 1 of this chapter for an example of a generic field preparation checklist specific to sediment sampling.

1.3 Locating Sampling Locations in the Field

It is the responsibility of field staff to locate all sampling stations accurately. To generate the data necessary to interpret temporal changes in sediment quality, samples must be consistently obtained from a known location or series of known sampling locations. To achieve this goal accurately written station location descriptions that identify key landmarks must be prepared for each sampling site. Effective photographic documentation and visible markings will help ensure that sample sites are accurately located. A map depicting the sample sites and landmarks should accompany the site identification log book. For streams and small rivers sampling sites can be marked by attaching flagging tape to shoreline vegetation.

Basic site location data such as latitude, longitude, map sheet number, site identification number, should be incorporated into the database (EMS in the case of ENV). Handheld Global Positioning System (GPS) devices should also be used where possible to mark sampling locations and for navigation back to the sampling locations.

1.4 Field Notes and Observations

Good sampling practice includes the creation and use of detailed field notes. Specific information regarding ambient conditions such as time of day, weather conditions, and activities taking place in the area surrounding the sample site provide important information when reviewing and interpreting the analytical results of sediment samples. A field log book containing water-proof paper should be dedicated for each project. In addition to daily recordings of ambient conditions, field measurements, sample ID and matrix characteristics should be recorded and entered by date, directly into the field log book.

The following list emphasizes the information and observations that should be recorded in a field log book:

› Site name and EMS code;
› Date, time, and weather conditions;
› Station depth;
Names of all personnel on the sampling crew;

Gross characteristics of the sediment;
  - Texture / grain size;
  - Colour;
  - Biological structure (e.g., shells, tubes, macrophytes);
  - Debris (e.g., wood chips, plant fibers);
  - Presence of oily sheen;

Obvious odour;

Gross characteristics of vertical profile (distinct layers, depth of layer changes; especially important for processing of sediment cores);

Penetration depth of sediment sampler;

Sampling protocol deviations and or difficulties encountered during sampling; and,

Any activities such as construction being conducted nearby.

All information recorded in the log book should be entered into the database as soon as possible upon return from the field.
2 Quality Assurance/Quality Control

2.1 Field Quality Assurance

The field quality assurance program is a systematic process which, together with the quality assurance programs of the laboratory and data storage unit, ensures a specified degree of confidence in the data collected for an environmental investigation, sampling program or survey. The field quality assurance program involves a series of steps, procedures, and practices which are described below.

The quality of data generated in a laboratory depends, to a large degree, on the integrity of the samples that arrive at the laboratory. Consequently, the field investigator must take the necessary precautions to protect samples from contamination and deterioration.

There are many opportunities for and sources of contamination that must be considered during the complete process of sampling and sample handling. The following basic precautions must be included in field quality assurance programs:

- Only the recommended type of sample container for each analysis should be used. Sample volumes and associated containers will vary by analytical method and laboratory. Confirm with the laboratory the type of sample container to be used, the volume of sample material required, and the preservation requirements for each analysis included in the planned sediment sampling program.

- With few exceptions only sample containers that have been provided by an analytical laboratory should be used. The containers should be certified as ‘contaminant free’ by the laboratory or their supplier.

- During field preparations ensure that the lids of all sample containers are securely fastened prior to transport to the field. If preservatives are required ensure they have not exceeded their expiry dates. Pack all sampling supplies in clean sealed totes or coolers for transport to and from the site.

- Vehicle cleanliness is an important factor in eliminating contamination problems.

- Ensure you have enough ice and or ice packs to keep your samples adequately cooled from the time the samples are collected until they arrive at the laboratory.

- Samples must never be permitted to get warm; they should be stored in a cool place; coolers packed with ice packs or double-bagged ice cubes are recommended, as most samples must be cooled to less than 10°C during transit to the laboratory. Conversely, samples must not be permitted to freeze unless freezing is part of the preservation protocol.

- While sampling, the inner portion of sample containers and caps must never be touched with anything including gloved hands.

- Petroleum products such as gasoline, oil, and exhaust fumes are prime sources of contamination. Spills or drippings which are apt to occur in boats must be controlled and or removed immediately. Exhaust fumes, which are of particular consideration when sampling from a boat must be downwind from the sampler during sample collection. Cigarette smoke can contaminate samples with lead and other heavy metals. Air conditioning units are also a source of trace metal contamination.
Sample collectors should keep their hands clean, gloved and refrain from smoking or eating while working with samples.

2.2 Decontamination Techniques

Standard decontamination techniques are required for sampling and field equipment to avoid contamination of sediment samples between sample locations. To decontaminate sampling equipment between each sample collection, wipe away visible sediment with clean paper towel, and or rinse the equipment with clean or deionized water. Detergents should be avoided unless the sampling equipment has come into contact with oil, grease or hydrocarbon compounds. This is especially important for samples that will be tested for phosphorous or phosphorous-containing analytes. Equipment which has been used for or has come into contact with oil, grease or hydrocarbon components should be washed in a dilute solution containing a mild detergent (e.g., Alconox™ or Liquinox™). Any equipment cleaned with detergent must be thoroughly rinsed with potable or preferably distilled/deionized water and dried with clean paper towelling. Do not deploy an acid rinse in the field if sediment pH will be analyzed by the laboratory. Dispose of all gloves, paper towel, and contaminated cleaning materials in an appropriate manner. To prevent cross contamination gloves must be changed between samples and after equipment decontamination.

2.3 Field Quality Control

Quality control is an essential element of a field quality assurance program. In addition to standardized field procedures, field quality control requires the submission of replicate, blank and in some cases, reference samples. The number and type of replicate, blank and reference sample submissions will depend in large part on the objectives of the sampling program.

Replicate samples detect heterogeneity within the sample material, allow the precision of the measurement process to be estimated, and provides an opportunity to demonstrate that a sample is reproducible. Blank samples are used to identify, where present, the inclusion of contaminants in or on equipment (equipment blank), the ambient environment (field blank), or the laboratory (travel blank). Blank samples can be prepared to capture any aspect of the sampling process. Reference samples are made up of prepared matrix materials with established analytical parameters. Reference samples are used primarily to document potential biases of the analytical (laboratory) process. The timing and the frequency of replicate, blank and reference samples are established during the project design and will vary with each project.

2.3.1 Replicate Samples

To determine the degree of heterogeneity within the sediment being tested as well as the precision of the analytical process, it is necessary to take replicate samples. These replicates can consist of multiple grab samples from the same general area to measure site heterogeneity, or portions of a single grab to measure more localized heterogeneity. Grab samples that are homogenized in the field by physical stirring and then sub-sampled into replicates serve as a tool to estimate the analytical precision of the testing process. Replicates from a sediment core sample would be collected from the same depth range of the same core sample. Sections 4.1 to 4.3 provide protocols for the collection of replicate samples.
2.3.2 Reference Samples

Reference samples are prepared using sediment that has been tested by a statistically significant number of laboratories and then preserved to maintain the stability of the matrix. Reference materials are certified by national, international or standards agencies such as the National Research Council of Canada. Reference materials are subjected to a large number of analyses performed by independent laboratories using several different analytical techniques. Data produced during this testing process provides mean values and confidence intervals for these substances.

Reference samples should be submitted to the analyzing laboratory along with the samples collected in field. Reference sediment samples are distributed as a dry dust, therefore, the analyzing laboratory will be aware that they are reference samples. Nevertheless, the reference material should be transferred into an appropriate laboratory-supplied sample container for submission. The sample container should be labelled in a manner that does not indicate the identification of the reference material.
3 Sampling Equipment

In general there are three established sediment sampling methods and each method deploys specific equipment. Surface sediments in shallow water is typically sampled by hand using a spoon, scoop or trowel. Grab samplers are deployed from a barge or boat to collect surface sediments in water that is too deep to stand in or wade into. Grab samplers, due to their ease of use and the large volume of sediment they capture, are ideal for assessing the quality of relatively shallow sediment and to evaluate the horizontal distribution of parameters. Core samplers are used to collect a sediment depth profile and are better suited for assessing historical depositions and the vertical distribution of parameters. Table 3.1 provides a summary of the equipment used to collect surface sediment samples. Table 3.2 provides a summary of the equipment used to collect sediment core samples. The selection of an appropriate sampling method is constrained by site conditions and sample analytical requirements and will ultimately be dictated by the purpose of the study and the resulting sampling program design.

3.1 Sampling by Hand: Scoop, Spoon or Trowel

Sampling by hand using a scoop, spoon or trowel is the simplest and most efficient way to obtain a sample of exposed sediments or of sediments in shallow water, under minimal current conditions. Typically, this type of sampling is most effective for small streams, stream/river banks or sandbars, or intertidal zone sediments under low tide conditions. Sediments located below shallow water can be sampled from shore or by wading if care is taken to minimize the loss of fine-grained sediments during retrieval. Sampling equipment required for this method of sample collection includes a scoop, spoon or trowel and a bowl or pail.

In water that is too deep to wade into scoops or spoons may be attached to a piece of conduit to collect the sample providing the water body does not exhibit a current. This method is typically not recommended as sediment retrieval is difficult and not reliable under less than ideal conditions. Instead, for surface sediment sampling in aquatic environments where sediments are submerged beyond a wadeable depth, grab sampling is recommended.

3.2 Grab Samplers

Due to their ease of deployment and capture capacity, grab samplers are widely used to collect sediment samples. Most designs incorporate a set of jaws which bite into the sediment when activated and shut to contain the captured material. Certain designs, like the Ekman and Ponar grab samplers, include vented or hinged tops that allow water to flow freely through the device during descent. This free-flow feature reduces sediment disturbance that would otherwise be created by a shock wave inherent in grab samplers which don’t provide this feature.

Two advantages of grab samplers are that they are easy to use and that they obtain relatively large volumes of sediment per grab. A disadvantage is that during retrieval fine surface particulates can be carried away by outflowing water during ascent. Additionally, sediments must be relatively soft/fine-grained for grab sampling as gravel and other debris can prevent the jaws from fully closing which would result in sample loss during retrieval. Several designs of grab samplers are available, varying by size, weight and sediment penetration depth. Brief descriptions of select available grab samplers are provided in the sub-sections below. Summaries of equipment specifications, including advantages and disadvantages for these samplers, are provided in Table 3.1.
3.2.1 Ekman Grab

Ekman grabs (Figure 3.1) are variable in size with larger models requiring the use of a winch or crane hoist for operation. The dimensions of a common size deployed are 15 cm x 15 cm. These grab samplers have historically been fabricated in brass, but stainless steel is now used and is more desirable as they present fewer problems with corrosion and they are less likely to affect metal concentrations in sediment samples. The spring-tensioned, scoop-like jaws are mounted on pivot points and are set with a trigger assembly which is activated from the surface by a messenger. Flaps on the top of the grab open during descent to allow water to flow freely through and close during ascent to reduce the loss of sample material during retrieval. The sediment collected in the sampler can either be sub-sampled through the top flaps or the contents of the sampler can be dumped into a tray and treated as a bulk sample. The Ekman sampler is suitable for collecting soft, fine-grained sediments (silt and sand). Larger substrate particles such as gravel and objects such as shells and wood tend to prevent the jaws from fully closing which results in a loss of sample material. If the jaws are not fully closed upon retrieval, then the sample is not considered to be representative of the sampling location and must be discarded.

3.2.2 Petersen Grab

The Petersen grab sampler (Figure 3.2) consists of a pair of weighted semi-cylindrical jaws which are held open by a catch bar. Upon impact with the sediment (slackening of the rope), the tension on the catch bar is reduced allowing the jaws to close. Auxiliary weights can be added to the jaws to improve penetration into harder, more compacted sediments. There is no access to the sample through the top of the grab sampler and consequently the sediments must be dumped into a tray and treated as a bulk sample. The Petersen grab is suited to the collection of hard bottom material such as sand, marl, gravel, and firm clay.
3.2.3 Ponar Grab

The Ponar grab sampler (Figure 3.3) consists of a pair of weighted, tapered jaws which are held open by a catch bar. It is triggered to close in much the same fashion as the Petersen grab. The upper portion of the jaws is covered with a mesh screen which allows water to flow freely during descent, significantly reducing the shock wave that precedes the sampler. Upon recovery, the mesh can be removed to allow access to the sediment for sub-sampling purposes. The Ponar grab is suitable for collecting fine-grained to coarse material and comes in 2 sizes: a smaller, hand-held design referred to as a mini or petite Ponar, and a standard design, which due to its weight will often require a winch/crane to operate.

Figure 3.3: Petite and Standard Ponar Grab Samplers
A. Schematic Diagram of a Ponar Grab Sampler; and, B. The two sizes of the Ponar Grab; the Petite (left) and the Standard (right).

3.2.4 Van Veen Grab

The Van Veen grab sampler (Figure 3.4) consists of a pair of weighted jaws which are held open by suspension chains. The Van Veen is a large grab sampler which requires the use of a winch or crane and is typically deployed from a boat or other sampling platform. When the sampler contacts the sediment, the lowering wire slackens and a hook on the release device rotates allowing the suspension chains to fall free. When the lowering wire becomes taut, the chains attached at the top of the release device exert tension on the arms, which cause the jaws to dip deeper into the sediment and close tightly. The upper portion of each jaw is covered by a mesh screen, which allows water to flow freely through the sampler during descent; rubber flaps on the mesh screens prevent loss of sediment during retrieval. The Van Veen grab is suitable for collecting sediments ranging from soft, fine-grained to sandy material.

Figure 3.4: Schematic Diagram of a Van Veen Grab Sampler
### Table 3.1: Sediment Grab Sampler Comparison Chart

<table>
<thead>
<tr>
<th>General Sampler Type</th>
<th>Specific Sampler Type</th>
<th>Equipment Information</th>
<th>Sediment Sample Specifics</th>
<th>Appropriate Site Conditions</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ekman</td>
<td>Standard</td>
<td>Weight Empty (kg): 3 to 10; Weight With Sediment (kg): 10 to 16</td>
<td>Winch/ Crane Required?: No</td>
<td>Sediment Depth Sampled (cm): 0 to 10; Sampled Area (cm x cm): 15 x 15; Sample Volume (L): 3 to 3.5</td>
<td>Clay and Silt</td>
<td>Zero to slight</td>
</tr>
<tr>
<td></td>
<td>Tall</td>
<td>Weight Empty (kg): 5; Weight With Sediment (kg): 21</td>
<td>Winch/ Crane Required?: No</td>
<td>Sediment Depth Sampled (cm): 0 to 23; Sampled Area (cm x cm): 15 x 15; Sample Volume (L): 5 to 5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>Weight Empty (kg): 13; Weight With Sediment (kg): 35 to 40</td>
<td>Winch/ Crane Required?: Likely</td>
<td>Sediment Depth Sampled (cm): 0 to 10; Sampled Area (cm x cm): 23 x 23; Sample Volume (L): 12 to 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petersen</td>
<td>n/a</td>
<td>Weight Empty (kg): 34; Weight With Sediment (kg): 40 to 60</td>
<td>Winch/ Crane Required?: Yes</td>
<td>Sediment Depth Sampled (cm): 0 to 30; Sampled Area (cm x cm): 30 x 30; Sample Volume (L): 9 to 10</td>
<td>Clay to fine gravel</td>
<td>Zero to slight</td>
</tr>
<tr>
<td>Ponar</td>
<td>Petite</td>
<td>Weight Empty (kg): 6 to 11; Weight With Sediment (kg): 10 to 15</td>
<td>Winch/ Crane Required?: No</td>
<td>Sediment Depth Sampled (cm): 0 to 10; Sampled Area (cm x cm): 15 x 15; Sample Volume (L): 1 to 2.5</td>
<td>Fine-grained, soft to firm, sandy</td>
<td>Zero to medium</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>Weight Empty (kg): 23; Weight With Sediment (kg): 30 to 35</td>
<td>Winch/ Crane Required?: Likely</td>
<td>Sediment Depth Sampled (cm): 0 to 10; Sampled Area (cm x cm): 23 x 23; Sample Volume (L): 7 to 8.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Van Veen</td>
<td>Standard</td>
<td>Weight Empty (kg): 30; Weight With Sediment (kg): 40</td>
<td>Winch/ Crane Required?: Yes</td>
<td>Sediment Depth Sampled (cm): 0 to 30; Sampled Area (cm x cm): 35 x 70; Sample Volume (L): 18</td>
<td>Fine-grained to sandy</td>
<td>Zero to strong</td>
</tr>
<tr>
<td></td>
<td>Large</td>
<td>Weight Empty (kg): 65; Weight With Sediment (kg): 85</td>
<td>Winch/ Crane Required?: Yes</td>
<td>Sediment Depth Sampled (cm): 0 to 30; Sampled Area (cm x cm): 50 x 100; Sample Volume (L): 75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- Equipment weights, sampling depths and sampled areas vary by commercial product and/or can be customized; these values/ranges are provided as estimates for comparison purposes only.
3.3 Core Samplers

Core samplers penetrate the sediment more deeply than grab samplers; consequently, they provide a cross-sectional slice of sediment layers and information about sediment deposition. The information provided by a core sample enables a vertical evaluation of sediment characteristics as well as the vertical distribution of contaminants. Generally, core samplers consist of a hollow pipe (the core barrel), which varies in length and diameter; a core cutter or cutting head is located at the advancing end of the core barrel to facilitate the sampler's advancement into the sediment. Core samplers are typically lined with replaceable internal liners to prevent contamination between samples. Selection of the liner type is dependent on the sampler type and the type of contaminants being evaluated. Potential liner materials include stainless steel, glass, Teflon®, polyvinyl chloride (PVC) or carbon steel. A valve or piston mounted on the top of the core barrel allows water to flow through the barrel during the sampler's descent. The valve shuts following advancement into the sediment to prevent the sediment from flowing out through the valve as the sampler is retrieved. Core catchers are commonly inserted into the cutting head to prevent sample loss during retrieval, and can vary in dimensions depending on the sediment type being sampled. Additional features available for core samplers include weights to increase penetration depth and stabilizing fins.

Core samplers typically fall into one of four categories: hand core samplers, gravity core samplers, piston core samplers and vibracore samplers. The coring method selected will depend on a number of site-specific factors including overlying water depth, sediment characteristics and the length of the core desired. Two inherent effects of core sampling that can alter the physical integrity of the core sample are spreading and compaction. Spreading occurs when sediment is pushed to the side as the core barrel advances into the sediment. Compaction occurs when the sediment is pushed downward as the core barrel advances. Both of these factors require consideration when selecting an appropriate coring method for a given site.

3.3.1 Hand Core Samplers

Most hand core samplers are suitable for collecting sediments of soft or medium firmness which are typically encountered in shallow marshes, tidal flats and rivers. In special circumstances hand corers are used in deep waters by a diver. Most core barrels are relatively short, ranging in length from 50 cm to 120 cm and weigh between 5 kg and 17 kg. An example of a hand core sampler is a multi-stage sludge sampler. The sludge sampler collects a 5 cm diameter by 30 cm long sludge/sediment core sample. Additional 30 cm sections can be added to extend the core to a maximum length of 1.2 m. Another example is a Russian peat borer (Figure 3.5), which is a side filling corer designed to collect un-compacted sediment samples. Following insertion the core tube is rotated to fill the core tube. The Russian peat borer can be used to obtain core samples to a depth of 3 m with little core loss.

![Figure 3.5: Schematic Diagram of a Russian Peat Borer](image)
3.3.2 Gravity Core Samplers

Gravity core samplers rely on the weight of the device and the force of gravity to penetrate sediments. For these samplers to be most effective, the water depth must be sufficient to obtain adequate velocity for the sampler to penetrate the sediment. In soft, fine-grained sediments, gravity core samplers can penetrate up to 3 m. An example of a commonly used sampler for this purpose is the Kajak-Brinkhurst sampler (Figure 3.6). Gravity check valves are used in gravity core samplers to allow air and water to pass through the tube as it descends; this mechanism creates a vacuum pressure, which minimizes sample loss. A core catcher at the end of the core sampler will help retain the core inside the sampler upon retrieval. Gravity core samplers can be modified to consist of several core barrels mounted on a single fin/weight system. These multiple-gravity corers have been developed to collect multiple samples from a single location, for evaluation of sediment sampling precision and/or sediment heterogeneity over a small area. Descriptions of select gravity core samplers, including equipment specifications and the advantages and disadvantages of their use are included in Table 3.2.

Box Core Samplers

Box corers are also considered gravity core samplers, but instead of a cylindrical core barrel, the sampler is shaped like a rectangular box. These samplers are used to collect large, relatively undisturbed, rectangular sediment cores for biological and geological studies at various water depths and in different sediment types.

Figure 3.6: Schematic Diagram of a Kajak-Brinkhurst Core Sampler

Figure 3.7: Schematic Diagram of a Reineck designed Box Core Sampler
There are two typical box-core designs; the Ekman design, in which there are two bottom flaps that can be triggered and closed like the Ekman grab sampler; and the Reineck design (Figure 3.7), in which a large, shovel-like device slides across the bottom of the box corer to cut off the sample. Many box corers of different designs and sizes are available; Table 3.2 describes box corers, including equipment specifications and advantages and disadvantages.

### 3.3.3 Piston Core Samplers

Similar to gravity core samplers, piston core samplers are lowered to the streambed using gravity; however when the piston core sampler reaches the sediment surface a piston located inside the core barrel stops and the core barrel continues to advance and penetrate the sediment. This creates a vacuum within the core barrel, reducing resistance and enabling a deeper penetration of the core barrel into the sediment. In soft-sediment, piston core samplers can penetrate up to 30 m. The vacuum in the core barrel also reduces sample disturbance and sample loss. Due to their large size and required retrieval mechanisms, these samplers are typically deployed from large boats or platforms.

### 3.3.4 Vibracore Samplers

Vibracore samplers are equipped in a variety of configurations. The penetration and advancement of a core barrel into sediment is facilitated through vibration. An electric motor creates a vibration frequency range that enables the corer to displace sediment and advance the corer with limited sediment compaction or spreading, making it an ideal method of sampling for soft or loosely consolidated sediments. Vibracore samplers can collect cores of over 10 m in length. Due to their large size, required deployment with an electric motor and retrieval mechanisms, these samplers are typically deployed from large vessels or platforms as shown in Figures 3.8 and 4.3.

*Figure 3.8: Vibracore Sampler  (www-udc.ig.utexas.edu)*
### Table 3.2: Sediment Core Sampler Comparison Chart

<table>
<thead>
<tr>
<th>General Sampler Type</th>
<th>Specific Sampler Type</th>
<th>Equipment Informationa</th>
<th>Sediment Sample Specificsa</th>
<th>Appropriate Site Conditions</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight Empty (kg)</td>
<td>Winch/ Crane Required?</td>
<td>Sediment Core Length (cm)</td>
<td>Core Barrel Inner Diameter (cm)</td>
<td>Substrate Types</td>
</tr>
<tr>
<td>Hand Corer</td>
<td>Multi-stage sludge/sediment sampler</td>
<td>5 to 17</td>
<td>No</td>
<td>50 to 120</td>
<td>3.5 to 7.5</td>
<td>Fine to medium-grained, soft to semi-compacted</td>
</tr>
<tr>
<td></td>
<td>Gravity Corer</td>
<td>Kajak-Brinkhurst (K-B) Corer</td>
<td>9</td>
<td>No</td>
<td>50 to 75</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Phleger Corer</td>
<td>8</td>
<td>No</td>
<td>50</td>
<td>3.5</td>
<td>Fine to coarse-grained, soft to semi-compacted, peat and vegetation roots</td>
</tr>
<tr>
<td></td>
<td>Benthos Gravity Corer</td>
<td>25</td>
<td>Yes</td>
<td>Up to 6 m</td>
<td>5 to 7</td>
<td>Fine-grained, soft</td>
</tr>
<tr>
<td></td>
<td>Box Corer</td>
<td>Up to 800</td>
<td>Yes</td>
<td>Up to 1 m</td>
<td>Up to 2 m x 2 m</td>
<td>Fine-grained, soft</td>
</tr>
<tr>
<td></td>
<td>Up to 1,500</td>
<td>Yes</td>
<td>3 to 30 m</td>
<td>9 to 10</td>
<td>Most sediment types</td>
<td>Recovers longer, less disturbed and more complete cores (compared to gravity corers)</td>
</tr>
<tr>
<td></td>
<td>Up to 4,000</td>
<td>Yes</td>
<td>Up to 10 m</td>
<td>7 to 11</td>
<td>All sediment types</td>
<td>Vibration enables penetration of sediments with higher resistance (e.g., sandy, unconsolidated sediments)</td>
</tr>
</tbody>
</table>

Notes:

a Equipment weights, barrel lengths and diameters vary by commercial product and/or can be customized; these values/ranges are provided as estimates for comparison purposes only.
3.4 Other Sediment Sampling Equipment

3.4.1 Bilge Pump: The “Guzzler” Method

The Guzzler method employs a hand-held, piston-type bilge pump to assist in sampling sediments in shallow freshwater environments, including streams, lakes and rivers. Typically, the Guzzler method is used when fine-grained sediments are patchy or limited in thickness (i.e., deposition is limited to a few millimetres), making surficial grab sampling or scooping difficult and/or ineffective. The guzzler method is typically employed in waters that are less than 1.5 m deep, but can be used in waters up to 3 m deep if there is minimal current and the equipment is modified.

Prior to sampling the target area (e.g., 1 m²) is defined and marked. A hand-operated bilge pump is then used to “vacuum” sediments from the defined area into a bucket. Bucket contents are mixed well and the bucket is then left undisturbed to allow suspended sediments to settle out. Overlying water in the bucket is slowly decanted and discarded allowing the remaining sediments to be sampled.

3.5 Sediment Particle Size Samplers

Although sediment samplers can be used for the purpose of determining the distribution of streambed particle sizes, they are not ideal. Much of the very fine sediments are lost as a result of the pressure wave that precedes these samplers and the washout that occurs as the samplers are retrieved. Better estimates of particle size distribution can be obtained through the use of sediment traps which are deployed over a prescribed time frame, or samplers that collect an entire portion of the streambed such as the McNeil sampler and the Freeze core sampler. The Freeze core technique is elaborate and cumbersome and consequently will not be discussed here. Detailed descriptions can however be obtained from Ryan (1970) and Sookachoff (1974).

Sediment traps are simply open buckets of a given volume that are filled with cleaned gravel and immersed in the streambed. They are collected at a later date and submitted for mechanical analysis of sediment particle size.

The McNeil sampler shown in Figure 3.9 consists of a cylinder that defines the portion of the streambed to be sampled and an attached basin that is used to store the collected sediments and trap the suspended fines.

Figure 3.9: McNeil Particle Size Sampler
4 Sediment Sampling Methods

Sediment samples are collected for analysis of the chemical and physical properties of sediment, or to assess the benthic biotic community structure (biomass and/or taxonomy). For either analysis a number of basic requirements must be met to ensure that the sediment samples are representative of the sampled body:

- The sampling device must penetrate the sediment to a sufficient depth to accurately measure the variables of concern.
- The sampling device must enclose the same volume of sediment each time a sample is collected.
- The sampling device must close completely each time.
- Care should be taken not to disturb the sediments prior to deployment of the sampling device. Note that since sediment samplers disturb overlying waters, they should be used only after any ambient water sampling has been completed at the site.

The sediment sampling methods described below are presented in one of three groups which are defined by the techniques and associated equipment used to obtain sediment samples. The groups are:

1. Sampling by hand, using a scoop, spoon or trowel (Section 4.1);
2. Grab sampling (Section 4.2); and
3. Core sampling (Section 4.3).

Appropriate sampling methods are determined during the sampling program design and planning stages. Upon arrival at the sampling site, it is important to confirm that the site's current conditions satisfactorily concur with the assumptions made during the planning stage such as water depth, current speed, sediment grain size, etc. This is important because it is these assumptions upon which the equipment and methods for sampling were selected. If the site's conditions differ significantly, modifications and or changes may be required to ensure the safety of field staff and or the effectiveness of the equipment and methods deployed.

Additionally, before employing any of these techniques in the field, samplers must be confident that they have all the information and training required to effectively and safely collect sediment samples. This is especially important when operating grab and core sampling devices. The jaws of grab samplers are often spring-loaded when set and great care and experience is required to ensure that the sampler is safely deployed and retrieved. Large core samplers deployed from vessels or platforms should be operated by trained personnel. While samplers have been grouped by type, specific devices will differ by manufacturer. Operating instructions provided by the manufacturer should be carefully reviewed prior to deployment of the selected sampling device.

Prior to deployment, sampling equipment should be decontaminated using the methods described in Section 2.2. If relevant and/or applicable, sampling should begin in the suspected “cleanest” area of the site, and proceed to the more contaminated area/s of the site. The physical locations selected for sampling should contain sufficient sediment and not be located in rocky areas or areas of bedrock. If possible, each sampling location should be physically marked for easy reference and to enable efficient relocation of the sampling location if the site is to be sampled again at a later date. For example streams
Part D3
Sediment Sampling

and small rivers are typically marked with flagging tape fixed to shoreline vegetation. Ensure that GPS coordinates are collected and recorded in real time at each sampling location.
4.1 Sampling by Hand: Scoop, Spoon or Trowel

<table>
<thead>
<tr>
<th>SAMPLING by HAND - PROTOCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Using a scoop, spoon or trowel, scoop sediment to a predetermined sampling depth (e.g., 0-5 cm, as outlined in the sediment sampling program plan).</td>
</tr>
<tr>
<td>(b) If sediments being sampled are submerged, slowly and with control retrieve the scoop, spoon or trowel through the water column to minimize turbulence and the loss of fine-grained surface sediments.</td>
</tr>
<tr>
<td>(c) A consistent and predetermined sediment volume should be retrieved from each sampling location. Sample from downstream to upstream locations.</td>
</tr>
<tr>
<td>(d) Collect sediment from the same sampling depth and ensure that sufficient sediment is obtained for the selected laboratory analyses. If the lab is to be instructed to screen the sediment to 63 µm for metals testing ensure that enough sediment is collected to satisfy the volume required for the analytical test by including extra material to compensate for a potential loss of material during screening.</td>
</tr>
<tr>
<td>(e) Place the retrieved sediments into a container such as a shallow pan, a pail or bowl. Allow suspended sediments to settle out and carefully decant excess water.</td>
</tr>
<tr>
<td>(f) Immediately record, in the field log book, observations of the sediment such as texture, colour, odour, presence of biota, presence of detritus, and the depth of sediment sampled (as outlined in Section 1.4).</td>
</tr>
<tr>
<td>(g) With the exception of samples collected for analysis of volatile organic compounds, use a clean spatula or spoon to thoroughly mix the sediment to a homogeneous state. Place an aliquot of the sediment into a pre-labeled laboratory supplied sediment sample container.</td>
</tr>
<tr>
<td>Note: For samples that are to be analyzed for organics, the spatula/spoon and container must not be plastic and the sample container must be a laboratory-supplied glass jar. For samples that are to be analyzed for metals, the spatula/spoon must not be metallic.</td>
</tr>
<tr>
<td>(h) Place the collected samples directly into a cooler containing ice packs.</td>
</tr>
</tbody>
</table>

Tip: Second hand stainless steel spoons can be purchased for this type of sampling. Prior to use decontaminate the spoons using nitric acid. Decontaminated spoons can be placed into sealable bags in preparation for the sampling event. If enough spoons are prepared, decontamination in the field can be avoided.

Sample Homogenization

Sediment samples must be thoroughly mixed to ensure that any given sub-sample is representative of the sampled sediment at that particular location and depth. Note that samples collected for volatile organic compound analysis should not be homogenized. If homogenization is occurring in a mixing bowl, adequate mixing can be achieved by stirring the material in a circular fashion, reversing direction and occasionally turning the material over. Repeat several times until the sample is well-mixed.

Figure 4.1: Sample Homogenization
4.2  Grab Sampling

**GRAB SAMPLING - PROTOCOL**

(a) Set the grab sampling device with the jaws cocked open. Great care should be taken while dealing with the device while it is set; accidental closure could cause serious injuries. Manufacturer’s operating instructions should be reviewed prior to device use.

(b) Ensure that the rope is securely fastened to the sampler and that the other end of the rope is tied off to the sampling platform (e.g., to bridge, boat or barge) to prevent device loss.

(c) Slowly lower the sampler over the upstream side of the bridge or boat until it is resting on the sediment; the weight of the sampler is adequate to penetrate soft sediments. At this point, the slackened line will activate the mechanism that releases the jaws of Ponar and Petersen grab samplers.

(d) If using the Ekman grab sampler, send the messenger down to ‘trip’ the release mechanism.

(e) Retrieve the sampler slowly to minimize the turbulence effect which may result in the loss of surface sediments.

(f) Place a container such as a shallow pan or a mixing bowl beneath the sampler as soon as it is reaches the sampling platform. Inspect the sediment sample through the screen or flaps of the sampler to confirm that a complete sample has been obtained.

   *Note: If the jaws were not closed completely, the sample must be discarded over the downstream side of the bridge or boat, or at shore if sensitive water uses exist immediately downstream. Dump the unwanted sediment only after a sample has been successfully collected.*

(g) If a target depth is to be sampled use a clean spatula or spoon to select that layer of sediment from the top flaps of the grab sampler. A depth selection can be made of the surface sediments (1 – 2 cm) by carefully scooping off the top undisturbed layers. In some lakes, for example, a grab sample to a depth of 10 – 15 cm is typical and the vertical heterogeneity may represent many years of lake or watershed changes. If a bulk sample is required gently open the jaws and allow the sediments to empty into the container.

(h) Immediately record in a field log book, observations of the sediment such as texture, colour, odour, presence of biota, presence of detritus, and the depth of sediment sampled (as outlined in Section 1.4).

(i) With a clean spatula or spoon, either remove the top portion of the sediment (when this is outlined by the study design), or thoroughly stir the sediment to homogenize. Place aliquots of the homogenized sediment into pre-labelled sediment sample bottle/s as needed. Replicate samples can be collected from the homogenized mixture.

(j) Place the samples in a cooler with ice packs without delay.

   *Note 1: Many lake and marine sediment samples are anoxic and a number of chemical changes will take place if the samples are exposed to atmospheric oxygen. If samples are to be retained with as low an oxygen content as possible, they will need to be packed inside multiple airtight containers and frozen to minimize the chemical and microbial transformations. Be warned that it may still have a strong odour even if sealed and frozen! If samples are frozen, allow sufficient head space for expansion of the sample. Otherwise, the container will split or break when the sample freezes.*

   *Note 2: For samples that are to be analyzed for organics, the spatula/spoon and container must not be plastic (the container must be a glass bottle provided by the laboratory). For samples that are to be analyzed for metals, the spatula/spoon must not be metallic.*
4.3 Core Sampling

The core sampling procedures described in this protocol provide general instruction for gravity core sampling. This protocol assumes that large coring equipment such as gravity corers, piston corers and vibracorers will be deployed from a large vessel or barge and operated by trained professionals. For this reason a description of core processing techniques and considerations is provided however specific instruction on core sampler deployment of large equipment is not included.

**CORE SAMPLING - PROTOCOL**

(a) Open the valve and set the trigger mechanism. Ensure the rope is securely fastened to the corer and attach the other end of the rope to the sampling platform (e.g., to bridge or to boat).

(b) Lower the corer to approximately 5 m above an area of undisturbed sediment. Allow the corer to fall freely into the sediments (drop depth may vary with sampler size, weight, and sediment type). Sufficiently heavy corers can simply be lowered into the sediments to avoid disturbance caused by impact.

(c) Send the messenger down to release the trigger mechanism.

(d) Carefully retrieve the sampler stopping its ascent before breaching the water’s surface. Prior to removing the corer from the water place a stopper into the bottom opening to prevent the loss of sample material.

(e) Remove the liner from the corer and stopper the upper end. Store erect. Repeat this procedure to obtain replicate cores of at least 0.5 m in length.

(f) Carefully siphon off most of the water overlying the sediments in the core tube leaving a small amount at the sediment-water interface. Take care to not disturb the sediment-water interface. Processing is typically completed onshore however this can be done on the sampling platform if space and time permit.

(g) Make careful measurements of the total length of the core and precise points (nearest mm) of any layers of sediment that appear to be different. Note any changes in stratigraphy, such as colour and texture.

(h) Insert a rubber stopper into the lower end of the liner tube to form a watertight seal. The core is then
Part D3
Sediment Sampling

gently and slowly forced upward to the top of the tube. Some advanced corers come equipped with a stopper which allows the increment of each sediment slice to be adjusted.

(i) As the sediment core is extruded, carefully cut slices (one cm or more thick) with clean spatulas and place the slices into labeled sample jars. A core slicer greatly assists in this operation, however good samples can be obtained without a core slicer when processed carefully.

Note: For samples that are to be analyzed for organics, the spatula and container must not be made of plastic and the container must be a laboratory supplied glass jar. For samples that are to be analyzed for metals, the spatula must not be metallic.

(j) Place the samples directly into a cooler filled with ice packs without delay.

Large gravity corers, piston corers, or vibrocorers, will be operated by trained personnel who will remove the sediment core from the equipment; typically, the sediment core will be in a liner. Core sample recovery is highly dependent on the drillers’ technique and experience, and the sediment conditions of the site. After the core barrel is advanced to the limit of the run, the core barrel and extensions are withdrawn from the hole. Typically the recovered sediment core is then collected from the core barrel in the liner material. Cores may be processed on the sampling platform or vessel, if space and time permit, or retained for evaluation on shore.

› As a result of the drilling technique, the outer surface of the core may be smeared or disturbed obscuring stratigraphic detail. To reveal these details the core should be split longitudinally to expose a fresh surface for logging.

› Sediment cores should be logged in accordance with SOP D3-1. The exposed core should be photographed, with markers placed along the core to identify the depth at the top and bottom of the core run, and a placard identifying the borehole number, the project number and date.

› Consideration should be given to collecting samples at changes in stratigraphy as inferred from changes in drilling action, observed changes in sediment characteristics, or at predetermined depths [(e.g., continuous, every 0.75 m (2.5 ft) or 1.5 m (5 ft)].

› Samples for laboratory or headspace analysis may be collected directly from the recovered core. Laboratory and headspace samples should be collected from the inner portion of the core where possible to minimize the possibility of including contamination which may be present on the outer surface of the core sample from shallower soils or liquids co-recovered in the core run.

› Information specific to the method of drilling should be recorded along with the length of run and the length of core recovered. During extrusion, the core will have a tendency to compress or lengthen and logging of the core should account for this.

› If possible, an opinion should be made of the depth interval in a run in which missing core sample is located when core recovery is not 100%. Core recovery should be recorded on the sediment core log. In some cases this may be obvious, for instance drilling from a dense material into a softer material may result in spreading or compaction, rather than recovery.
4.4 Sampling Methods for Special Conditions

4.4.1 Stream and River Sediment Sampling

Sediment sampling in deep sections of rivers and streams rarely involves the use of core samplers as these devices require that flow be minimal (very few rivers world-wide have sufficiently low flow). Alternatively, core samples can be collected in shallow, flowing waters by physically pushing the corer into the sediment by hand.

It is useful to have some understanding of the currents at the sampling site. Strong near-bottom currents can lead to poor equipment deployment, deflect a grab sampler, or require a long cable/wire to be deployed. Care should be taken to ensure that the weight of the sampler is adequate for working in the particular current conditions and that the sampler collects sediment at or very near the desired sampling site. Strong current conditions can pose a safety risk to sampling personnel wading into these waters or sampling from a platform/shoreline. For sampling programs that include locations with strong currents and/or other potentially dangerous conditions extra safety precautions should be included in the sampling plan. These precautions may include special training such as swift water training and equipment such as lifejackets and safety harnesses.

4.4.2 Lake Sediment Sampling

Regardless of the equipment chosen for sample collection, it is necessary to know the water depth at each station before starting. If water depth information is unavailable, it is recommended that it first be measured. Measurement equipment can range from a weighted rope to an electronic depth sounder. The purpose is to ensure adequate cable (rope) length for operation of the equipment and to control the speed of entry of the sampler into the sediment. The speed of deployment of the sampler can be critical to good operation and sample recovery. A deployment that is too rapid will generate an increased shock wave advancing in front of the equipment. This shock wave can displace the soft unconsolidated surface sediments that may be desired for the sample. Rapid deployment may also cause equipment malfunction,
such as activating the trigger mechanism before the device reaches the sediment. In the case of core samplers, if the deployment is too slow an insufficient quantity of sediment will likely result. Since the site-specific conditions will dictate the speed of sampler deployment, the specifics should be recorded in the field log book (i.e., the height from which the corer was allowed to free fall).

4.4.3 Marine Sediment Sampling

Sediment sampling can be planned for the intertidal or subtidal zone of marine environments. It is generally recommended that surficial sediment sampling in the intertidal zone be completed by hand in low tide conditions. Subtidal sampling or sampling of the intertidal zone at high tides will need to be completed from a boat (Section 4.4.4) or a barge/platform. The progression of these sampling programs is highly weather dependent, as weather, particularly wind, can create wave activity that can disrupt sediment sampling operations by affecting the efficacy of the sampling equipment’s deployment and retrieval.

Currents, typically associated with tides, are important to consider when sediment sampling in the marine environment. Additionally, water depths to sediment can change significantly in nearshore areas due to tidal fluctuations, and should be considered when planning sampling programs and determining the appropriate sampling equipment to be employed. Care should be taken to ensure that the weight of the sampler is adequate for working in the particular current conditions and that the sampler collects sediment at or very near the desired sampling site.

4.4.4 Sediment Sampling from a Boat

The collection of deep water samples requires that at least one member of the sampling group be very familiar with boat operation and safety. If the sampling trip involves the use of a boat one member of the group must be designated as the vessel operator. The vessel operator must possess ‘proof of competency’ to operate the vessel. It is the vessel operator’s responsibility to ensure that the weather forecast and/or marine conditions for the sampling period do not exceed the vessel’s ability. If conditions are poor, then the sampling trip should be postponed. Establish a trip contact and advise the contact of your departure and expected return times. Check in with the contact before you set off in the boat and upon your return to shore.

Fast flowing river water requires specific training and or experience. If the boat is being used for river sampling it is essential that the vessel operator be very experienced with river boating. Ideally, there should be three people involved in the sampling trip when it involves boating on a river. Two people are responsible for collecting the samples, taking field measurements and recording field notes. The remaining person is responsible for boat operation only.

If sampling for hydrocarbons, be aware of boat exhaust as a potential source of contamination. Do not retrieve sediment samples next to the engines exhaust outflow, and be mindful of wind direction while processing samples on the boat.

Sampling trips should start at the sampling site that is most downstream and work upstream from there. This proactive measure will allow the current to return your vessel to your starting point if mechanical problems are encountered.
SEDIMENT SAMPLING from a BOAT - PROTOCOL

(a) When a sample site is reached, the boat operator will idle into the current to maintain the boat’s position. Use reference points on shore to do this.

(b) Water column samples must be obtained before sediment samples.

(c) Collect sediment samples with the relevant sampler, as outlined in Sections 4.2 or 4.3, above.

4.4.1 Winter Sampling and Sampling Through Ice

Sampling in winter weather conditions present additional elements of danger and as such a safety assessment should always be conducted once on site. If conditions present unreasonable safety risks abandon the sampling event. Always proceed with caution over ice and do not jeopardize your safety in pursuit of sample collection. Check the ice for thickness with a rod or ice chisel every few steps and do not proceed if the ice thickness is less than 8 cm. Wear a harness and life-line and always have a team member on shore.

For lake sampling, it is important to consider that ice near the outlet of a lake is often thin; therefore, caution should be used when sampling this area of a lake. Ice may also be thin where a stream enters a lake or where groundwater enters a lake.

As flow patterns in rivers and streams are generally more complex than in lakes, there are additional safety factors to consider. Honeycombed ice and areas over rapids should always be avoided. Be aware that ice downstream from bridge supports may be thin as a result of modified flow patterns and de-icing agents.

Generally, winter sampling on rivers follows a similar protocol to sampling lakes in winter. The primary exception occurs when the ice is unsafe; when this is the case, sample stations that are accessible from a bridge are the only option.

WINTER & ICE SAMPLING - PROTOCOL

(a) With safety considerations in mind, winter sampling locations should be as close as possible to the summer locations. The sites should be chosen where the water is known to be deep enough to avoid stirring up bottom sediments while drilling the hole and to ensure that there is water movement under the ice at the selected spot (in a river/stream environment).

(b) Clear loose ice and snow from the sampling location, and drill through the ice with a hand or motorized auger. Keep the area around the hole clear of potential contamination (e.g., dirt, fuel, oil, etc.). At least one member of the sampling team should be familiar with the operation and safety of both motorized and hand operated augers.

(c) Follow sampling procedures for grab or core sampling as outlined above.
4.5 Other Sediment Sampling Methods

4.5.1 The Guzzler Method

The GUZZLER METHOD - PROTOCOL

(a) Define the sampling area by placing a frame (e.g., 1 m²) on the sediment bed to define the sampling area.

(b) Use a hand-operated bilge pump to “vacuum” sediments from the defined sampling area and transfer the collected sediments into a clean bucket. As sediments are highly disturbed through this sampling process, this collection method is not suitable for the analysis of volatile organic compounds (VOCs), or any sampling that requires minimally disturbed sediment.

(c) Mix the contents of the bucket well and leave to sit undisturbed allowing suspended sediments to settle out. When the coarse-grained sediments have settled out, excess water should be carefully decanted from the bucket, and the bucket should again be left to sit undisturbed allowing the finer-grained sediments to settle out. When the sediments have satisfactorily settled out, carefully decant the remaining water from the bucket, leaving behind the collected sediment.

(d) Estimate and record the quantity (volume/weight) of sediment recovered and record observations of the sediment such as texture, colour, odour, presence of biota, presence of detritus, and the depth of sediment sampled (as outlined in Section 1.4).

(e) With a clean spatula or spoon, thoroughly stir the sediment in the bucket to homogenize. Place aliquots of the homogenized material into pre-labeled sediment sample jars.

   Note: For samples that are to be analyzed for organics, the spatula/spoon and container must not be plastic and the container must be a laboratory supplied glass jar. For samples that are to be analyzed for metals, the spatula/spoon must not be metallic.

(f) Place the samples into a cooler with ice packs without delay.
4.6  Sampling for Sediment Particle Size

4.6.1  McNeil Sampler

<table>
<thead>
<tr>
<th>McNEIL SAMPLER - PROTOCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Wade into the water downstream of the intended sample collection site.</td>
</tr>
<tr>
<td>(b) Remove the cap from the sampling tube. Ensure that you are in water that is sufficiently shallow so the sampler will not be swamped when the tube portion is inserted into the sediment.</td>
</tr>
<tr>
<td>(c) Thrust the sampler through the water column and force the tube into the sediment until the bottom of the collecting cylinder is on the streambed.</td>
</tr>
<tr>
<td>(d) Reach in and remove all the streambed material that is in the tube.</td>
</tr>
<tr>
<td>(e) Recap the tube and carefully withdraw the sampler from the sediment. Return to shore and pour the contents of the sampler through a fine mesh sieve into a collecting pan.</td>
</tr>
<tr>
<td>(f) Transfer the water from the pan to a pre-labeled bottle. This bottle can either be submitted for total suspended sediment analysis (non-filterable residue), or to a pre-determined lab for hydrometric particle size analysis (the Ministry of Agriculture, Food and Fisheries or the Ministry of Highways have the capability to conduct this type of analysis). The larger materials that were trapped in the sieve must be submitted to one of the facilities capable of mechanical analysis for size. These can be transported in well labeled heavy duty plastic bags.</td>
</tr>
</tbody>
</table>

4.6.2  Sediment Traps

<table>
<thead>
<tr>
<th>SEDIMENT TRAPS - PROTOCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) In preparation for the sampling trip, gravel of fairly uniform size should be collected and cleaned. Place the cleaned gravel in four litre buckets (fill each bucket to the rim). Replace the lids.</td>
</tr>
<tr>
<td>(b) Once in the field, dig a hole in the streambed large enough that the bucket will be immersed in the sediment to the point that the top will be flush with the streambed. Wait until the disturbed fine sediments have cleared before you place the bucket in the hole.</td>
</tr>
<tr>
<td>(c) While the lid is still on, gently place the bucket in the hole and surround it with streambed material until it is secure. Once again, wait until disturbed materials have cleared before removing the lid.</td>
</tr>
<tr>
<td>Note: Never walk upstream of the buckets as this will disturb sediments that will be captured in the sediment trap.</td>
</tr>
<tr>
<td>(d) After the time outlined by the project design (usually 2 - 4 weeks), gently replace the lid and remove the bucket from the streambed.</td>
</tr>
<tr>
<td>(e) Submit the bucket(s) to a pre-determined lab for mechanical (particle size) analysis. The Department of Agriculture Food and Fisheries or the Ministry of Highways have facilities that conduct this sort of analysis.</td>
</tr>
</tbody>
</table>
4.7 Sampling for Parameters Requiring Special Handling

4.7.1 Volatile Organic Compounds

Sampling sediment for VOCs requires careful selection of sampling methodologies and handling procedures to minimize the loss of VOCs through volatilization and biodegradation. Careful sampling handling and transfer are critical to minimize losses due to volatility. The sample must be collected in a manner that minimizes the disturbance of the sample material. The sample should be collected directly from the sample device if possible. If that is not possible, such as with the grab samplers, then the sample should be collected from the sampler contents immediately, prior to any sample mixing.

The VOC sample should be collected prior to any other procedures, such as logging sediment characteristics etc. Samples for VOCs can be collected using methanol preservation or hermetically sealed field sample methods. Refer to SOP D3-1 for a detailed sampling methodology specific to VOCs.
5 Shipping

Each sampling schedule must be designed to ensure that the samples arrive at the shipping agency’s terminal well before the end of business hours. Since some analytes have very limited hold times (applicable hold times should be confirmed with the laboratory), every effort must be made to avoid delays in shipping. The following procedure must be followed to maintain the integrity of the samples during transit.

**SHIPPING - PROTOCOL**

*Note: Ice packs should be used instead of loose ice or bagged ice. When loose ice melts, the contents of the cooler are free to shift, potentially allowing contamination of samples with melted ice water and/or breakage of glass bottles. If loose ice is used it should be double bagged and placed on the bottom of the cooler.*

(a) Pack the samples upright in the cooler. During the winter season the cooler should include as a minimum, a volume of ice pack equal to the volume of sample material stored in the cooler. During the spring, summer and fall seasons the minimum volume of ice pack should be twice the volume of the sample material. Ensure that glass sample bottles are individually wrapped in bubble-wrap bags or equivalent material and where possible separated from each other by plastic bottles or clean packing material to prevent them from shifting, falling over and/or breaking. Use clean packing materials to fill any void in the cooler which will further prevent samples from shifting and potentially breaking.

(b) Complete the laboratory requisition form/s and enclose it/them in a sealed plastic bag, and place the bag in the cooler on top of the samples. The recommended minimum information that should be included in each requisition form is listed below:

- Site name;
- EMS site number/s;
- Date and time of sample collection;
- Name of sampler/collector;
- Field measurements;
- Comments on sample appearance;
- Weather conditions; and,
- Any other observations that may assist in interpreting data.

(c) Seal the cooler with heavy duty packing tape to reduce the possibility of it accidentally opening and to prevent tampering. Coolers arriving at the laboratory with torn or absent tape should be noted by lab staff with notification sent by lab reception to the sample submitter.

(d) Attach a label on top of the cooler to prominently display the destination.
6 Sources of Further Information


United States Environmental Protection Agency (US EPA). 2015. SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205-R3,


7 Revision History

› March 30, 2018: This section updated to include additional information regarding sediment sampling designs, sampling equipment and sampling methods.

› October 10, 2013: This section republished without change. Appendix 2 - Sample containers, Storage™, Preservation and Holding Times updated.

› February 28, 2001: This section republished without change. Note added to Appendix 2 requiring use of glass or Teflon™ containers for samples to be analyzed for mercury.

› November 1996: Initial publication.
Appendix I

Generic Field Checklist
Appendix I: Generic Field Checklist
(for water, sediments, biota and effluents)

General:
Log Books _____ Pencils ____
Cooler (with ice packs)____ Felt Markers (waterproof)____
Rope____ Tape____
Camera (film)____ Requisition forms ____
Way bills ____ Shipping labels ____
De-ionized water (4L)____ Squirt bottle____
Resealable bags ____

Labeled Sample Bottles:
General chemistry (1 L) #____ General chemistry (2 L) #____
Dissolved Metals #____ Total Metals #____
Total Organic Carbon #____ Low-level nutrients #____
Coliforms #____ Sediments #____
Zooplankton #____ Phytoplankton #____
Periphyton #____ Invertebrates #____
Tissue cups #____ Macrophytes #____
Extras - two of each

Sampling Equipment (clean, in working order, batteries charged):
DO Sampler (BOD bottle, Winkler reagents)____
Thermometer____ DO meter____
pH meter____ Conductivity meter____
Hydrolab____ Secchi disc ____
Van Dorn____, rope ____ messenger ____ Through Ice Sampler____
Auger (bit sharpened, skimmer)____ Spare probe membranes (repair kit)____
Sediment grab ____ messenger ______ Sediment corer ____ sample tubes ____
Sieves____ Zooplankton tow nets____
Benthic invertebrate sampler (Hess, drift net, Surber)____
Periphyton kit (cup, denture brush, baster)____
Macrophyte sample kit (buckets, garbage bags, float tray, plant press, blot paper, herbarium sheets, newsprint, corrugated cardboard)____
Part D3
Sediment Sampling

Filtration and Preservation Equipment:
Filter Pots  Syringe(s), Hose
Tweezers  0.45 µ membrane filters
Preservative Vials  Disposal Container (for used vials)
70% ethanol  Formalin
Lugol's solution  Magnesium carbonate

Boat Equipment:
Canoe (or boat)  Paddles
Motor  Fuel
Life jackets  Ropes
Anchor  Tool kit

Personal Gear:
Lunch  Survival suit
Rain gear  Gum boots
Waders (hip, chest)  Sun screen
Flash light

Safety:
WHMIS guidelines  First Aid Kit
Goggles (or safety glasses)  Rubber gloves