

**U.S. Geological Survey
Techniques of Water-Resources Investigations**

**Book 9
Handbooks for Water-Resources Investigations**

**National Field Manual
for the Collection of
Water-Quality Data**



**Chapter A4.
COLLECTION OF
WATER SAMPLES**

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Foreword

The mission of the Water Resources Discipline of the U.S. Geological Survey (USGS) is to provide the information and understanding needed for wise management of the Nation's water resources. Inherent in this mission is the responsibility to collect data that accurately describe the physical, chemical, and biological attributes of water systems. These data are used for environmental and resource assessments by the USGS, other government agencies and scientific organizations, and the general public. Reliable and quality-assured data are essential to the credibility and impartiality of the water-resources appraisals carried out by the USGS.

The development and use of a *National Field Manual* is necessary to achieve consistency in the scientific methods and procedures used, to document those methods and procedures, and to maintain technical expertise. USGS field personnel use this manual to ensure that the data collected are of the quality required to fulfill our mission.

Robert M. Hirsch
Associate Director for Water

To field rinse the cone splitter:

1. Put on gloves.
2. Uncover the splitter reservoir and pour or pump 2 to 4 L of rinse water into the cone-splitter reservoir, one liter at a time.
3. Lightly tap the splitter to dislodge adhering water drops. Discard rinse water.
4. Cover the splitter.

Isokinetic, Depth-Integrated Sampling 4.1.3.A Methods at Flowing-Water Sites

Collection of isokinetic, depth-integrated samples involves using either an equal-width-increment (EWI) or equal-discharge-increment (EDI) sampling method. The EWI or EDI methods usually result in a composite sample that represents the discharge-weighted concentrations of the stream cross section being sampled.

The EWI and EDI methods are used to divide a selected cross section of a stream into increments having a specified width. The term vertical refers to that location within the increment at which the sampler is lowered and raised through the water column.

- ▶ EWI verticals are located at the midpoint of each width increment.
- ▶ EDI verticals are located at the centroid, a point within each increment at which stream discharge is equal on either side of the vertical.

If properly implemented, EDI and EWI methods should yield identical results. The uses and advantages of each method are summarized below and in table 4-5. Isokinetic samplers usually are used to obtain a discharge-weighted sample along the stream cross section. **When using an isokinetic sampler there should be no change in velocity (speed and direction) as the sample enters the intake (fig. 4-3).**

Table 4-5. Uses and advantages of equal-width-increment (EWI) and equal-discharge-increment (EDI) sampling methods

EWI method	Advantages of the EWI method
<p>EWI is used when information required to determine locations of sampling verticals for the EDI method is not available, and (or) the stream cross section has relatively uniform depth and velocity.</p> <p>Use EWI whenever:</p> <ul style="list-style-type: none"> • The location of EDI sampling verticals changes at the same discharge from one sampling time to another. This situation occurs frequently in streams with sand channels. 	<ul style="list-style-type: none"> • EWI method is easily learned and implemented for sampling small streams. • Generally, less time is required onsite if the EWI method can be used and the information required to determine locations of sampling verticals for the EDI method is not available.
EDI method	Advantages of the EDI method
<p>EDI is used when information required to determine locations of sampling verticals for the EDI method is available.</p> <p>Use EDI whenever:</p> <ul style="list-style-type: none"> • Small, nonhomogeneous increments need to be sampled separately from the rest of the cross section. The samples from those verticals can be analyzed separately or appropriately composited with the rest of the cross-sectional sample. (Have the sampling scheme approved.) <p style="text-align: center;">or</p> <ul style="list-style-type: none"> • Flow velocities are less than the isokinetic transit-rate range requirement. A discharge-weighted sample can be obtained, but the sample will not always be isokinetic. <p style="text-align: center;">or</p> <ul style="list-style-type: none"> • The EWI sampling method cannot be used. For example, isokinetic samples cannot be collected because stream velocities and depths vary so much that the isokinetic requirements of the sampler are not met at several sampling verticals. <p style="text-align: center;">or</p> <ul style="list-style-type: none"> • Stage is changing rapidly. (EDI requires less sampling time than EWI, provided the locations of the sampling verticals can be determined quickly.) 	<ul style="list-style-type: none"> • Fewer increments are necessary, resulting in a shortened sampling time (provided the locations of sampling verticals can be determined quickly and constituents are adequately mixed in the increment). • Sampling during rapidly changing stages is facilitated by the shorter sampling time. • Subsamples making up a sample set may be analyzed separately or may be proportionally composited with the rest of the cross-sectional sample. • The cross-sectional variation in constituent discharge can be determined if subsample bottles are analyzed individually. • A greater range in velocity and depths can be sampled isokinetically at a cross section. • The total composite volume of the sample is known and can be adjusted before sampling begins.

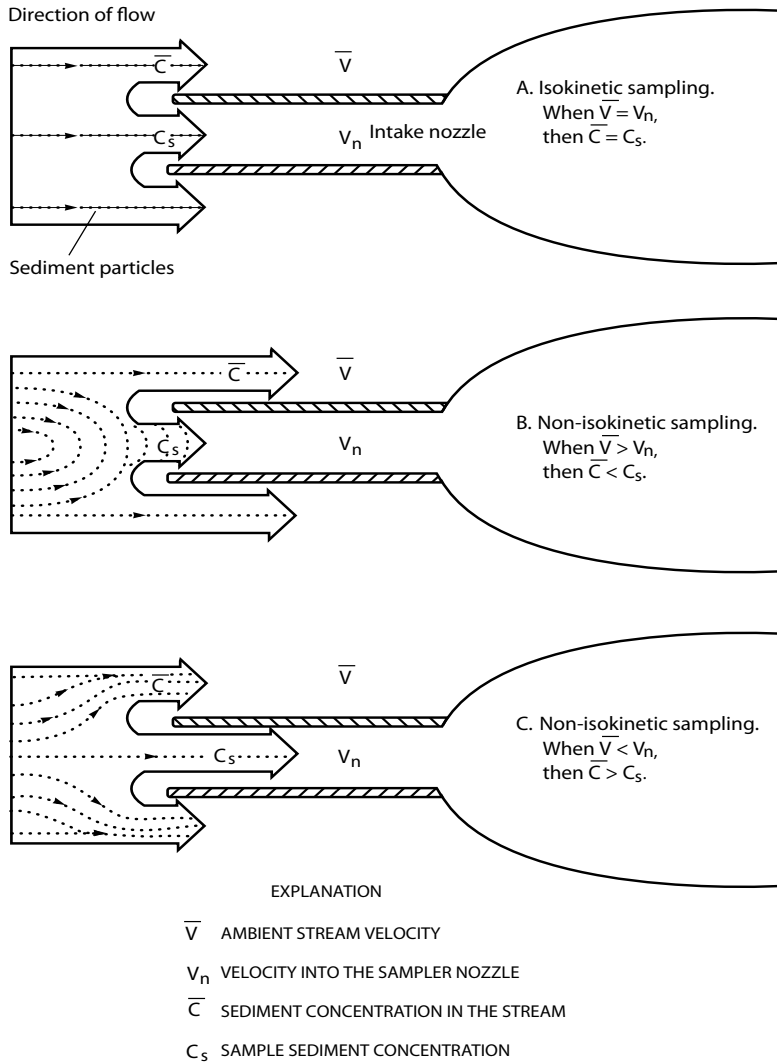



Figure 4-3. Relation between intake velocity and sediment concentration for isokinetic and nonisokinetic collection of water samples that contain particulates greater than 0.062 millimeters (modified from Edwards and Glysson, 1999, p. 14).

- ▶ Collect isokinetic, depth-integrated samples by using a standard depth- and width-integrating method if analysis of a representative sample from a cross section of flowing water is required for discharge computations. Appendix A4-A and Edwards and Glysson (1999, figures 39–43), provide detailed information about isokinetic, depth-integrating transit rates for collecting samples.
- ▶ For isokinetic sampling, the mean velocity of the vertical that is sampled must exceed the minimum-velocity requirement of an isokinetic sampler—the minimum velocity requirements are 1.5 ft/s for a bottle sampler, 2 ft/s for a 1- or 3-liter bag sampler, or 3 ft/s for a 6-liter bag sampler (Appendix A4-A).
 - The transit rate (the rate at which the sampler is lowered or raised) used to collect an isokinetic, depth-integrated sample is mainly a function of the nozzle diameter of the sampler, volume of the sampler container, stream velocity, and sampling depth (Appendix A4-A). The maximum allowable transit rate for a bag sampler is 0.4 multiplied by the mean stream velocity.
 - An error in concentrations of suspended particulates coarser than 62 μm can be important when the velocity of the sample entering the nozzle and the stream velocity differ significantly. Too fast a transit rate will cause a sampler to undersample sand-sized particulates (Edwards and Glysson, 1999).
 - The transit rate must be kept constant during sampler descent through a vertical and also during sampler ascent through a vertical.

The number of increments needed in order to get a discharge-weighted sample at a site is related primarily to data objectives (for example, the accuracy needed) and how well-mixed or heterogeneous the stream is with respect to the physical, chemical, and biological characteristics of the cross section. The recommended number of increments for EWI and EDI methods are discussed in the sections to follow. Edwards and Glysson (1999) describe a statistical approach for selecting the number of increments to be used, based on sampling error and suspended-sediment characteristics.

Selecting the number of increments

- ▶ Examine the variation in field-measurement values (such as specific electrical conductance, pH, temperature, and dissolved oxygen) along the cross section (NFM 6).
- ▶ Consider the distribution of streamflow (discharge), suspended-materials concentration and particle-size distribution, and concentrations of other targeted analytes along the cross section. Consider whether the streamflow distribution or analyte concentrations will change during sample collection.
- ▶ Consider the type of sampler that will be used and the volume of sample that will have to be collected for the analysis of the target analytes.
- ▶ Avoid side-channel eddies. EDI and EWI methods cannot be used at locations with upstream eddy flow.

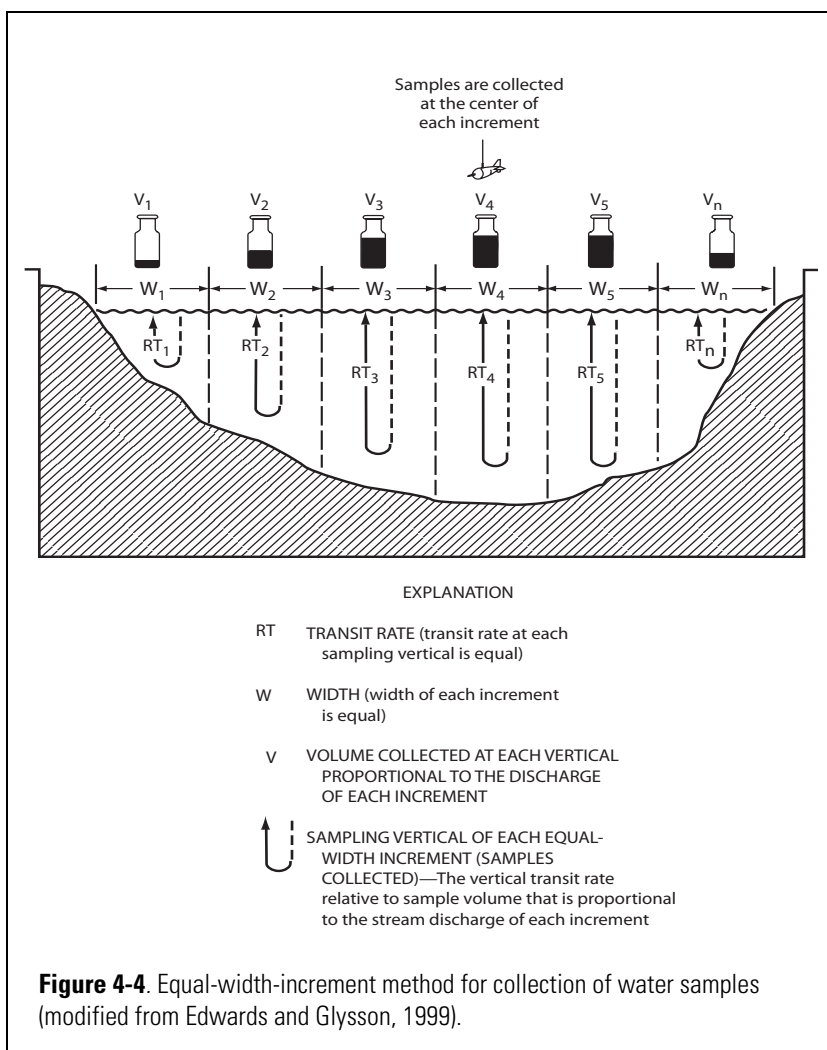
 **RULE OF THUMB:** For isokinetic, depth-integrating sampling, do not exceed the designated maximum transit rate.

Equal-width-increment (EWI) method

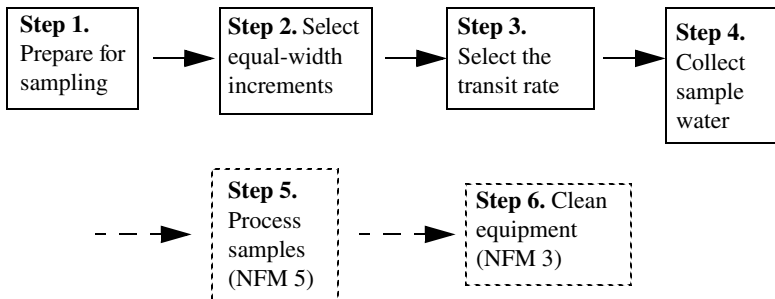
For the EWI sampling method, the stream cross section is divided into a number of equal-width increments (fig. 4-4). Samples are collected by lowering and raising a sampler through the water column at the center of each increment. (This sampling location is referred to as the vertical.) The combination of the same constant transit rate used to sample at each vertical and the isokinetic property of the sampler results in a discharge-weighted sample that is proportional to total streamflow.

- ▶ **Isokinetic sampling is required for the EWI method.** Use isokinetic, depth-integrating sampling equipment (NFM 2.1.1.A).
 - **Use the same size sampler container (bottle or bag) and nozzle** at each of the sampling verticals (fig. 4-4).
 - **Collect samples using the same transit rate** at each vertical during descent and ascent of the sampler. The transit rate must be constant and within the operational range of the sampler (Appendix A4-A).
- ▶ Composite the subsamples from all verticals in a churn splitter or process subsamples through the cone splitter (NFM 2.2.1 and NFM 5.1.1).

**Do not use EWI when stream velocities are less than the minimum velocity required for the isokinetic sampler selected:
1.5 ft/s for the bottle sampler.**



Steps for the *EWI* sampling method



Be sure that the field effort is adequately staffed and equipped. Check QC requirements before departing—QC samples require additional equipment and supplies.

Step 1. Prepare for sampling⁷

- a. Upon arrival at the field site, set out safety equipment such as traffic cones and signs. Park vehicle in a location and direction so as to prevent sample contamination from vehicle emissions.
- b. Assemble sampling equipment and set up a clean work space.
 - **Organic compounds.** Select equipment with fluorocarbon polymer, glass, or metal components if components will directly contact samples to be analyzed for organic compounds. **Do not use plastics other than fluorocarbon polymers.**
 - **Inorganic constituents.** Select equipment with components made of fluorocarbon polymer or other relatively inert and uncolored plastics or glass if components will directly contact samples to be analyzed for inorganic constituents. **Do not use metal or rubber components for trace-element sampling.**
 - **Microbiological analyses.** Collect samples for microbiological analyses using equipment and techniques described in NFM 7.

⁷Preparations for water sampling are described in NFM 2 and 3. Consult NFM 5 for sample processing, NFM 6 for field measurements, NFM 7 for biological indicators, NFM 8 for bottom-material sampling, and NFM 9 for field safety.

Step 2. Select the number and width of equal-width increments.

- a. Visually inspect the stream from bank to bank and longitudinally, observing velocity, width, and depth distribution, and apparent distribution of sediment and aquatic biota along the cross section. Note and document the location of stagnant water, eddies, backwater, reverse flows, areas of faster than normal flow, and piers or other features along the cross section.
- b. Determine stream width from a tagline or from distance markings on a bridge railing or cableway.
- c. At sites with little sampling history, measure and record the cross-sectional variation of field measurements (such as specific electrical conductance, pH, temperature, and dissolved oxygen). Review the magnitude of the variations along the cross section.
- d. Determine the width of the increment. To obtain the number of increments, divide the stream width by the increment width. **The number of increments must be a whole number.** Increment width is based on study objectives, variation in field measurements and flow, and stream-channel characteristics along the cross section.
 - Collect the subsample at the center of each equal-width increment (the vertical).
 - If the subsample does not represent the mean value for that increment, decrease the increment width until the mean value for the increment is represented. This will increase the number of increments sampled.
- e. Locate the first sampling vertical at a distance of one-half of the selected increment width from the edge of the water. Locate all the other verticals at the center of each remaining equal-width increment along the cross section.

Example:

- If a stream 56 ft wide has been divided into 14 increments of 4 ft each, the first sampling vertical would be 2 ft from the water's edge and subsequent verticals would be at 6, 10, 14 ft from the water's edge, and so forth.
 - Even if streamflow is divided, as in a braided channel, equal-width increments must be identical from channel to channel, and the same constant transit rate must be used at each vertical.
- f. Make slight adjustments to sampling locations, if necessary, to avoid sampling where the flow is affected by a pier or other obstruction.

TECHNICAL NOTE: Sampling near or downstream from large in-stream obstructions such as bridges and piers could result in artificially elevated concentrations of suspended sediments if the sampler is immersed in an eddy that is caused by the obstruction. If it is necessary to include an eddy in the cross section to be sampled, consider treating the eddy as a solid obstruction: subtract the eddy width from that of the total cross section, and determine the width of the increments based on the remaining stream width.

RULE OF THUMB

When selecting the number of equal-width increments:

- Cross-sectional width ≥ 5 ft—use a minimum of 10 equal-width increments
- Cross-sectional width < 5 ft—use as many increments as practical, but equally spaced at a minimum of 3 inches apart.

Equipment limitations also constrain the number of increments selected; for example:

- When using a 1-L bottle sampler at maximum depth with a 14-L churn splitter, EWI samples can be collected at no more than 14 to 17 verticals.
 - If an 8-L churn splitter is used, samples can be collected at no more than 10 verticals.
 - A cone splitter must be used if the total volume collected will exceed the recommended volume for the churn splitter.
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Step 3. Select the transit rate.

- a. Refer to Appendix A4-A for guidelines for determining the transit rates for collecting isokinetic, depth-integrated samples. Unless the mean velocity is actually determined, use the trial-and-error method to determine the minimum transit rate.
- b. Locate the equal-width increment containing the largest discharge (largest product of depth times velocity) by sounding for depth and either measuring or estimating velocity. At the vertical for this increment, use of the minimum transit rate results in the maximum allowable filling of the sampler bottle or bag during one vertical traverse.

- c. Determine the minimum transit rate at this vertical for the type of sampler (bottle or bag), size of sampler nozzle, and the desired sample volume.
- Approximate the mean velocity of the vertical in feet per second by timing a floating marker (such as a peanut) as it travels a known distance. (A known length of flagging tape tied to the cable where the sampler is attached often is used to measure the distance.) Divide the distance (in feet) by the time (in seconds) and multiply by 0.86.
 - Make sure that the transit rate does not exceed the maximum allowable transit rate to be used at any of the remaining verticals along the cross section. This can be determined by sampling the slowest increment. **If the minimum volume of sample (relative to depth of the vertical) is not collected at this vertical, then the EWI method cannot be used at this cross section to collect a discharge-weighted sample (Appendix A4-A).**
 - Remember that you must keep the transit rate unidirectional, constant, and within the isokinetic transit range of the sampler when collecting isokinetic samples at each centroid.

Guidelines for selecting the transit rate for EWI sampling

- The descending and ascending transit rate must be constant in each direction and must be the same for each vertical along the cross section.
- **Do not exceed the maximum allowable transit rate if using EWI.** If the transit rate must exceed the maximum allowable rate, use EDI instead of EWI.
- The transit rate selected must be sufficiently rapid to keep from overfilling the sampler. The sampler is overfilled when the water surface in the sampler container is above the bottom edge of the nozzle when the sampler is held in the sampling position.
- The same size sampler nozzle and container must be used at all verticals along the cross section.
- If the total volume collected will exceed the recommended volume for the churn splitter, then a cone splitter must be used.

Step 4. Collect sample water.

The sample-collection procedure is the same whether you are wading or using the reel-and-cable suspension method. When sampling from a bridge, deploy the sampler from the upstream of the bridge, if possible, to avoid bridge-related contamination of the sample. **Use CH/DH techniques, as required (section 4.0.2). Always follow safety procedures (NFM 9).**

- a. Move to the first vertical (midpoint of first EWI near edge of water) and field rinse equipment (section 4.1.3). Collect the rinse water at the edge of the stream in a section of low stream velocity to minimize including suspended sediment.
- b. Record start time and gage height.
- c. Lower field-rinsed sampler at the predetermined constant transit rate until slight contact is made with the streambed. **Do not pause** upon contacting the streambed. Raise the sampler immediately at the same constant transit rate until sampler completes the vertical traverse.
 - Take care not to disturb the streambed by bumping the sampler on it; bed material may enter the nozzle, resulting in erroneous data.
 - Do not overfill the sampler container. Overfilling results in a sample that is not isokinetic and that could be enriched with heavy particulates because of secondary circulation of water through the sampler (from nozzle through air exhaust). This enrichment will result in an artificially increased sediment concentration and will bias particle-size distribution toward heavier and larger particulates.
 - Do not underfill the sampler container (Appendix A4-A). Underfilling will result in a sample that is not isokinetically collected because the maximum transit rate has been exceeded.
 - If the required volume cannot be collected, use the EDI method to obtain discharge-weighted samples.
- d. Inspect each subsample as it is collected, looking for overfilling or underfilling of the sampler container and (or) the presence of anomalously large amounts of particulates that might have been captured because of excessive streambed disturbance during sample collection. **If you note any of these conditions, discard the sample, making sure there are no residual particulates left in the container, and resample.**

- e. Move sampling equipment to the next vertical. Maintain the selected transit rate. The volume of the subsample can vary considerably among verticals. Subsamples can be collected at several verticals before emptying the sampler container, as long as the maximum volume of sample in a bottle or bag sampler has not been exceeded. If the container is overfilled, it is necessary to resample.

TECHNICAL NOTE: The tables in Appendix A4-A apply to the first complete round-trip transit, starting with an empty sampler container. These tables cannot be used if the sampler is not emptied between verticals.

- f. Continue to the next vertical until no more samples can be collected without overfilling the sampler container. Empty the subsample into a field-rinsed churn or cone splitter and repeat sample collection in the same manner until subsamples have been collected at all the verticals.
 - If the total volume of the subsamples to be collected will exceed the operational capacity of the churn, select from the following options: use a smaller nozzle; or, use a cone splitter; or, use the EDI method, if appropriate.
 - To ensure that all particulates are transferred with the sample, swirl the subsample gently to keep particulates suspended and pour the subsample quickly into the churn or cone splitter.
 - Sample EWI verticals as many times as necessary to ensure that an adequate sample volume is collected as required for analysis, **but sample at each vertical an equal number of times.** (The composite cross-sectional sample will remain proportional to flow at the time of sampling.)
 - If flow is stable during sampling, then multiple samples can be collected at each vertical during a single traverse along the cross section. If flow is changing, however, study objectives should determine whether to collect multiple samples at each vertical during a single traverse or to collect one sample at each vertical during multiple traverses along the cross section. Document on field forms the method used.
- g. Record the following information after all samples have been collected:
 - Sampling end time.
 - Ending gage height.
 - All field observations and any deviations from standard sampling procedures.

Step 5. Process Samples → Refer to NFM 5.

Step 6. Clean Equipment → Refer to NFM 3.

- If the sampler will not be reused during a field trip, rinse sampler components with deionized water before they dry and place them into a plastic bag for transporting to the office laboratory to be cleaned.
- If the sampler will be reused during the field trip, rinse the components with DIW while still wet from sampling and then field-clean while at the sampling site using the prescribed procedures (NFM 3). Reassemble the sampler.
- Collect a field blank, if required, after sampling equipment has been cleaned at the sampling site.
- Place the cleaned sampler into a plastic bag and seal for transport to the next site.