ERDC/CRREL SR-09-1

Cold Regions Research and Engineering Laboratory

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User's Manual for the CRREL Multi-Increment Sampling Tool

Michael R. Walsh

June 2009r

Front cover photo: Characterization of a demolition range at Fort Richardson, Alaska, by a joint Canadian / U.S. research team using prototype CRREL multi-increment sampling tools.

ERDC/CRRELL SR-09-1
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Final report

Approved for public release; distribution is unlimited.

Prepared for Strategic Environmental Research and Development Program
Arlington VA 22203

Under Project ER-1481

Abstract: The CRREL Multi-Increment Sampling Tool (CMIST) was developed to facilitate collecting multi-increment soil samples. The design is simple yet flexible, enabling the investigator to configure the tool to meet the collection needs of the sampling plan. This manual describes the tool, how to use the tool, and how to maintain the tool in the field.

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Preface

This work has been funded by the U.S. Department of Defense through the Strategic Environmental Research and Development Program (Projects CP-1155 and ER-1481) and the Environmental Security Technology Certification Program (Project ER-0628). Additional support has been provided by the U.S. Army Alaska and the U.S. Army Garrison, Alaska, through the Eagle River Flats Restoration Project and the Soil and Water Quality Program.

This technical note was prepared by Michael R. Walsh, Mechanical Engineer, Engineering Resources Branch (RV-E), U.S. Army Engineer Research and Development Center – Cold Regions Research and Engineering Laboratory (ERDC-CRREL). At the time of publication, Thomas J. Tantillo was Chief, CEERD-RV-E; Deputy Director of ERDC–CRREL was Dr. Lance D. Hansen, and the Director was Dr. Robert E. Davis.

The Commander and Executive Director of ERDC was COL Gary E. Johnston and the Director was Dr. James R. Houston.

Acknowledgements

Multi-increment sampling is a new and innovative method to obtain representative soil samples from areas (decision units) suspected of contamination. Biasing of the sampling and the difficulty of obtaining hundreds of increments was a hurdle to the acceptance of this method. With the help of Mr. Chuck Ramsey of Envirostat and Dr. Tom Jenkins, formerly of CRREL, we developed this tool over several years to be a simple, rugged, and effective aid in the multi-increment sampling process. Many thanks to all involved in this process, especially those who took up the tool in the early years and provided much valuable feedback.

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
hectares	1.0 E+04	square meters
inches	0.0254	meters
miles (U.S. statute)	1,609.347	meters
ounces (mass)	0.02834952	kilograms
ounces (U.S. fluid)	2.957353 E-05	cubic meters
pints (U.S. liquid)	0.473176	liters
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
yards	0.9144	meters

1 Introduction

The CRREL (Cold Regions Research and Engineering Laboratory) Multi-Increment Sampling Tool (CMIST) was developed to facilitate the collection of multi-increment soil samples. Multi-increment sampling requires the collection of many increments that are combined to form a single sample. This sample, if collected properly, will enable the characterization of a decision unit. Decision units (DU) can range from as small as a few square meters to over a hectare. Typical DUs are on the order of 0.25 ha. The number of increments required to properly characterize a DU will vary from a minimum of 30 to over 100, depending on data quality objectives.

Fieldwork often occurs in remote areas. Tools need to be rugged, simple, lightweight, easy to use, and flexible. In the case of a sampling tool, it also needs to enable the acquisition of consistent samples. These are all design criteria used to develop the CMIST. This manual will enable you, the user, to get the most out of the tool and optimize your time in the field.

This manual addresses only the use of the CMIST tool and does not delve into sampling theory or how to set up a sampling strategy. If you are interested in these topics, we recommend works by Pierre Gy, the U.S. Environmental Protection Agency (EPA), the U.S. Army Environmental Command (AEC), and Envirostat. This manual assumes that the general outline for a sampling strategy (multi-increment sampling) has been established, with some leeway allowed for on-site adjustments of DU size and shape as well as the number of increments per sample.

2 Description

The CMIST tool

The CMIST sampling tool is designed to facilitate the collection of sample increments of a given volume in cohesive soils. Its basic parts are a lightweight aluminum handle, a rugged carbon steel base with a combination depth-control / increment-ejection pusher mechanism, and interchangeable stainless steel (SS) bits (Figure 1). It disassembles easily for packing and transport and will fit in most 50-L (12-gal) coolers or a 36- x 56-cm shipping container (Rubbermaid ActionPacker Model 1172). Component sizes and weights are given in Table 1. (See Appendix A, Table A1, for a parts list for both tool and supporting equipment.)

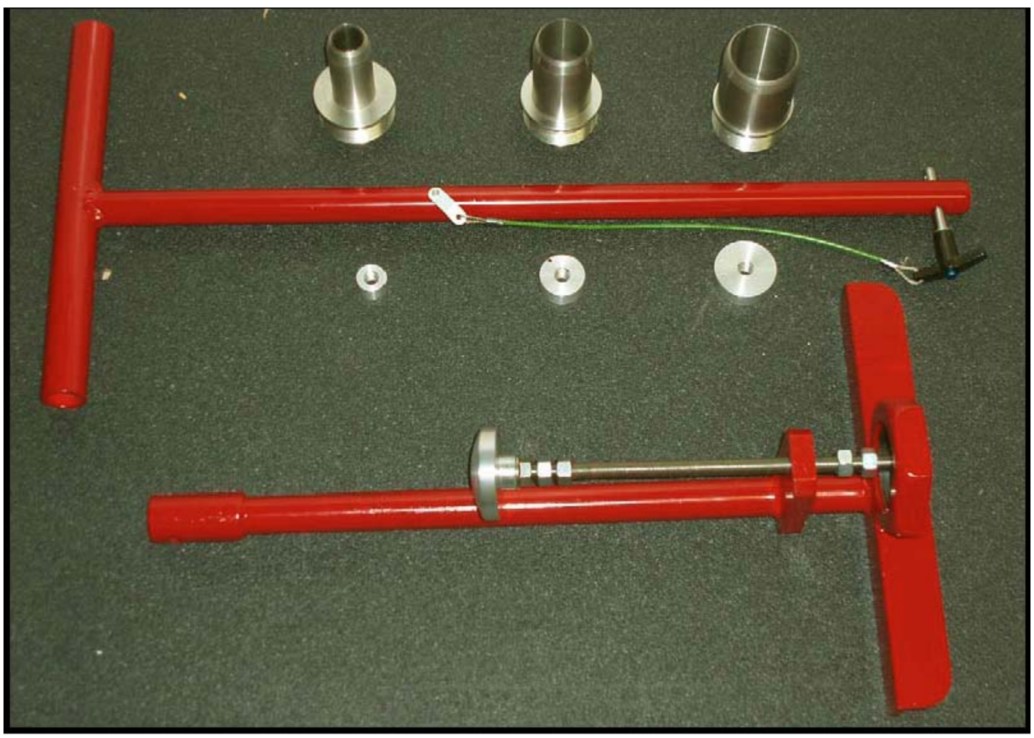

Figure 1. The CRREL Multi-Increment Sampling Tool. Coring tips are 2-, 3-, and 4-cm diameter (left to right). Corresponding disks are shown below the handle.

The handle is a lightweight aluminum weldment that attaches to the base with an 8-mm (diameter) x 3.2-cm (5/16- x 1.25-in.) quick-release pin. The standard length is 56 cm, but shorter lengths are possible through an easy modification of the existing handle, done by cutting it to length and then cross-drilling with a 9-mm bit at 2 cm from the end.

Table 1. CMIST component weights and dimensions.

Component	Weight	Dimensions (cm)
Handle	0.43 kg	26 W x 56 L
Base assembly	1.8 kg	26 W x 44 L
Coring bits (3)	1.1 kg (≈350 g each)	5 x 8.5 L

The base assembly has attachment points for the handle and the interchangeable coring bits. The bits thread onto the lower end of the base. The integral depth/pusher mechanism consists of an aluminum knob, a 23-cm length of ⅜ in.–24 SS threaded rod, four ⅜-in.–24 SS hex nuts, and two ⅜-in.–24 SS serrated flange nuts. A depth-control disk attaches to the end of the threaded rod opposite the knob. The disk size will depend on the coring bit size.

Coring bits come in three standard sizes: 2-,3-, and 4-cm diameter. All bits are stainless steel, machined from a solid blank. The thread size is 1 ⅞-in.–12. The inside of the bit is tapered at a 1° angle to expedite removal of the sample plug. The tips are double-beveled to provide a sharp cutting edge as well as strength. The recommended usable length of the coring bits is 5 cm. If the need arises, longer coring bits can be supplied to obtain longer sample plugs, although longer plugs are more difficult to obtain and extract, especially in more consolidated (hard-packed) soils.

Supporting tools and equipment

To ensure proper operation of the CMIST, we recommend the following tools and equipment (shown in Figure 2). Two 9/16-in. open-end wrenches are needed to assemble and adjust the pusher assembly. A set of slip-joint pliers is used to install and remove the coring bits. These pliers should have a range of 2.5 to 5 cm. A metric-graduations tape measure is needed to set the depth of the pusher mechanism. A half-round metal file is useful to maintain the edge of the bits, and a 0.5-kg dead-blow (lead-shot-filled) hammer is indispensable when a sample gets stuck in the bit or when sampling in compact soil.

If samples are to be split, such as with a surface/subsurface split, a modified putty knife works well. Sharpen both side edges of the putty knife. On one edge, use a metal file to file in serrations. The serrations are handy for cutting through root material. We also recommend an AMS stainless #2 scoop (or two), to be used when sampling soils that are not cohesive enough to stay in the coring bit.

Figure 2. Some supporting tools used with the CMIST.

Cleaning equipment and supplies

The tool must be cleaned between sampling locations to avoid cross-contamination and to ensure proper operation of the tool. To remove adhered soil, we use stainless steel wool pads and a parts-cleaning brush with stainless bristles and a Delrin handle (Figure 3). The brush is very useful to clean the threads of the bits, bit holder, and depth-adjustment rod. To wash down the tool, we use both water and acetone. The final rinses should be with distilled, deionized, or ultra-filtered water followed by a light acetone rinse. A 16-oz (0.5-L) polyethylene spray bottle is useful for the acetone. For water, we use either a 4-L spray bottle or a larger, backpack compression sprayer. The compression sprayer works well when samples are consolidated at a central field point. The tool can then be cleaned when the sample is turned in. We use 4-L polyethylene jugs to store water for the day's use in the field. A 20-L pail is needed to collect waste acetone from the cleaning process. Finally, a couple boxes of clean paper wipes (Kimwipes or Techwipes) are handy for wiping down the CMIST tool.

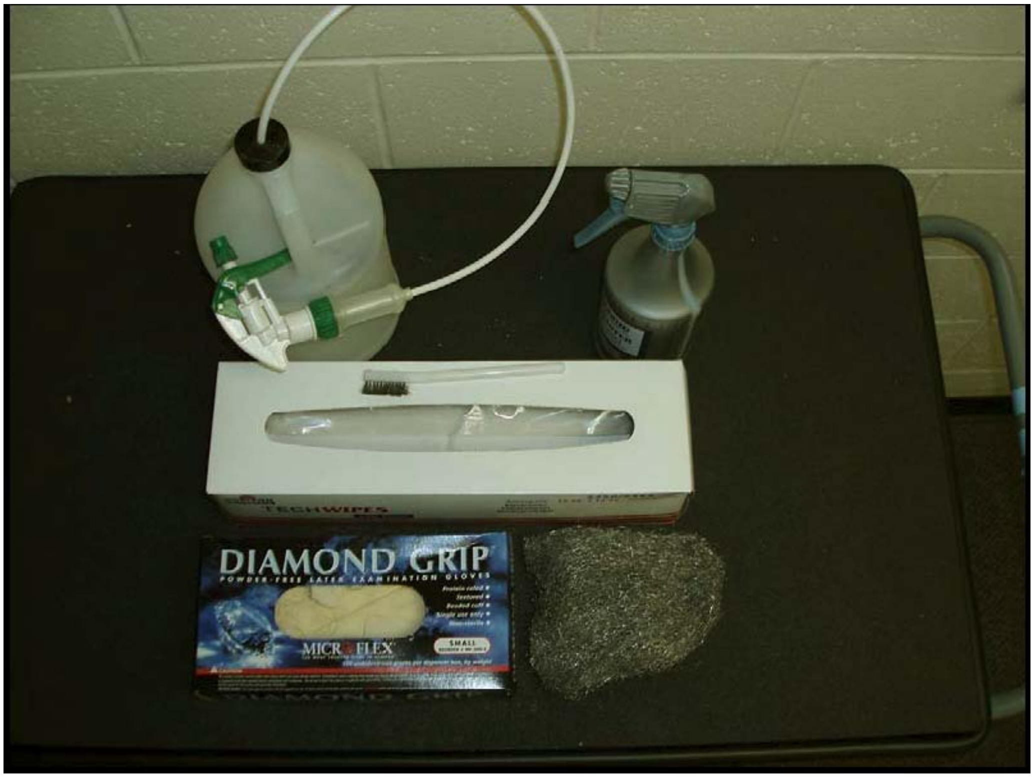

Figure 3. Some cleaning supplies and equipment for the CMIST.

3 Setting Up the CMIST

Setting up the CMIST is quite easy. First, the coring bit must be selected. This is determined in large part by the number of increments to be taken per sample or the depth of the increments. A good rule-of-thumb is to collect enough mass to end up with a 1- and 2-kg sample. To determine the correct core diameter, work backwards from this as follows:

Note: The first three inputs are predetermined in the sampling plan. In our example, we will use typical values for energetics residues sampling.

- Target mass per sample (M_S): 1.2 kg
- Sampling depth (D_S): 2.5 cm
- Number of increments (n): 40
- Soil density (ρ): 1.6 g/cc (standard soil density per ASCE, a good starting estimate)

The formula for determining the sample mass is:

$$M_S = \rho \, n \, D_S \, \pi \, (Ø/2)^2 \tag{1}$$

where Ø is the coring bit diameter. To solve for Ø, we get:

$$Ø = 2 \, (M_S / n \, \rho \, D_S \pi)^{0.5}$$

$$Ø = 2 \, (1200/(40*1.6*2.5*\pi)^{0.5}$$

For our example, the best choice of core diameter is 3 cm, which will produce a sample mass of slightly less than 1.2 kg. This is the theoretical result. Vegetation, differences in density of the soil, moisture content, and other variables will affect the final mass. In highly vegetated areas, we sometimes set the depth of the sample a little deeper to obtain a sample mass closer to that desired. We have developed several Microsoft Excel spreadsheets to assist in setting the sampling parameters and thus assist in setting up the sampling tool. An example is in Appendix B.

With a sampling depth and core diameter in hand, we now need to configure the tool. First, assemble the 3-cm-diameter disk to the threaded rod of the depth-control mechanism (Figure 4). Thread the disk onto the rod until the end of the rod is even with the bottom of the disk. Run the flange nut down to the disk, and tighten with the slip-joint pliers and an open-end wrench. With the disk in place and secured, install the coring bit to the base. Tighten with the pliers.

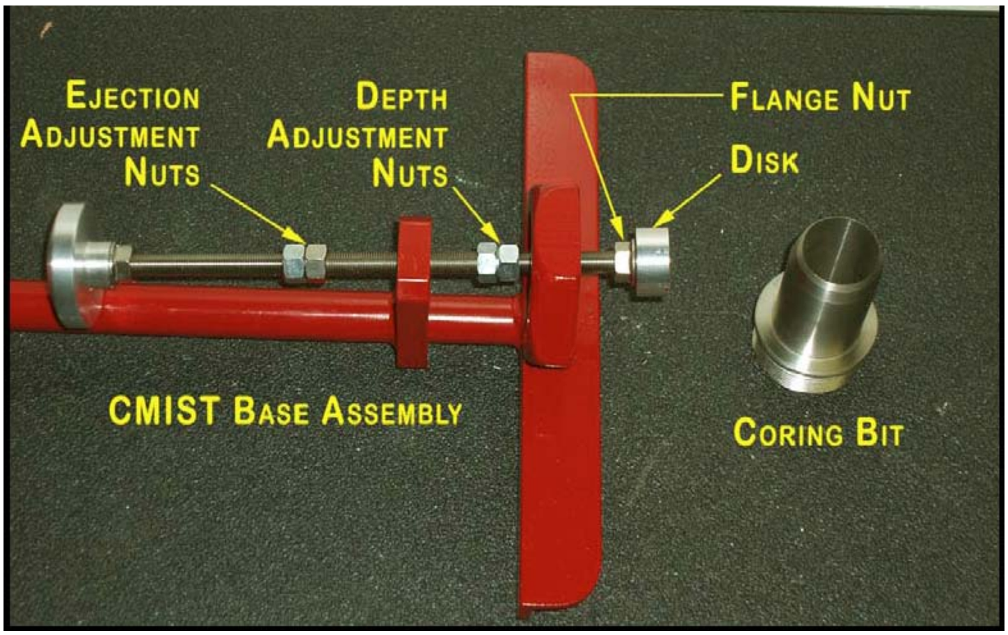

Figure 4. The depth control mechanism.

With the bit in place, pull the disk as far into the bit as possible and measure with the tape. Using your fingers, back the depth adjustment nuts off the depth mechanism guide block until the correct depth (2.5 cm in our example) is achieved. Tighten the nuts against each other to lock them in place (Figure 5). If you need to fine-tune increment depth, loosen the nuts, readjust the depth setting, and retighten the nuts. Always make sure the nuts are locked against each other because these control the consistency of the sample plug length.

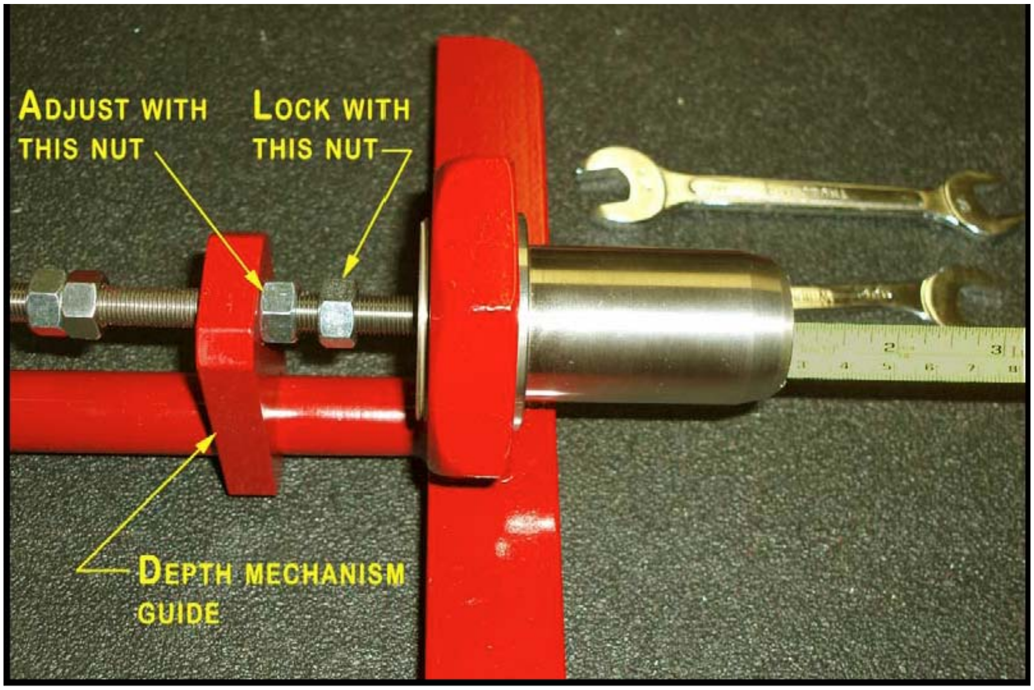

Figure 5. Setting the stop for sample depth.

To adjust the disk position for increment ejection, push face of the disk all the way to the coring bit tip. Run the nuts up to the guide and tighten them against each other to lock them in place. The disk should be flush or a little recessed into the end of the bit (Figure 6). Maladjustment of the disk position will result in an overhanging disk. This will catch on the coring bit tip when taking a sample increment, damaging the disk and tip, and preventing the tip from penetrating the ground. The ejection setting should not have to be readjusted if the depth is changed. This setting will only need to be changed if a different length coring bit is installed.

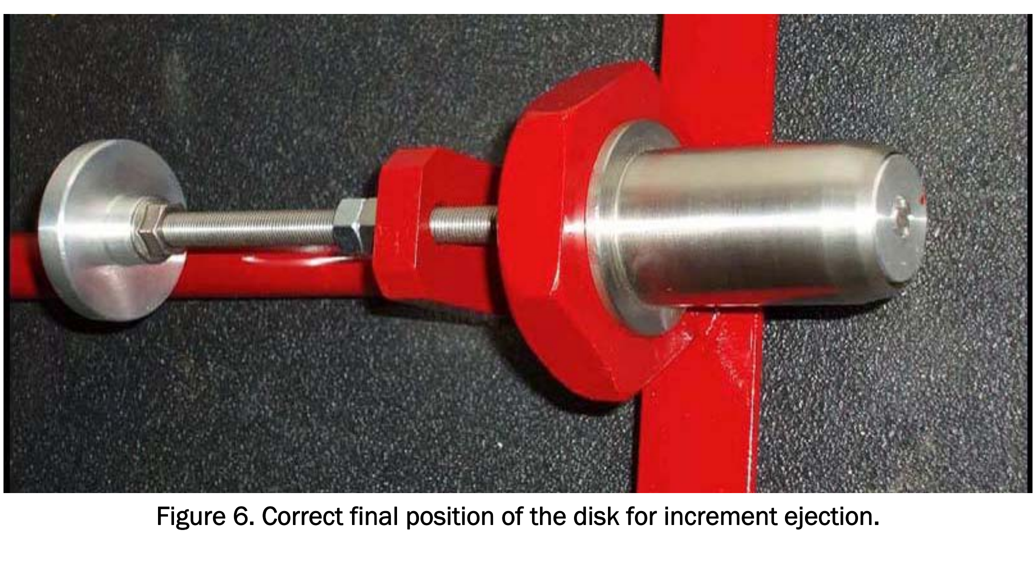

Figure 6. Correct final position of the disk for increment ejection.

4 Use of the Tool in the Field

The CMIST sampler is best used in soils that are cohesive but not hard-packed. We have used the tool in non-cohesive soils that are sandy or gravelly with large cobbles, but the increment mass was consistent and the large cobbles took a toll on the tip of the coring bits. The tool can also be used in hard pack. However, the sampling technician needs to have some mass to drive the bit into the ground, and a dead-blow hammer should be used to eject the increment to prevent hand injuries.

We have found that a two-person team is most efficient when obtaining a sample (Figure 7). One person keeps track of the position within the DU, paces out the distance to each sample increment point, and collects the increment. The second person holds the sample bag and keeps track of the number of increments taken; a handheld counter substantially helps with the latter process. To take an increment, set the tip of the corer at the desired location, step on the footrest to force the tip into the soil, push until progress stops, tip and pull the tool out of the soil, and now push on the plunger to eject the soil plug into the sample bag. The depth mechanism can either face you or be away from you. After some use, you will find which way is most comfortable. Do not spear the tip into the ground. This tends to damage the tip if stones are present. Furthermore, the increment location need not be precisely at a grid point. If a large cobble or root is at your sample point, take the sample increment from a point as near to that point as you can.

The presence of vegetation is not a serious deterrent to the use of the CMIST. It easily cuts through grass and small roots. In many cases, it is important to include this matter with the sample because many contaminant particles reside on the ground surface and can be lost if moss or other vegetative matter is removed or discarded. In brushy areas, the tool can reach into areas that would be difficult to sample otherwise. In a desert environment where the soils were non-cohesive, the tool allowed sampling around and under cacti, areas that could not otherwise be sampled. With some practice, the samplers obtained consistent samples by using a scooping motion when taking the sample increment.

Figure 7. Sampling team using the CMIST.

Splitting the core plug while in the field can be done to compare surface analyte levels to those directly below. For example, to compare energetics residues levels in the top 2.5 cm with those in the 2.5-cm layer just below, we set the coring depth to 5 cm. After obtaining the plug, we ejected it from the CMIST into a gloved hand and split it with a putty knife. We found it useful to mark the end of the putty knife with a felt marker to the length of one of the sections of the plug. The bag person then deposited each of the two plug sections in their respective sample bags.

5 Cleaning the Tool

We recommend cleaning the tool with water between repetitions in the same DU, especially in areas with very cohesive soils. Keep an eye on the adjustment nuts to ensure that no soils are packing around them and affecting the operation of the depth mechanism. Soil and vegetation will sometimes also build up around and behind the disk, causing the depth mechanism to be harder to operate.

To quickly clean the tool, simply spray down the unit wherever soil has adhered. If the soil remains, loosen it by using the steel wool pad or brush. Check the threads on the depth mechanism and clean them with the brush and water as well. It is important to check the adjustment nuts and disk at this time to ensure they are still well secured. A final rinse with clean water should be done as a final step. Cleaning of the tool generally takes less than a minute and can be conducted while your partner is labeling the sample.

At minimum, a thorough cleaning of the tool should be done when changing DUs. Repeat the process as outlined above, except use acetone for the final rinse. Do the final rinse over a pail to contain the acetone. Very little acetone is required for this operation, but it still is best to consider it a hazardous waste and thus it should be controlled. A plastic bottle with a screw top should be used for the collection and transport of the waste acetone at the end of the day. Always do a thorough cleaning before storing the tool. A little lubricating oil on the threaded rod will help to preserve the operation of the depth mechanism.

6 Maintenance

A well-maintained tool is an efficient tool. This may seem an obvious statement, but maintenance is often not at the forefront of concerns in the hectic field environment (Figure 8). Maintaining the CMIST is quick, simple, and well worth the effort; time spent will be paid back in the ease and efficiency of use.

While sampling, make sure the adjustment nuts and depth adjustment mechanism disk do not loosen. Their status may not need to be addressed immediately, but be aware of them at all times. Soil and vegetation will sometimes also build up around and behind the disk, causing the depth mechanism to be hard to operate. Be prepared to address this immediately because it will adversely affect the increment mass and thus the sample quality. Finally, periodically check the tip to make sure it has not been loosened from the mount. The flange of the bit should be tight up against the mount at all times to ensure proper increment depth and to protect the mounting threads.

Figure 8. Field maintenance of the CMIST tool.

After collecting a multi-increment sample and cleaning the tool, inspect the tip of the coring bit. If the tip is damaged, and especially if it is bent inward, you will need to straighten it with pliers and re-sharpen the tip with the half-round file. A damaged coring bit can cause the disk to jam, further damaging the unit and resulting in a loss in efficiency. Make sure the tip is tightly secured against the flange before reuse of the tool.

7 Conclusion

The CMIST device was developed by CRREL for sampling soil in areas with non-homogeneous contaminants that are distributed as particles. It has a simple, rugged design that is very easy to use and maintain. It is easily adjusted to fit most sampling requirements. It enables a sampling team to collect consistent sample increments more efficiently than with a hand scoop or spoon. Properly maintained and employed, it will greatly facilitate the collection of multi-increment samples in many types of soils and through many types of vegetation.

Appendix A: Equipment and Supplies List

Table A1 lists tools, equipment, and supplies that we at CRREL have found to be helpful in taking multi-increment samples using the CMIST tool. This list also includes some sample collection items not covered in the body of this report. Items listed in bold type are considered essential.

Table A1. Tools, equipment, and supplies for multi-increment sampling with the CMIST tool. Items in boldface type are the minimum recommended.

Item Description	Qty*	Purpose	Source/Part Number**
Sampling Tools			
Coring tools		*Obtain soil sample increments*	
Coring tool	1		CRREL or GPL Labs, LLLP
2-cm-diameter coring bit	1[†]		
3-cm-diameter coring bit	2[†]		
4-cm-diameter coring bit	1[†]		
Support tools and equipment		*Adjust and repair coring*	
Wrench, 9/16-in.	2	Adjust lock-nuts	M-C #5400A18
File: metal, half-round	1	Sharpen ID of coring bit	M-C #6073A11
Hammer: dead-blow 1 lb.	1	Eject stuck core	M-C #6051A31
Pliers: slip-joint, 2.25-in.	1	Install coring bits	M-C #5368A14
Pin: 5/16- x 1.25-in.	1	Spare connecting pin	M-C #93750A402
Tool: multi-purpose	1	Handy for many tasks	(e.g., Leatherman)
Nuts: hex, 3/8-in.–24SS	4	Replacements	
Nuts: flange, serrated, 3/8-in.–24SS	2	Replacements	
Tape measure: metric, 3-m	2		M-C #68025A55
Splitting tools		*Used to subsample cores*	
Putty knife (modified)	1	Sharpen one edge, tooth the other	M-C #3658A13
Putty knife	1		M-C #3658A31
Scoops		*Used where corers do not work*	
Stainless #2	2		AMS #428.02 or #427.82
Cleaning Equipment and Supplies			
Equipment		*Durables*	
Stainless steel pads	6		M-C #7364T75
Brush: parts-cleaning	1		M-C #7448T67
Bottle: spray, 16-oz (0.47 L)	1	For acetone	M-C #9864T52
Bottle: spray, 4-L	2	For water	M-C #9864T15
OR **Sprayer: compression**	1	For water	M-C # 9864T15
Bottle: HDPE, 4-L	2	Extra water storage	M-C # 7528T36
Pail: 20-L, w/cover	1	Field waste storage	

Item Description		Qty*	Purpose	Source/Part Number**
Supplies			*Disposables*	
	Kimwipes or Techwipes	2		M-C # 7036T12
	Acetone	6	0.5–1 L should work	
Sample Collection Materials				
Decision unit demarcation			*Marking area to be sampled*	
	Flagging, PVC stake	24	Color, qty., size discretionary	FSI # 33702
	Wrench: Allen, T-handle,	2	Setting pin flags in hard soil	M-C # 5374A55
	Stake: survey, 4-ft	6	Marking corners and active lanes	
	Tape measure: 30-m	2	Lay out DU	FSI # 39941
	Tape measure: 8-m	2		FSI # 39415
	Rangefinder: Nikon 1200 7 x 35	1	11–1200 yd	Eagle Optic # RAN-NK-8358
	Flagging: roll, pink	2	Marking avoidance items	FSI # 57905
Collection			*For field samples*	
	Bags: clean, PE, 15- x 15-in., 6 mil	100	EPA Level 100 clean	KNF # 300010-02 (LB 106:1515)
OR	**Bags: clean, PE, 17- x 12-in., 6-mil**	100		KNF #300010-02 (LB 106:1217)
	Ty-wraps: black, SS tongue	200	For bags and tags	M-C #6614K54
	Tags: 2.5- x 5-in. self-laminating	120		Brimar (Ref. CRREL Invoice #96886)
	Counter: handheld, push-button	2	Keeping track of increments	M-C #1707T5
Personnel Protective Equipment			*Visibility and worker protection*	
	Gloves: latex, diamond-grip	20	Hand protection (sized M, L, XL)	C-P # EW-86231-31, 32, or 33
	Vest for each surveyor		High-visibility orange	
	Site-specific items (masks, etc.)		Depends on operation area	
Documentation				
	Book: recording, level	2	Field sample logging and notes	FSI #49496 (Rite-in-the-Rain)
	Marker: black, fine-point, permanent	6	Marking bags and tags	(Sharpie)
	Marker: black, X-fine point	6	Field book and tags	
Other				
	Container: storage, lockable	2	To carry kit	(Rubbermaid Action- Packer, 24-gal)
	Locks: keyed-alike	4	To lock the storage boxes	M-C #1834A36
	Water bottles		For personal use	

*Quantities shown are recommended for each tool.
**Sources: M-C is McMaster-Carr (www.mcmaster.com); AMS is Art's Mfg. & Supply Inc. (ams-samplers.com); FSI is Forestry Suppliers, Inc. (www.forestry-suppliers.com); KNF is KNF Clean Room Products Corp. (www.knfcorporation.com); Bi is Brimar Industries Inc. (www.brimar.com); C-P is Cole-Parmer Inc. (Cole-Parmer.com); GPL is GPL Laboratories, LLLP (gplab.com). Items where vendor is not given are locally available.
† Size and number depends on task; bring spares of commonly used tips.

Appendix B: Sample Coring Device Set-Up Sheet

Table B1 is an example of a set-up sheet for configuring a CMIST tool to obtain a multi-increment sample with a target sample mass (g) and number of increments. In highly vegetated decision units, the core depth should be set deeper to compensate for the vegetation.

The table is set up with the following notations:

- The core depth is set and is the same over all.
- Soil density is fixed.
- Results give the rounded number of sample increments to reach a given mass (g) in the field for a given core diameter.

The target mass is 1,000 g and that column is highlighted.

Table B1. CMIST tool set-up sheet for multi-increment sampling.

Soil Density (g/cc): 1.4 Core Depth (cm): 2.5					
Corer Diameter (cm)	Number of increments to reach given mass (g)				
	500	750	1000	1500	2000
2.0	45	68	91	136	182
3.0	20	30	40	61	81
4.0	11	17	23	34	45
Soil Density (g/cc): 1.5 Core Depth (cm): 2.5					
Corer Diameter (cm)	Number of increments to reach given mass (g)				
	500	750	1000	1500	2000
2.0	42	64	85	127	170
3.0	19	28	38	57	75
4.0	11	16	21	32	42

Soil Density (g/cc): 1.6 Core Depth (cm): 2.5					
Corer Diameter (cm)	Number of increments to reach given mass (g)				
	500	750	1000	1500	2000
2.0	40	60	80	119	159
3.0	18	27	35	53	71
4.0	10	15	20	30	40

Soil Density (g/cc): 1.7 Core Depth (cm): 2.5					
Corer Diameter (cm)	Number of increments to reach given mass (g)				
	500	750	1000	1500	2000
2.0	37	56	75	112	150
3.0	17	25	33	50	67
4.0	9	14	19	28	37

Soil Density (g/cc): 1.8 Core Depth (cm): 2.5					
Corer Diameter (cm)	Number of increments to reach given mass (g)				
	500	750	1000	1500	2000
2.0	35	53	71	106	141
3.0	16	24	31	47	63
4.0	9	13	18	27	35

Soil Density (g/cc): 2.0 Core Depth (cm): 2.5					
Corer Diameter (cm)	Number of increments to reach given mass (g)				
	500	750	1000	1500	2000
2.0	32	48	64	95	127
3.0	14	21	28	42	57
4.0	8	12	16	24	32

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
June 2009	FINAL	

4. TITLE AND SUBTITLE
User's Manual for the CRREL Multi-Increment Sampling Tool

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT

6. AUTHOR(S)
Michael R. Walsh

5d. PROJECT NUMBER
ER-1481

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Research and Development Center (ERDC)
Cold Regional Research and Engineering Laboratory (CRREL)
72 Lyme Road
Hanover, NH 03755-1290

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CRREL SR-09-1

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Strategic Environmental Research and
Development Program/ Environmental Security
Technology Certification Program
901 N. Stuart St, Suite 303
ARLINGTON VA 22203

10. SPONSOR/MONITOR'S ACRONYM(S)
SERDP/ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The CRREL Multi-Increment Sampling Tool (CMIST) was developed to facilitate collecting multi-increment soil samples. The design is simple yet flexible, enabling the investigator to configure the tool to meet the collection needs of the sampling plan. This manual describes the tool, how to use the tool, and how to maintain the tool in the field.

15. SUBJECT TERMS
Multi-increment sampling; sampling design; sampling tools; soil samples

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (include area code)
Unclassified	Unclassified	Unclassified		29	