John Meade TestAmerica

Soil Sampling the "ISM" Way

Explaining the use of Incremental Sampling Methodology to overcome soils sampling challenges.

BY BRENT SCHNEIDER AND SHAKIB BAYANZAY

Conventional soil sampling and sample preparation methodologies can be inadequate in addressing the level of contaminant heterogeneity in both residential and industrial sites. The Escambia County (Florida) Waste Services Department (ECWSD) assessed the utility of multi-increment sampling versus traditional grab/discrete sampling and found that it yielded reproducible and more representative soil characterization than the conventional grab sampling methods.

When sampling soil at potentially contaminated sites, the goal is to collect representative samples that will lead to quality decisions. Unfortunately, traditional soil sampling methods often lack clear environmental objectives as the result of poor spatial coverage of the targeted area for exploration and insufficient sample density. Additionally, randomly selected samples or aliquots prepared by the laboratory do not necessarily represent the actual field conditions. Incremental Sampling Methodology (ISM) can help overcome these soil sampling challenges. The main objective of ISM is to obtain a single sample for analysis that has the mean analyte concentration

representative of the sample area. This is achieved by employing structured sampling procedures and processing protocol that reduces data variability and increases sample representativeness.

Site Background

The Perdido Landfill in Escambia County has accepted Class I and III waste since 1981. From 1981 to 1989, Class I waste was disposed in 45 acres of unlined landfill cells using the trench and fill disposal method. Subsequently, lined cells were constructed in Sections 1, 2A, 2B, 3A, 3C, and 4, which are contiguous to the unlined landfill area. From 2009 to 2011, approximately 500,000 cubic yards of waste materials and cover soil were mined from 17 acres of the unlined cells. The excavated waste was typically screened to recover soil-like material for use as a daily cover for the active landfilling operation onsite with the screened waste deposited in the active cell. The Section 5 cell was designed and permitted as a lined Class I landfill to be built within the previously mined area. Per design criteria, a depth of approximately 12 feet of native soil was to be excavated to achieve the proposed bottom liner grades for the new 15-acre cell expansion and accommodate additional valuable waste airspace.

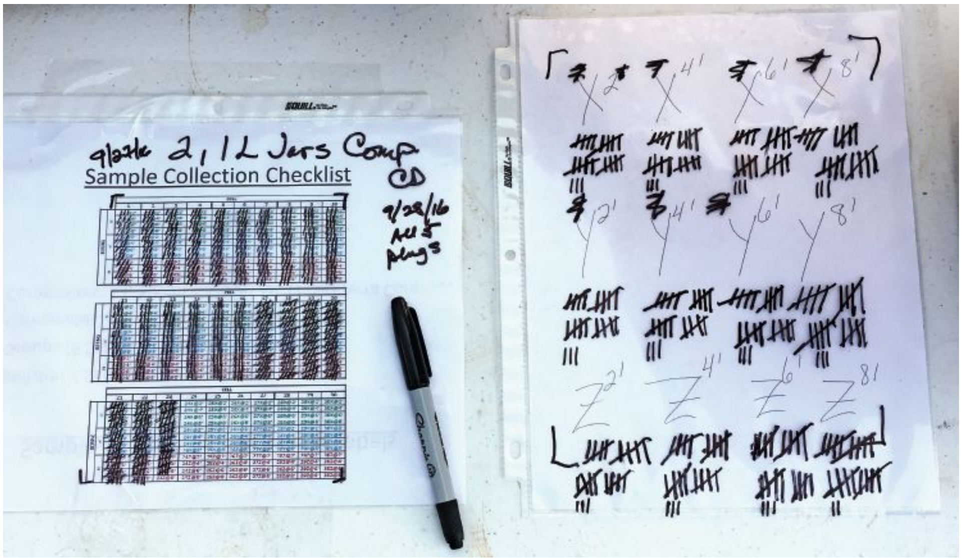
Overview

Soil sampling and analysis was required by permit to adequately determine the horizontal and vertical extent and magnitude of the previously identified contamination in the native soils, and thus provide options for proper disposal of the excavated soil from the subject area. A discrete soil sampling plan had previously been permitted for the expansion site by the Florida Department of Environmental Protection (FDEP). However, upon further review of the permitted plan, it was determined that it would not adequately characterize subsurface conditions at the subject site. ECWSD presented to FDEP the merits of ISM, and the process appeared to be an ideal approach in this case as compared to more traditional discrete sampling methodologies. FDEP thoroughly reviewed and approved the ISM protocol. The proposed

Photos: John Meade

Top: Extracting samples
Below: Recording results
Opposite page: Low-tech data collection

advantages of ISM over discrete sampling included more justifiable results, greater reliability in an estimate of the mean, greater representativeness and less rigorous laboratory analysis, which offered the potential for cost savings. A report published by the Interstate Technology and Regulatory Council (ITRC) in 2012, titled "Technical and Regulatory Guidance, Incremental Sampling Methodology," details many of these advantages.



Using the ITRC report as guidance and in collaboration with an analytical laboratory, consultants, and FDEP, ECWSD developed a very thorough sampling and analysis plan. Much effort was spent on defining Quality Assurance (QA) and Quality Control (QC) measures to be implemented throughout the sampling event and not just in the laboratory. As part of the QA/QC, the project team rehearsed sampling roles, prepared equipment, and practiced recording documentation prior to the field work.

The pre-sampling planning efforts were crucial for successful completion of the project. During two days of field work the project team effectively sampled, composited, and stored 1,800 aliquots of soil collected from 90 borings across the 15-acre Decision Unit (DU). The DU was uniformly divided into 30 cells or Sampling Units (SU). Each SU consisted of three borings (X, Y, and Z) and each boring was extended 8 feet below surface grade using geoprobe drilling equipment. Soil samples were collected from each boring at 2-, 4-, 6-, and 8-foot increments using Encore and Terra Core samplers. The collected soil samples were then grouped and/or composited in-field, in accordance with the revised permitted work plan and laboratory testing limitations. The soil samples were sent to a state-certified laboratory for analysis. The chemical analyses were tabulated and statistically analyzed. Results demonstrated that the proposed relocation of the

soil from the expansion area to an unlined area is not expected to pose a significant risk to human health via direct exposure or result in violation of the FDEP's groundwater standards.

The implementation of ISM over the discrete sampling approach enabled the ECWSD to better characterize and interpret the 15-acre expansion site as a whole. Although the upfront planning for the field sampling and compositing quality control measures were much more labor-intensive than discrete sampling methodologies, one of the chief incentives was the significant reduction in laboratory analysis, resulting in a savings of more than 50%.

"The adequacy of ISM sample support reduces sampling and laboratory errors," and the ISM strategy improves the reliability of sampling data by reducing data variability.

ISM Implementation and Recommendations

ECWSD learned that the successful implementation of an ISM plan requires a comprehensive systems approach. Although every site is unique, the four key components of ISM are systematic planning, field sample collection, laboratory processing and analysis, and QA/QC. These categories are intended to be general, as they often consist of overlapping steps. "The adequacy of ISM sample support [sample mass] reduces sampling and laboratory errors," and the ISM strategy improves the reliability of sampling data by reducing data variability.

First, one must develop a comprehensive sampling plan to address the goals of the study and the needs for risk assessment. The sampling plan should act as a blueprint for carrying out the ISM. It should define the scope of the field work and laboratory analysis, provide a site layout plan, designate team members and their tasks, and establish a documentation and record-keeping protocol. For example, ECWSD developed a gridded site plan showing the sample area or DU subdivided into SUs. The location of the X, Y, Z boring points were staked and labeled in the field in advance to prevent any confusion or errors by the drillers. Certain samples were time- sensitive, so it was very important to position a centrally located

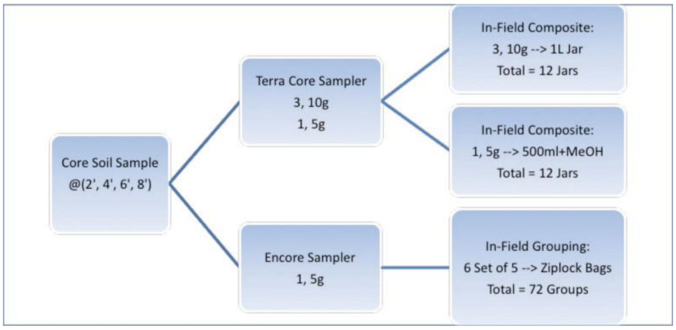


Figure 1. Example Soil Sample Collection Flow Chart

Photos: John Meade

TestAmerica field crew

sample processing and allocation station. The ECWSD sampling plan (excerpt, Figure 1) detailed the process flow that would occur at the field processing and allocation station. Within each cell (1–30) there was an X, Y, and Z boring. At each of these borings there were 2-, 4-, 6-, and 8-foot depth samples. And finally, for each sample there were five aliquots (3 x 10 gram Terra Cores, 1 x 5 gram Terra Core, and 1 x 5 gram Encore) for a total of 1,800 aliquots across the DU to be allocated into various in-field composites or groups. This emphasizes the importance of a comprehensive sampling plan.

The second, and perhaps most intensive ISM step, is the field work. To begin with, the field work should include the layout and labeling of each sampling point in accordance with the sampling plans. The drillers should be well-informed of the boring identifications as well as the transect route across the DU. Project team meetings should be conducted ahead of time to rehearse the soil sampling procedures as well as coordination with the drilling crew. The field organization should consist of collecting and labeling each core sample before exposing it to the atmosphere; this is time-sensitive if samples are to be analyzed for VOCs. Next, part of the sample to be grouped or composited should be collected. (Note that this may be done in the field or the lab.) The field documentation should consist of relevant information such as date, time, moisture, depth, color, texture, soil type, etc. in boring logs for each sampling point. ECWSD established a systematic, assembly line-like method of conducting the field work. At the processing and allocation station each person had a designated task and through repetition the process became very efficient. The layout of the sampling tables, equipment, containers, and even the positioning of the personnel, were optimized to improve the sampling efficiency and accuracy.

The third key component of ISM is the laboratory process and analysis. This requires detailed collaboration with the designated laboratory and the governing regulatory authority. The analysis should include soil characterization results, which will aid in setting the potential management options. In the case of the ECWSD project, the laboratory was heavily involved in all steps of the ISM, especially in the planning phases. The laboratory specified the sampling equipment to be used and provided the field team with the appropriate sampling protocols. The initial planning and training of the field team helped ensure that there were no surprises when the samples arrived at the laboratory for analysis. All samples arrived properly preserved, accompanied with completed chain of custody, labeled, and within appropriate hold times.

QA/QC is inextricably linked to all phases of ISM implementation. At a minimum, QA/QC should consist of a communication plan, checklists, supply list, sketch of the sampling collection station, and a flowchart of the sampling procedure. More specifically, the communication plan should spell out the verbal cues and acknowledgements to be used by members of the project team to ensure proper sampling, compositing, and storage of the samples. Checklists should be used to track a sample from its origination to the proper storage container. An adequate number of supplies and personnel should be prepared in advance. ECWSD employed multiple checklists, which were incorporated into the assembly line. An example is provided as Figure 2. This provided a convenient method for ensuring that appropriate samples were collected and stored.

Figure 2. Soil Sample Collection Checklist

		CELL (SAMPLING UNIT)									
		1	2	3	4	5	6	7	8	9	10
BORING	X	1X@2′	2X@2′	3X@2′	4X@2′	5X@2′	6X@2′	7X@2′	8X@2′	9X@2′	10X@2′
		1X@4′	2X@4′	3X@4′	4X@4′	5X@4′	6X@4′	7X@4′	8X@4′	9X@4′	10X@4′
		1X@6′	2X@6′	3X@6′	4X@6′	5X@6′	6X@6′	7X@6′	8X@6′	9X@6′	10X@6′
		1X@8′	2X@8′	3X@8′	4X@8′	5X@8′	6X@8′	7X@8′	8X@8′	9X@8′	10X@8′
	Y	1Y@2′	2Y@2′	3Y@2′	4Y@2′	5Y@2′	6Y@2′	7Y@2′	8Y@2′	9Y@2′	10Y@2′
		1Y@4′	2Y@4′	3Y@4′	4Y@4′	5Y@4′	6Y@4′	7Y@4′	8Y@4′	9Y@4′	10Y@4′
		1Y@6′	2Y@6′	3Y@6′	4Y@6′	5Y@6′	6Y@6′	7Y@6′	8Y@6′	9Y@6′	10Y@6′
		1Y@8′	2Y@8′	3Y@8′	4Y@8′	5Y@8′	6Y@8′	7Y@8′	8Y@8′	9Y@8′	10Y@8′
	Z	1Z@2′	2Z@2′	3Z@2′	4Z@2′	5Z@2′	6Z@2′	7Z@2′	8Z@2′	9Z@2′	10Z@2′
		1Z@4′	2Z@4′	3Z@4′	4Z@4′	5Z@4′	6Z@4′	7Z@4′	8Z@4′	9Z@4′	10Z@4′
		1Z@6′	2Z@6′	3Z@6′	4Z@6′	5Z@6′	6Z@6′	7Z@6′	8Z@6′	9Z@6′	10Z@6′
		1Z@8′	2Z@8′	3Z@8′	4Z@8′	5Z@8′	6Z@8′	7Z@8′	8Z@8′	9Z@8′	10Z@8′

		CELL (SAMPLING UNIT)									
		11	12	13	14	15	16	17	18	19	20
BORING	X	11X@2′	12X@2′	13X@2′	14X@2′	15X@2′	16X@2′	17X@2′	18X@2′	19X@2′	20X@2′
		11X@4′	12X@4′	13X@4′	14X@4′	15X@4′	16X@4′	17X@4′	18X@4′	19X@4′	20X@4′
		11X@6′	12X@6′	13X@6′	14X@6′	15X@6′	16X@6′	17X@6′	18X@6′	19X@6′	20X@6′
		11X@8′	12X@8′	13X@8′	14X@8′	15X@8′	16X@8′	17X@8′	18X@8′	19X@8′	20X@8′
	Y	11Y@2′	12Y@2′	13Y@2′	14Y@2′	15Y@2′	16Y@2′	17Y@2′	18Y@2′	19Y@2′	20Y@2′
		11Y@4′	12Y@4′	13Y@4′	14Y@4′	15Y@4′	16Y@4′	17Y@4′	18Y@4′	19Y@4′	20Y@4′
		11Y@6′	12Y@6′	13Y@6′	14Y@6′	15Y@6′	16Y@6′	17Y@6′	18Y@6′	19Y@6′	20Y@6′
		11Y@8′	12Y@8′	13Y@8′	14Y@8′	15Y@8′	16Y@8′	17Y@8′	18Y@8′	19Y@8′	20Y@8′
	Z	11Z@2′	12Z@2′	13Z@2′	14Z@2′	15Z@2′	16Z@2′	17Z@2′	18Z@2′	19Z@2′	20Z@2′
		11Z@4′	12Z@4′	13Z@4′	14Z@4′	15Z@4′	16Z@4′	17Z@4′	18Z@4′	19Z@4′	20Z@4′
		11Z@6′	12Z@6′	13Z@6′	14Z@6′	15Z@6′	16Z@6′	17Z@6′	18Z@6′	19Z@6′	20Z@6′
		11Z@8′	12Z@8′	13Z@8′	14Z@8′	15Z@8′	16Z@8′	17Z@8′	18Z@8′	19Z@8′	20Z@8′

		CELL (SAMPLING UNIT)									
		21	22	23	24	25	26	27	28	29	30
BORING	X	21X@2′	22X@2′	23X@2′	24X@2′	25X@2′	26X@2′	27X@2′	28X@2′	29X@2′	30X@2′
		21X@4′	22X@4′	23X@4′	24X@4′	25X@4′	26X@4′	27X@4′	28X@4′	29X@4′	30X@4′
		21X@6′	22X@6′	23X@6′	24X@6′	25X@6′	26X@6′	27X@6′	28X@6′	29X@6′	30X@6′
		21X@8′	22X@8′	23X@8′	24X@8′	25X@8′	26X@8′	27X@8′	28X@8′	29X@8′	30X@8′
	Y	21Y@2′	22Y@2′	23Y@2′	24Y@2′	25Y@2′	26Y@2′	27Y@2′	28Y@2′	29Y@2′	30Y@2′
		21Y@4′	22Y@4′	23Y@4′	24Y@4′	25Y@4′	26Y@4′	27Y@4′	28Y@4′	29Y@4′	30Y@4′
		21Y@6′	22Y@6′	23Y@6′	24Y@6′	25Y@6′	26Y@6′	27Y@6′	28Y@6′	29Y@6′	30Y@6′
		21Y@8′	22Y@8′	23Y@8′	24Y@8′	25Y@8′	26Y@8′	27Y@8′	28Y@8′	29Y@8′	30Y@8′
	Z	21Z@2′	22Z@2′	23Z@2′	24Z@2′	25Z@2′	26Z@2′	27Z@2′	28Z@2′	29Z@2′	30Z@2′
		21Z@4′	22Z@4′	23Z@4′	24Z@4′	25Z@4′	26Z@4′	27Z@4′	28Z@4′	29Z@4′	30Z@4′
		21Z@6′	22Z@6′	23Z@6′	24Z@6′	25Z@6′	26Z@6′	27Z@6′	28Z@6′	29Z@6′	30Z@6′
		21Z@8′	22Z@8′	23Z@8′	24Z@8′	25Z@8′	26Z@8′	27Z@8′	28Z@8′	29Z@8′	30Z@8′

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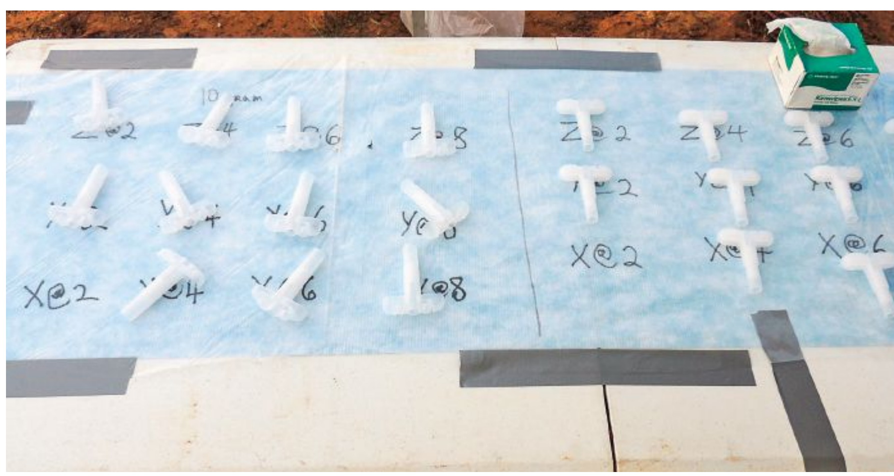

Clockwise from top left: Collecting samples; prepping samples for testing; keeping track of soil samples

For example, the 1X@2' box was checked off when all five of the aliquots (per Figure 1) within Cell 1 at Boring X at the 2-foot depth interval were sampled and stored. This nomenclature was repeated throughout the checklist. In addition, there were several team members dedicated to oversight and QA/QC of the entire operation. In summary, the QA/QC procedure should be designed to not only prevent mistakes, but also to catch them early in the process if they do occur to help ensure that the integrity of the data is maintained.

ISM Advantages

Overall, the advantages of ISM include more accurate data, less chance of extremes in the data population, and lower costs from fewer samples to run. Cost savings are difficult to quantify since there is no standard procedure for determining the number of soil samples to be collected from a defined area. The conventional approach for sample location identification is largely subjective, arbitrary, and dependent upon the stakeholders involved in the project.

Conclusion

For many residential and industrial sites with contamination concerns, cleanup activities can be prohibitively expensive. For many years, discrete sampling methodologies were considered the industry standard for evaluating the need to rehabilitate a site. These traditional sampling methods don't always provide a true representative characterization of the soil profile, especially for a heterogeneous site. The consequences can have a significant and costly impact on citizens, governments, and regulators. ISM is an improved approach to soil sampling that provides a structured system of sampling procedures that reduces data variability and increases sample representativeness.

Currently, ISM is mostly used at commercial/industrial sites, but it can also be employed at residential, ecological, agricultural, and recreational sites. Due to its versatility, ISM can be utilized at sites with a broad range of contaminants, such as explosives, metals, VOCs, pesticides, cyanide, perchlorate, PCBs, Dioxins, and TPH. The successful use of ISM by the Escambia County Waste Services Department is a great example of the growing interest of ISM in the environmental field and increasing acceptance by state and federal regulatory agencies. The lessons learned and recommendations contained herein can be used to continue to build the case for ISM. MSW

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