UN environment

Conducting detailed assessments of contaminated sites

Module 4

Contents

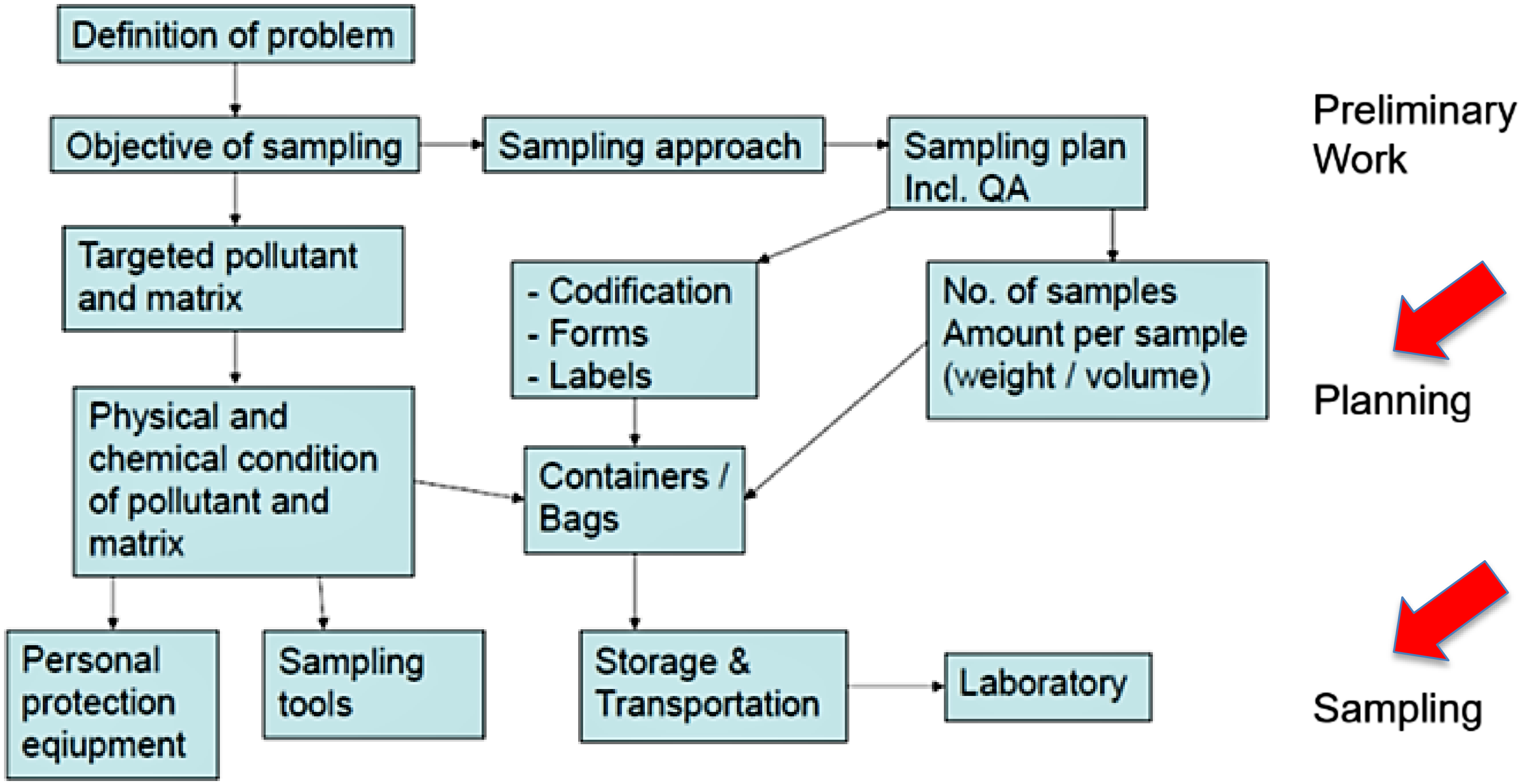
Understand how to plan and conduct detailed contaminated site assessment campaigns, from sample strategy to transport and storage of samples.

Topics

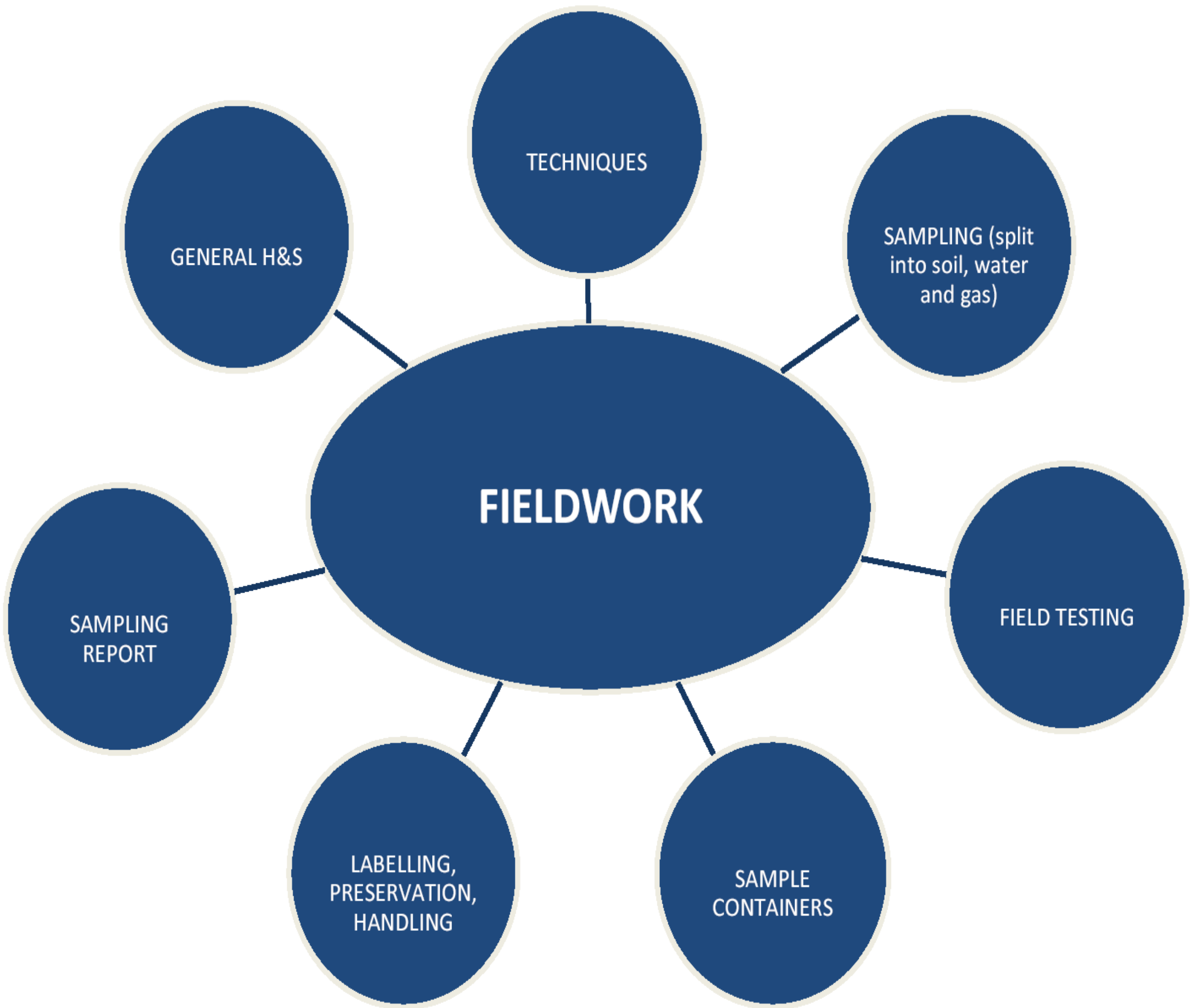
- Phase 2 Assessment Intrusive Sampling
- Sampling Planning Overview (re-visited)
- Sampling Strategy, Efficiency & Design
- Sampling Planning, Codification and Errors
- Sample Number, Methods, Depth
- Preparation for Sampling, Containers
- HSE, Site security and safety
- Chain of Custody
- QA and Laboratory

Sampling Planning Overview… reminder

Most important question:
What is the problem and
what is the objective?

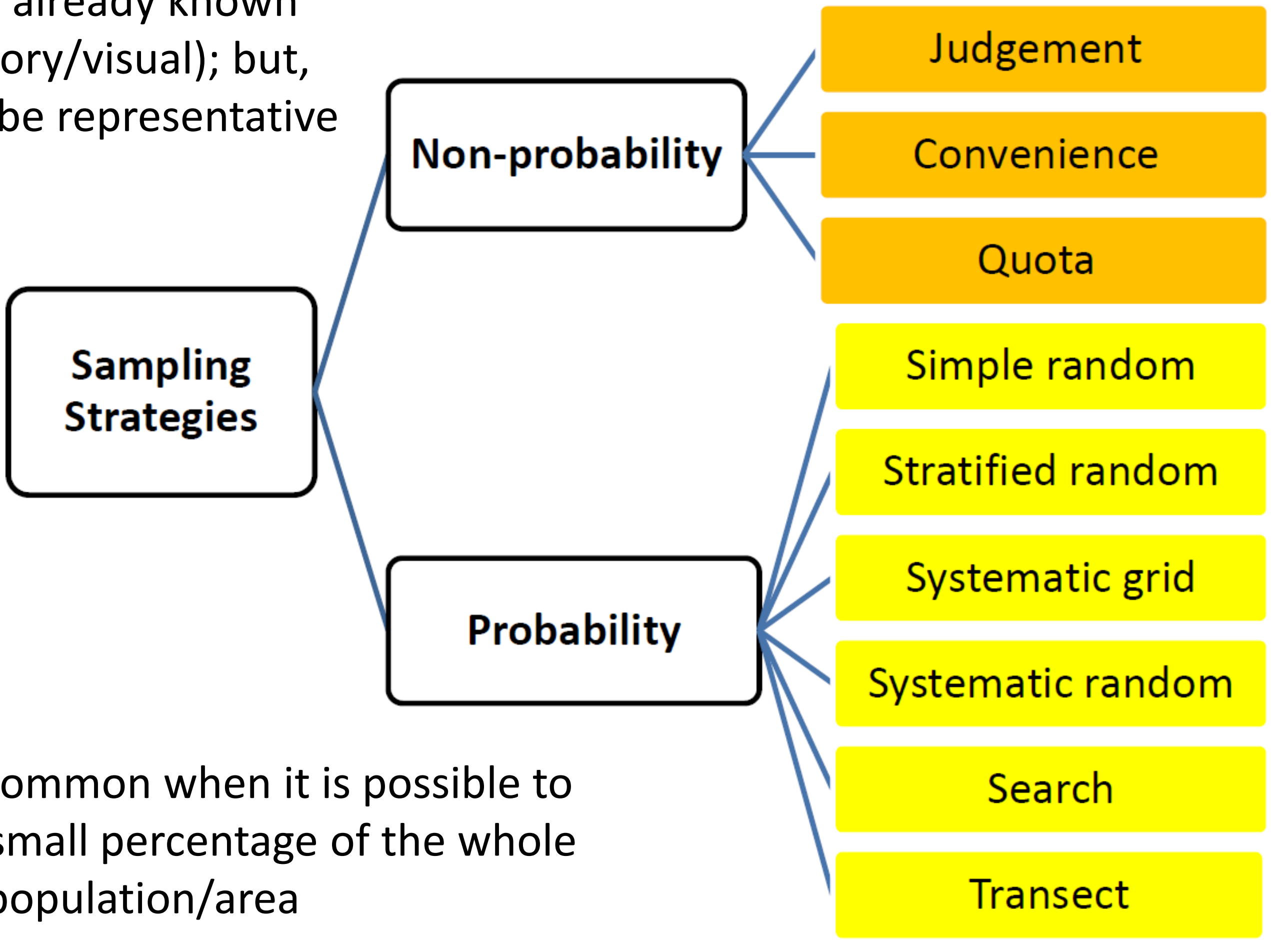


Sample Planning Overview



Sampling Strategy

Non-probabilistic: location of most interesting area already known (judgement/history/visual); but, samples may not be representative



Probabilistic: common when it is possible to sample only a small percentage of the whole population/area

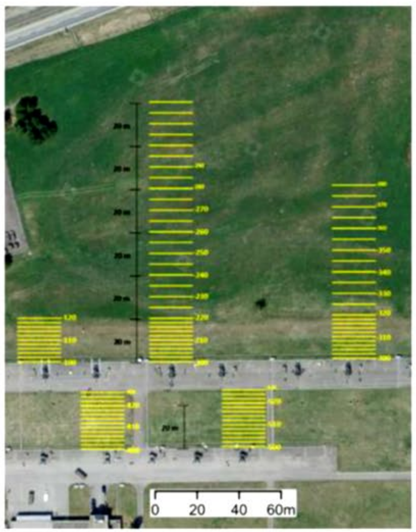
Where to Sample?

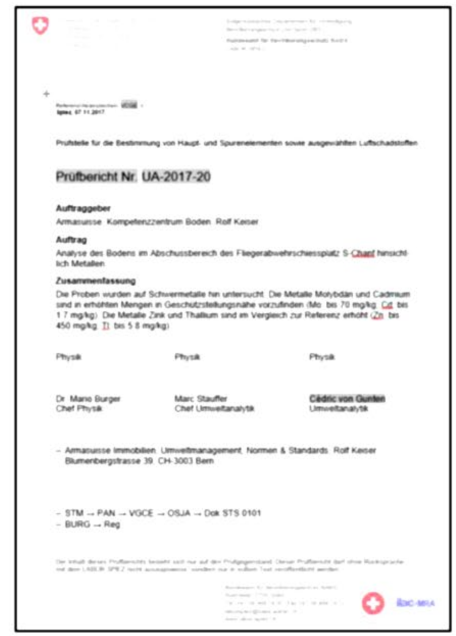
Where to Sample?

Reminder: Overall Objectives of a CSA

Traceability – Representativeness – Trust

Sampling Plan ⟶ Reality ⟶ Laboratory / Report





Spiez, 07.11.2017

Prüfstelle für die Bestimmung von Haupt- und Spurenelementen sowie ausgewählten Luftschadstoffen

Prüfbericht Nr. UA-2017-20

Auftraggeber
Armasuisse, Kompetenzzentrum Boden, Rolf Keiser

Auftrag
Analyse des Bodens im Abschussbereich des Fliegerabwehrschiessplatz S-Chanf hinsichtlich Metallen

Zusammenfassung
Die Proben wurden auf Schwermetalle hin untersucht. Die Metalle Molybdän und Cadmium sind in erhöhten Mengen in Geschützstellungsnähe vorzufinden (Mo: bis 70 mg/kg, Cd: bis 1.7 mg/kg). Die Metalle Zink und Thallium sind im Vergleich zur Referenz erhöht (Zn: bis 450 mg/kg, Tl: bis 5.8 mg/kg).

Physik	Physik	Physik
Dr. Mario Burger Chef Physik	Marc Stauffer Chef Umweltanalytik	Cédric von Gunten Umweltanalytik

– Armasuisse Immobilien, Umweltmanagement, Normen & Standards, Rolf Keiser, Blumenbergstrasse 39, CH-3003 Bern

– STM → PAN → VGCE → OSJA → Dok STS 0101
– BURG → Reg

EPA Sampling Guideline

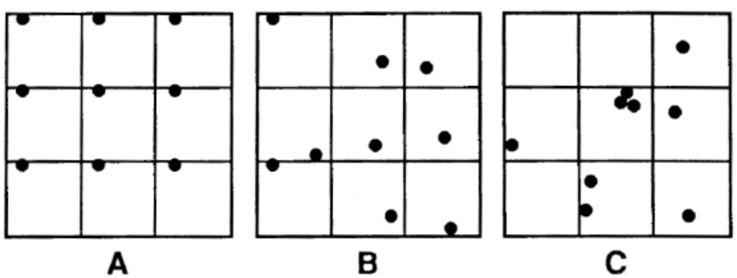
i.e. EPA 6000 series

ISO 17025

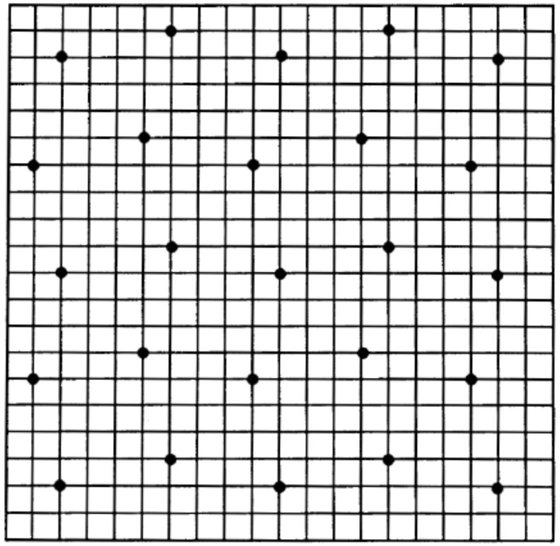
Sampling Efficiency and Designs

Many mathematical theories on optimization of spatial sampling exist. They conclude that efficient sampling design should satisfy four conditions:

1) It should be stratified i.e. the area to be sampled should be partitioned into regular sub-areas;
2) Each stratum (or sub-area) should carry only one sampling unit;
3) It should be systematic;
4) Sampling points should not be aligned.

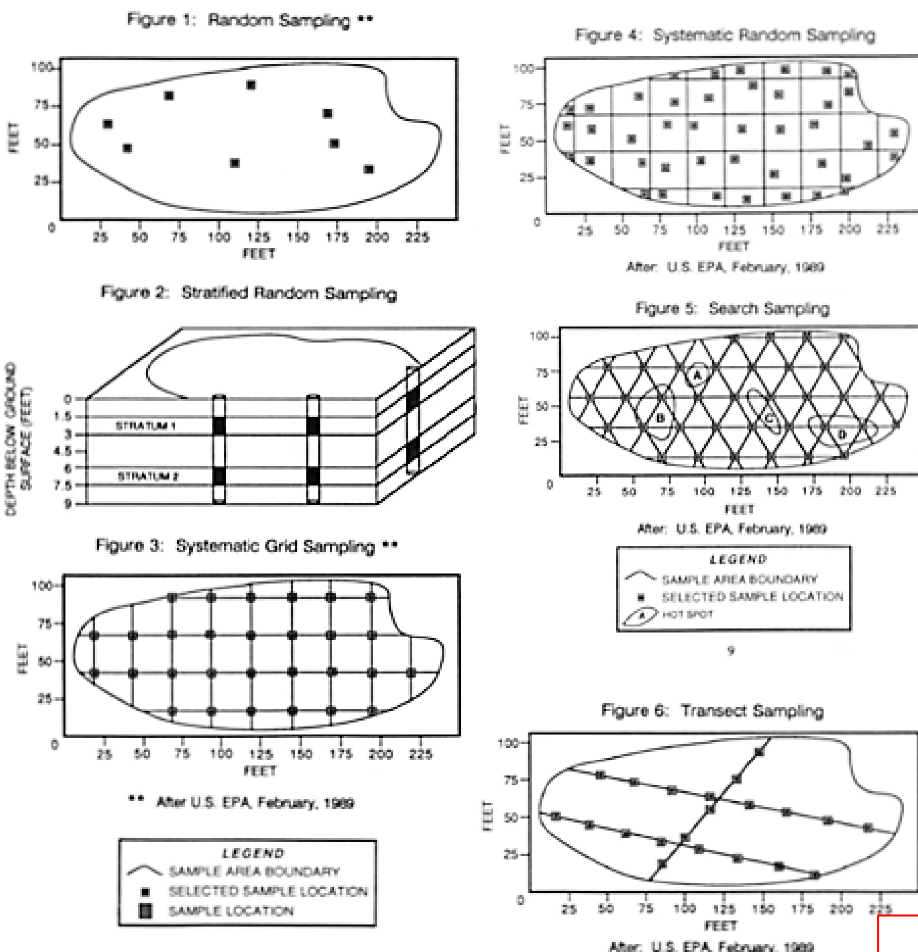


A Systematic grid (or regular square grid)
B Stratified random
C Simple random



Herringbone sampling design

Summary of Sampling Designs



Source: EPA. Removal Program Representative Sampling Guidance : Volume 1: Soil, Interim Final. 1991

Representative Sampling Approach Comparison

SAMPLING OBJECTIVE	SAMPLING APPROACH: JUDGMENTAL	RANDOM	STRATIFIED RANDOM	SYSTEMATIC GRID	SYSTEMATIC RANDOM	SEARCH	TRANSECT
ESTABLISH THREAT	1	4	3	2 [a]	3	3	2
IDENTIFY SOURCES	1	4	2	2 [a]	3	2	3
DELINEATE EXTENT OF CONTAMINATION	4	3	3	1 [b]	1	1	1
EVALUATE TREATMENT AND DISPOSAL OPTIONS	3	3	1	2	2	4	2
CONFIRM CLEANUP	4	1 [c]	3	1 [b]	1	1	1 [d]

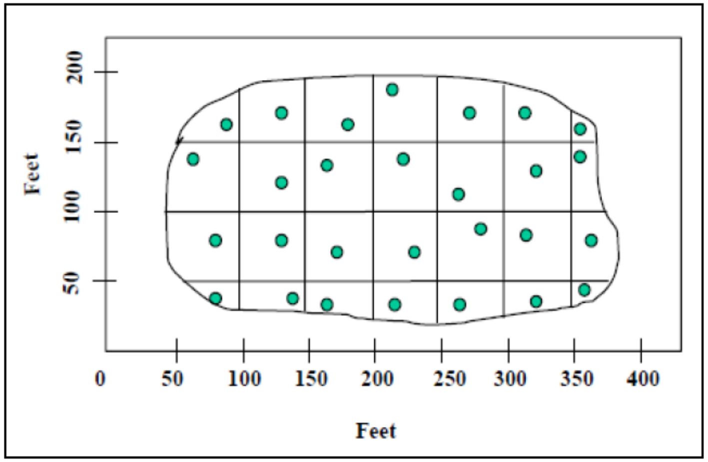
1 -- PREFERRED APPROACH
2 -- ACCEPTABLE APPROACH
3 -- MODERATELY ACCEPTABLE APPROACH
4 -- LEAST ACCEPTABLE APPROACH
a -- SHOULD BE USED WITH FIELD ANALYTICAL SCREENING
b -- PREFERRED ONLY WHERE KNOWN TRENDS ARE PRESENT
c -- ALLOWS FOR STATISTICAL SUPPORT OF CLEANUP VERIFICATION IF SAMPLING OVER ENTIRE SITE
d -- MAY BE EFFECTIVE WITH COMPOSITING TECHNIQUE IF SITE IS PRESUMED TO BE CLE AN

Systematic Grid and Random Sampling are probably the most used

Sampling Strategy: Systematic Random

i) Areas of 10 m^2, 16-25 punctures -> approx. 1 kg of sample
ii) Lines of max 20 m, 16-25 pu n ctures -> approx. 1 kg of sample

- It is probably the most commonly used method for field sampling
- Random sampling within subdivided smaller areas (square, rectangular or triangular grids) of the original area
- Small number of samples and small time expenditure
- Even distribution of sampling sites
- Number of samples proportional to area
- Inappropriate grid size can cause systematic errors



Objectives of Sampling

The challenge to achieving a 95% statistical chance of locating an area of contamination within a reasonable budget. The more samples to examine, the higher the cost.

Wilson & Stevens (1981) report that the compromise between statistical desirability and financial acceptability generally accepted for assessing chemical contamination in disused gaswork sites were spacings of 20–50 m, with a 25 m grid being fairly common. Based substantially on this, the British Standards Institute (1988) suggests the minimum number of sampling points should be:

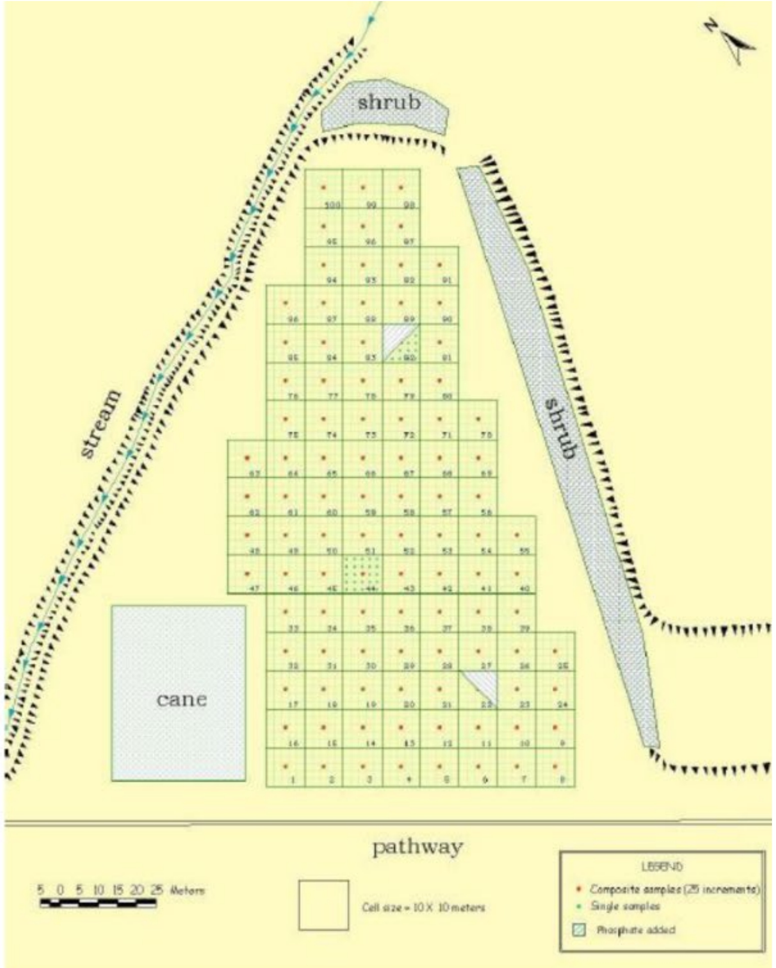
- 15 for 0.5 hectares = 18 m grids
- 25 for 1 hectare = 20 m grids
- 85 for 5 hectares = 24 m grids

In practice, **10 m grids (10x10m) are commonly used**, and most convenient. Within a 10 sqm grid, sampling can comprise **15-25 random cores** (or punctures), combined to generate ca. 1 kg of soil sample, per sample point.

Sources: https://www.ncbi.nlm.nih.gov/books/NBK310480/#_annex7_s7_ and Wilson & Stevens (1981) Problems arising from the redevelopment of gas works and similar sites. AERE Harwell Report R-10366, HMS

Sampling Plan including Codification & QA

- The sampling plan simplifies field and laboratory work
- It includes geo-data and codes which identify each sample
- The sampling plan is the most important quality assurance measure
- It starts the practical process of codification, labelling and field work preparation
- It usually includes a map and a list with all codified samples



Large area (10’000 m^2), subdivided into 100 sub-areas (10x10 m each)

Reducing the Number of Samples

It may be possible to further reduce numbers of samples needed to be taken by:

a) **Thoroughly investigating the site history** to determine where the likely "hot spots" are, and confining the sampling to these. If it is considered that areas of greatest contamination can be pinpointed from the history of the site, it may be acceptable to sample from just that site and to conclude that, if the contaminant is not found here, then the rest of the site can be assumed to have below detectable levels of the contaminant;
b) **Considering the intended uses of the site** and assessing whether contamination would be important (e.g. if the contaminated area will be covered by a hard surface, such as a car park, contamination of the underlying soil may be deemed irrelevant);
c) **Designing the use of the land around its potential contamination** (e.g. siting hard surfaces where contamination is suspected in the ground plan).
d) **Pooling portions of samples drawn separately into composite samples** from which a practical number of subsamples may be taken for testing. In the event of a positive in any of the composites, the individual samples making up that composite would have to re-examined separately.

Always remember: Sampling Errors

Possible "errors" during sample collection:

- Samples are not representative
- Meteorological influences
- Cross contamination

Sampling

Factors that may also influence the representativeness:

- Valid sampling techniques/procedures. Also, in order to compare the results of the studies carried out at sites with different environmental conditions and contaminants, harmonized sampling techniques must be used.
- Sample size
- Selection of appropriate sampling area
- Frequency of sampling
- Temporal and spatial variability of monitored parameter
- ...

Soil Sampling Depth

Decision on depth of sampling depends greatly on type of site. At former industrial sites such as tanneries, etc., contamination would have been largely of a **surface** nature and would only have penetrated at depth through drains.

Initial sampling need only be from the **top 0.25 m**; a decision might be taken to test sediment in drains that are found at a later stage.

At the site of a buried fuel storage tank, it is important to take samples up to **about 2 or 3 m below the surface** (using drilling equipment).

Preparing for Sampling

Things to remember, BEFORE leaving the home base/office:

Device: GPS/digital camera/smartphone

- check battery charged (spares?)
- check date and time correct
- check how to set and save waypoints and tracks
- check how to change coordinate settings/format: UTM/lat-long
- understand the precision/accuracy of GPS reading
- check storage space on device
- check how to use a compass

Have a map of the general area

- ideally 1:25,000 scale, or higher resolution
- or Google Earth print-out at same scale + grid

Correct sample containers (labelled), tools and equipment for sampling (spares)

Storage and refrigeration equipment

Pens/markers, PPE, emergency contact numbers/phones/radio

Preparing the Site for Sampling

Measuring out and setting the markers greatly simplifies later sampling and ensures accuracy in following the **Sampling Plan**

- Labels and forms
- Tools (auger diggers, spades, etc)
- Soil sample bags, containers
- Measuring tape, GPS, camera
- Setting marks, flags, signs

Some sampling tools

Containers: for Soil and Sediment

Amber Glass Jars

ALE210

ALE215

For analysis of: Organics, TPH, PAH, PCBs (pesticides), metals, inorganics/FOC

For analysis of: VOC, GRO, oxygenates, n-hexane, alcohols and acetates, VFA, low level VOC

Conditions in water samples collected

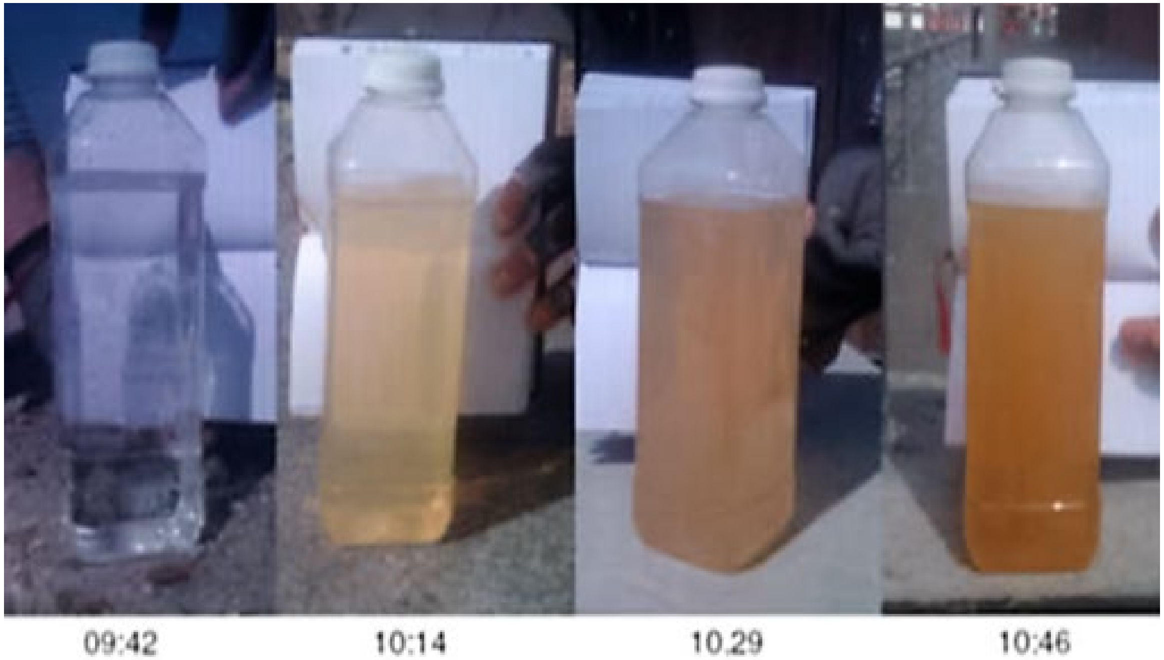
Water is a dynamic system

The following conditions may change:

- Temperature
- Exposure to light
- Oxidation
- Precipitation e.g. of metals
- Interaction with suspended solids
- Carbon dioxide affecting pH
- Interaction with container surfaces
- Microbial content
- pH of sample

Water = A dynamic system

Precipitation of metals in water samples, over ONE hour



Containers for water

Each water sample type needs a special bottle type

Containers for water samples

Each water sample type needs a special bottle type

Many chemical samples need to be stored in appropriate bottles, some laced with fixing agents or additives e.g. HCL acid spikes (drops).

Sample analyses:

General chemistry (pH, conductivity, turbidity): 1 litre clear plastic bottle

Metals: 1 litre clear plastic bottle or plastic zip-lock bag (for wet mud)

Sulphides: 25 ml clear glass bottle (with additive)

PAH: 500 ml glass container (with additive)

Pesticides: 1 litre amber glass PTFE lined screw cap or 1 litre plastic bottle (with additive)

Microbial activity: sterile glass bottle (with additive Sodium thiosulphate - used to neutralise the effect of any residual chlorine in sample and fix the sample)

Note: a certified **analytical laboratory** supplies the correct containers (with additives where necessary) for each type of analysis.

Sampling method: labelling samples

Sampling methods: river water

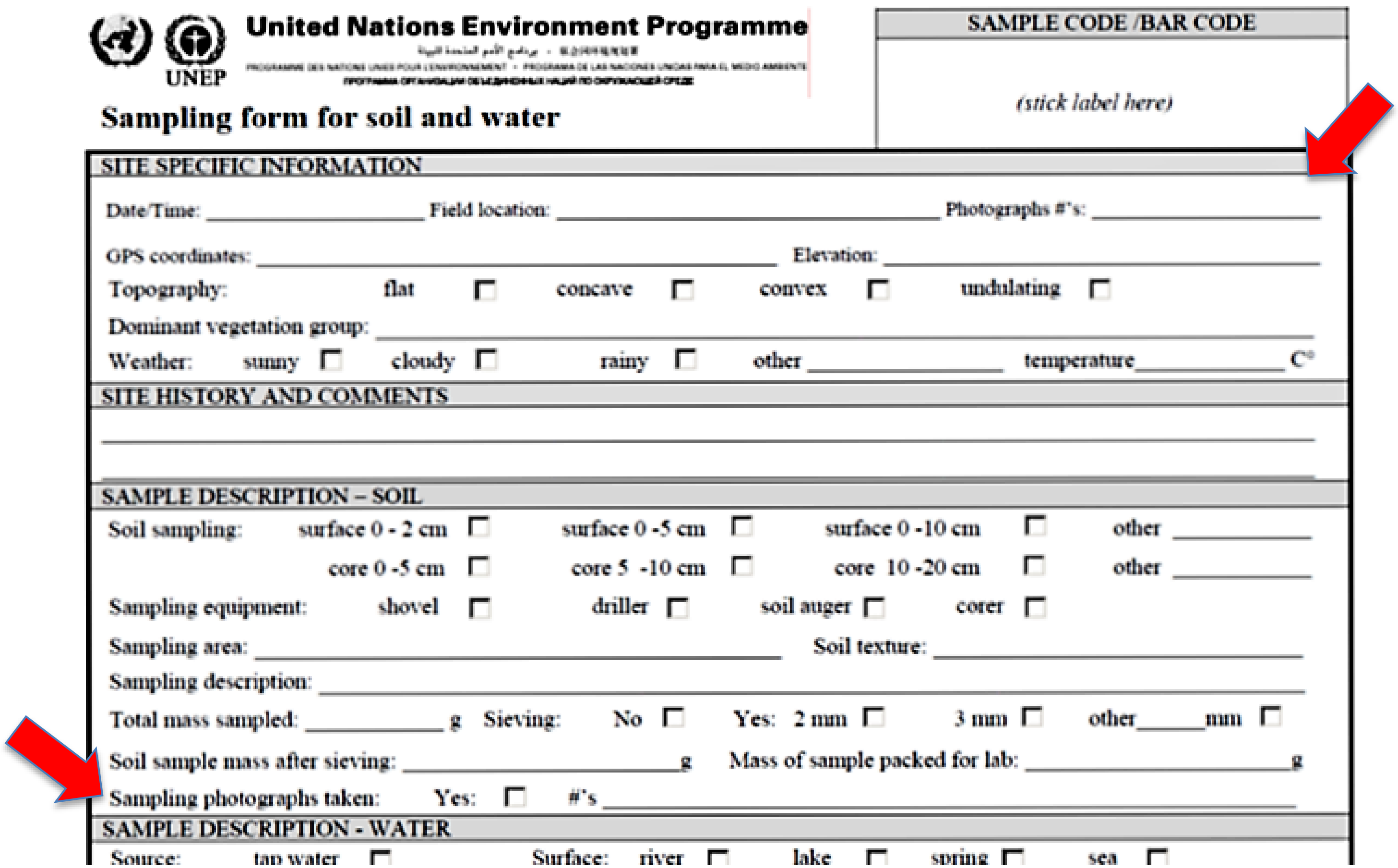
On site data recording: water parameters

Health & Safety and Security

Video: Phase 2 sampling

https://www.bing.com/videos/search?q=PHASE+2+contaminated+site+assessment&&view=detail&mid=E0E0D5774E9E1DE41D53E0E0D5774E9E1DE41D53&&FORM=VRDGAR

Standardized Sampling Form (top section)



United Nations Environment Programme

UNEP

Sampling form for soil and water

SAMPLE CODE /BAR CODE
(stick label here)

SITE SPECIFIC INFORMATION

Date/Time: ____________ Field location: ____________ Photographs #'s: ____________

GPS coordinates: ____________ Elevation: ____________

Topography: flat ☐ concave ☐ convex ☐ undulating ☐

Dominant vegetation group: ____________

Weather: sunny ☐ cloudy ☐ rainy ☐ other ____________ temperature ____________ C°

SITE HISTORY AND COMMENTS

SAMPLE DESCRIPTION – SOIL

Soil sampling: surface 0 - 2 cm ☐ surface 0 -5 cm ☐ surface 0 -10 cm ☐ other ____________

core 0 -5 cm ☐ core 5 -10 cm ☐ core 10 -20 cm ☐ other ____________

Sampling equipment: shovel ☐ driller ☐ soil auger ☐ corer ☐

Sampling area: ____________ Soil texture: ____________

Sampling description: ____________

Total mass sampled: ____________ g Sieving: No ☐ Yes: 2 mm ☐ 3 mm ☐ other_____mm ☐

Soil sample mass after sieving: ____________ g Mass of sample packed for lab: ____________ g

Sampling photographs taken: Yes: ☐ #'s ____________

SAMPLE DESCRIPTION - WATER

Source: tap water ☐ Surface: river ☐ lake ☐ spring ☐ sea ☐

Can also be used as sample-accompanying document, improving QA

Standardized Sampling Form (bottom)

SAMPLE DESCRIPTION - WATER

Source: tap water ☐ well ☐ Surface: river ☐ pond ☐ lake ☐ puddle ☐ spring ☐ other ______ sea ☐

Usage: potable ☐ industrial ☐ recreation ☐ other: ______

Water sampling method from/by: tap ☐ pump ☐ bailer ☐ other ______

Pump intake or bailer set at ______ m below water level

Test data:

pH	[Standard Units]	
Temperature	[°C]	
Conductivity	[S/cm]	
Salinity		
Total dissolved oxygen	[mg O_2/L]	

Filtration: No ☐ Yes: 0.1 µm ☐ 0.2 µm ☐ 0.45 µm ☐ other ______ µm

Filter type: membrane ☐ paper ☐ glass fibre ☐ other ______

Water sample appearance: ______ Oder of water: ______

Water Preservation No ☐ Yes, acidified with ______ ml of conc. HNO_3 other ______

Total mass sampled: ______ g Mass of sample packed for lab ______ g

Sampling bottle: plastic ☐ glass ☐ other: ______

Sampling photographs taken: Yes: ☐ #'s ______

RADIOACTIVITY PARAMETERS

Expected radioactivity level of sample: high ☐ medium ☐ low ☐

Ratemeter: ______ Dose rate measured in sampling area: ______ Sv/h

Surface activity of sample: ______ Sv/h or cps

PACKING AND PRESERVATION

PROBLEMS / COMMENTS

______

______

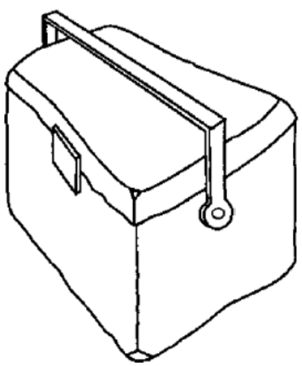
SAMPLING TEAM

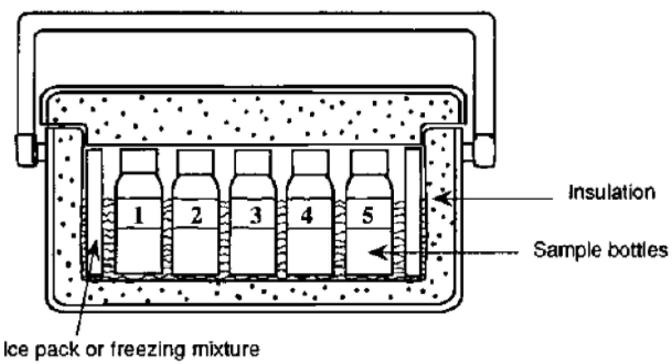
Name: ______

Signature: ______

Transporting Samples

Best practice!





Samples need to be:

- Kept cool 1-8 C
- Dark space
- Safe
- Protected
- Biological samples kept frozen

Chain of custody documentation

Right Solutions · Right Partner

CHAIN OF CUSTODY

Failure to complete all sections of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the terms and conditions as specified on the back of Chain of Custody

Page ____ of ______

REQUIRED PROJECT INFORMATION

- Company name
- Company address
- Project location
- Project reference
- PO Number
- ALS Quote number
- Report turnaround time (TAT) Please cross appropriately
  - ☐ Standard. According to agreement
  - ☐ Express. Required reporting date: ____ (Express fees may apply, contact laboratory for confirmation)

CLIENT CONTACT AND REPORTING INFORMATION

- Project contact name(s)
- Project contact email(s)
- Primary phone
- Secondary phone/contact

SUITE OR NAME OF ANALYSIS

Analysis 1 | Analysis 2 | Analysis 3 | Analysis 4 | Analysis 5 | Analysis 6 | Analysis 7 | Analysis 8 | Analysis 9 | Analysis 10 | Analysis 11 | Analysis 12

LABORATORY INFORMATION

SHIPMENT INFORMATION	ALS Life Sciences Ltd Units 7-8 Hawarden Business park, Manor Road Deeside, CH5 3US, United Kingdom
CONTACT INFORMATION	Phone: 01244 528 777 Email: hawardencustomerservices@alsglobal.com
COURIER INFORMATION	Phone: 0845 900 3800 (UK) XXXXXXXXXXXX (Ireland)

MATRIX CODE CLASSIFICATIONS - WATER		MATRIX CODE - OTHER
Ground Water (GW)	Treated Sewage (TS)	Soils (S)
Surface Water (SW)	Trade Effluent (TE)	Gas (G)
Drinking Water (DW)	Saline Water (SA)	Product (P)
Land Leachate (LE)	Process Water (PR)	Sludge (SL)
Prepared Leachate (PL)	Recreational Water (RE)	Unspecified Solid (UNS)
Untreated Sewage (US)	Unspecified Liquid (UNL)	

REPORTING AND INVOICING (optional)

3rd party invoicing details

SAMPLE IDENTIFICATION	MATRIX code	Depth in metres (top)	Depth in metres (bottom)	AGS sample type	AGS client sample reference	ANALYSIS REQUIRED (please cross appropriately)	SAMPLING AND CONTAINER INFO: Date	Time	Total bottles	REMARKS AND KNOWN HAZARDS

Date samples despatched | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only | For lab use only

Client's signature:	Consignment condition	Received by	Logged by	Laboratory comments
Date samples despatched	Arriving Temperature	Date and time	Date and time	

Essential element in the QA process

QA

QUALITY ASSURANCE

- Follow the Sampling Plan
- Follow the designated walking route to minimize cross-contamination
- ALWAYS take reference samples = “control” samples, with presumably no contamination (also called “upstream” samples)
- Include some duplicates, selected randomly, for QA against the laboratory analysis and sampling handling, to cover 3% of the total amount of samples
- Divide the storage space in the vehicle into “clean” and “dirty” zones
- Complete the Chain of Custody documentation
- Have the samples analysed (where possible) in the order of increasing expected concentrations
- Maintain ALL DOCUMENTATION: sampling forms, photos, GPS data, etc

At the Analytical Laboratory

Remember the objective of sampling:

"To deliver samples to the laboratory that are representative of the original material"

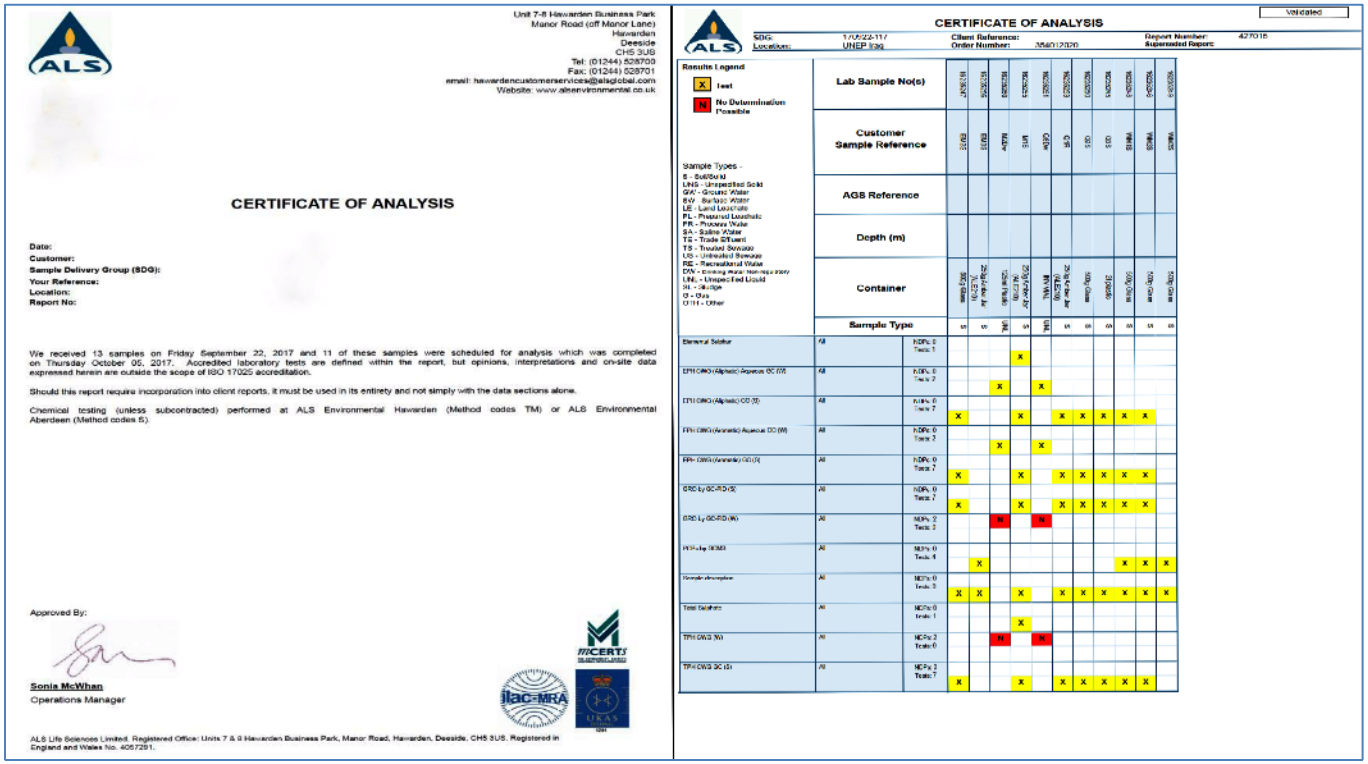
What happens next?

1. Samples arrive
2. Samples are registered
3. Samples are analysed
4. Results are compiled
5. Results are checked

At the Analytical Laboratory

Then what happens?

6. Results & Certificates sent to client
7. Client pays for the analyses
8. JOB DONE!



Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

CERTIFICATE OF ANALYSIS

Date:
Customer:
Sample Delivery Group (SDG):
Your Reference:
Location:
Report No:

We received 13 samples on Friday September 22, 2017 and 11 of these samples were scheduled for analysis which was completed on Thursday October 05, 2017. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

Approved By:

Sonia McWhan
Operations Manager

ALS Life Sciences Limited. Registered Office: Units 7 & 8 Hawarden Business Park, Manor Road, Hawarden, Deeside, CH5 3US. Registered in England and Wales No. 4057291.

Validated

CERTIFICATE OF ANALYSIS

SDG: 170922-117
Location: UNEP Iraq
Client Reference:
Order Number:
Report Number: 427016
Superseded Report:

Results Legend
X Test
N No Determination Possible

Sample Types -
S - Soil/Solid
UNS - Unspecified Solid
GW - Ground Water
SW - Surface Water
LE - Land Leachate
PL - Prepared Leachate
PR - Process Water
SA - Saline Water
TE - Trade Effluent
TS - Treated Sewage
US - Untreated Sewage
RE - Recreational Water
UNL - Unspecified Liquid
SL - Sludge
G - Gas
OTH - Other

Lab Sample No(s)
Customer Sample Reference
AGS Reference
Depth (m)
Container
Sample Type

Key Messages

The Conceptual Site Model provides the first indication of where samples should be taken, with the arrangement of sampling based on a number of criteria.

Sampling should be stratified; each stratum (or sub-area) should carry only one sampling unit; it should be systematic; and sampling points should not be aligned. Systematic random is a typical sampling pattern.

Preparing the site using the correct sampling tools and storage containers for each sample and type of analysis are vital for efficient and high quality surveys.

Quality Assurance (QA) is vital at all stages from sampling in the field, in transport and storage, and sample analysis in the laboratory.

Thank you

UN environment

(Insert the below information if required)
Name of the presenter / division / unit / office
Address / email / contact information
(Maximum 5 lines of text is permitted)
All in Roboto Regular 9pt..