



INTERPOL

ENVIRONMENTAL SECURITY SUB-DIRECTORATE

Pollution Crime Forensic Investigation Manual

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Volume I of II



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A. INTRODUCTION

INTERPOL is the world's largest international police organization, with 190 member countries. Created in 1923, it facilitates cross-border police cooperation, and supports and assists all organizations, authorities and services whose mission is to prevent or combat international crime.

INTERPOL aims to facilitate international police cooperation even where diplomatic relations do not exist between particular countries. Action is taken within the limits of existing laws in different countries and in the spirit of the Universal Declaration of Human Rights. INTERPOL's constitution prohibits 'any intervention or activities of a political, military, religious or racial character'.

B. BACKGROUND AND PURPOSE

Environmental crime is considered a serious crime. Very often it is perpetrated by organized crime and can have an extremely detrimental impact on the planet, biodiversity, the global economy and human life. INTERPOL has identified environmental crime as a growing international crime area.

In 2010, the INTERPOL Environmental Crime Committee proposed a new project on pollution crime forensics, which was adopted during the 7th International Conference on Environmental Crime in Lyon, recognizing the use of forensics as a crucial component of successful environmental prosecutions.

The Committee established a working group to set up and maintain a network of environmental technical and forensic experts, promote the exchange of best practices in environmental forensics with the professional community, condense these into a manual and distribute it through INTERPOL's global channels and training sessions. In 2011, a meeting of 50 representatives from 17 member countries in Lakewood, Colorado USA, established an environmental forensics manual conceptual design. In 2012, a larger meeting in Bangkok ratified the manual design.

The purpose of this manual is to disseminate the basic principles and techniques of environmental forensic inspections and investigations and provide member countries with a technical resource to enhance their environmental crime enforcement programs.

INTERPOL wishes to express its gratitude to the 43 participating countries and their agencies and 16 corporate and non-governmental organizations for their contributions to this manual. Their participation has been an excellent example of how worldwide cooperation can lead to protection of the world's citizens and the environment. See **ACKNOWLEDGEMENTS**

INTERPOL wishes to express a special appreciation to Environment Canada for the use of "The Inspector's Field Sampling Manual" as the

basis for this manual and the extensive contribution of its staff in the overall project design and management for the development of this INTERPOL manual.

C. DISCLAIMER

Best Practices: This manual has been written to provide a baseline of best practices for forensic environmental inspections and legal investigations undertaken by enforcement officers, other public officers and lay samplers (hereinafter referred to as “the investigators”). Techniques and protocols described in this manual are based on a condensation of best practices, but do not necessarily represent official policy of INTERPOL’s member countries. INTERPOL does not require any member country or agency to adopt the procedures, practices or recommendations contained in this manual.

Limitation Of Liability: This manual is provided for information and training purposes only. Neither INTERPOL nor any external contributor to this manual assumes any legal liability or responsibility for any issues or damages which may result from the use of the techniques or protocols described or depicted in this manual.

NO GUARANTEE OR WARRANTY

Accuracy of information: This manual recognizes that environmental forensics is a continually developing field and therefore subject to improvements. While this manual was compiled based on the current legislative environment at the time of writing, and while every care has been taken to ensure that the information contained within this manual is correct, INTERPOL cannot guarantee or warrant its accuracy, reliability or completeness.

Legal sampling: This manual focuses on techniques to collect environmental evidence suitable for use in a court of law when sampling for inspections, investigations and emergency response, and provides examples of how evidence can be presented in a prosecution brief. However, these techniques are merely recommendations. Besides, environmental sampling is a complex field and technology is evolving rapidly, and the investigator(s) should stay aware of changes to legislation, regulations, methods and standard practices as they occur in their local jurisdiction as well as internationally. It follows that INTERPOL does not provide any warranty or guarantee of the acceptance of the sampling techniques described in this manual by any enforcement agency or court of law.

Adoption Of Procedures And Standards: Where local standards, procedures, and analytical criteria exist, the investigators are recommended to follow local standards and utilize the criteria in this manual as supplemental reference information. Where local procedures or standards do not exist, the local jurisdiction may adopt the procedures and standards described in this manual.



Health and safety; This manual has been written to include some specific warnings on hazards involved in sampling procedures and the general procedures for developing a task hazard analysis (THA) for specific tasks related to inspection and investigation work which are unique to each situation. The investigators should also familiarize themselves with and comply with the health and safety criteria which are specified by local laws or policies.

No endorsement: Mention of trade names, companies or trademarks does not constitute endorsement by INTERPOL.

D. MANUAL STRUCTURE

This manual is designed to assist the investigator through the forensic environmental investigation process from initial receipt of information of a potential violation, through planning and implementation of the evidence gathering process, to preparation and presentation of data and evidence in a prosecution brief.

Scenarios: The first section consists of common environmental investigation scenarios and presents a step wise approach to gathering evidence. Water Scenario 1 is a comprehensive scenario which provides a summarized example of how evidence is collected and how it can be portrayed in a prosecution brief. All subsequent scenarios provide variations and illustrations of the evidence collection strategies and unique features specific to the scenario. Some of the scenarios also provide examples of how environmental evidence can be presented in an understandable format to non-scientifically trained people.

Reference: Reference material follows the scenarios in an order which follows a generally logical approach to preparing and implementing a forensic environmental investigation. These chapters can be used to obtain more detailed information on how to implement a particular step in the investigation or provide basic science and engineering information which explains why particular techniques, procedures or equipment should be used.

E. INTERNET ACCESS TO MANUAL RESOURCES

Copies of this manual may be obtained at the "Resources" page of the INTERPOL Environmental Security unit.

<http://www.interpol.int/Crime-areas/Environmental-crime/Resources>



F. PRECAUTIONARY PRINCIPLES

Precautionary principles should be used in assessing environmental hazards or implementing enforcement actions in response to an environmental offence and should consider the following:

- The toxicity of industrial chemicals and the potential for harm;
- Taking preventative action to reduce harm in the face of scientific uncertainty;
- Exploring remediation alternatives including the alternatives of no action;
- Considering the full cost of environmental and health impacts over time;
- Increasing public participation in decision making;
- Shifting the responsibility for providing evidence of no harm to the proponent;
- Consider if an action or policy in regards to a suspected risk will cause harm to the public or the environment;
- The public and the proponent should be able to play a role in risk assessment and management.

G. REGULATORY AUTHORITY AND ENVIRONMENTAL ENFORCEMENT AGENCY POLICY RECOMMENDATIONS

In order to establish a reputable and skilled environmental law enforcement program, it is recommended that the responsible agency in any country have enabling legislation that grants enforcement powers to its field and analytical staff, and that the department sets minimum training standards for those staff. Typical enabling legislation and policy documents may be written in a general term as follows:

Enabling Legislation

"[Insert Section #] The [Minister, or Director etc.] may designate persons or classes of persons as [inspectors or officers or analysts] for the purposes of the administration and enforcement of this Act."

Environmental Departmental Policy Document for Designation of Inspectors, Officers or Analysts

The basic qualifications for an environmental law enforcement field inspector/officer are commonly as follows:

- Diploma or degree from a recognized college or university in science, chemistry, biology, environmental sciences or engineering;
- Completion of departmental training courses in law enforcement techniques, environmental law and specific regulations;
- Completion of departmental training courses in health and safety, legal sampling, evidence collection, interview techniques, writing of prosecution briefs, hazardous site entry, vehicle and boat or other all-terrain vehicle operation.



The basic qualifications for an analyst are as follows:

- Diploma or degree from a recognized college or university in science, chemistry, biology or toxicology;
- Completion of departmental training courses in evidence handling, analytical techniques, and expert witness testimony;
- Completion of departmental training courses in laboratory health and safety.





1

SCENARIOS

Scenarios

Successful prosecution of an environmental case involves four major steps:

1. Collection of the appropriate evidence.
2. Maintenance of legal continuity of the evidence.
3. Organization and documentation of evidence.
4. Presentation of the evidence to the various audiences (enforcement office management, police, prosecutors, judges and the court).

INTRODUCTION

BACKGROUND

These scenarios deal with situations where the source of the illegal discharges may be visible or invisible and hazardous to life or health. Every situation is unique and you should use these scenarios as guides to assist with real situations.

SCENARIO WATER 1 lays out examples of how evidence can be collected and presented so as to make it more understandable, especially to an audience with limited scientific or technical background. This simulated pollution case concerns a septic waste/sewage hauler who bypasses an authorized disposal site at a sewage treatment plant and instead discharges the load into a nearby creek to avoid tipping fees. Sampling and analysis determines there is also cadmium in the sewage. Various examples of how to present the data in a prosecution brief are provided in the following pages.

Various examples of how to present the data are provided in **WATER 1**. Subsequent scenarios can use this example as a guide to prosecution brief preparation and case presentation. For each scenario, see **SECTION 2.0 TO 2.6** for information on Sampling and Health and Safety planning. For details on equipment, sampling techniques, engineering considerations, bottles and preservatives, see **SECTIONS 3 TO 12**.

BEFORE YOU GET TO THE SITE

- > Obtain as much information as possible about the discharge and the type of contaminant or chemical product present at the site.
- > Contact firefighters, police officers or any other personal related to the case, in order to:
 - Identify possible witnesses to the event and obtain reports from the first person to arrive at the site.
 - Help isolate the area from disturbance by the public or animals and prevent disturbance of evidence.
 - Maintain the security of the site considering the risks of fire, explosion or contamination of the population.



AT THE SITE

1. Using binoculars or other means, try to establish the type of waste by examining labels or markings on the outfalls, containers or vehicles (if there are any there).
2. Establish safety zones: If not trained in Hazardous Site Entry, contact the Hazardous Materials Response Team or others trained in hazardous site entry. (See **HAZARDOUS WASTE 1, 2 AND 3 AND SECTION 2.6**)
3. If necessary, establish decontamination zones and equipment/wash areas.
4. Enter the site **only when it is safe to do so**.

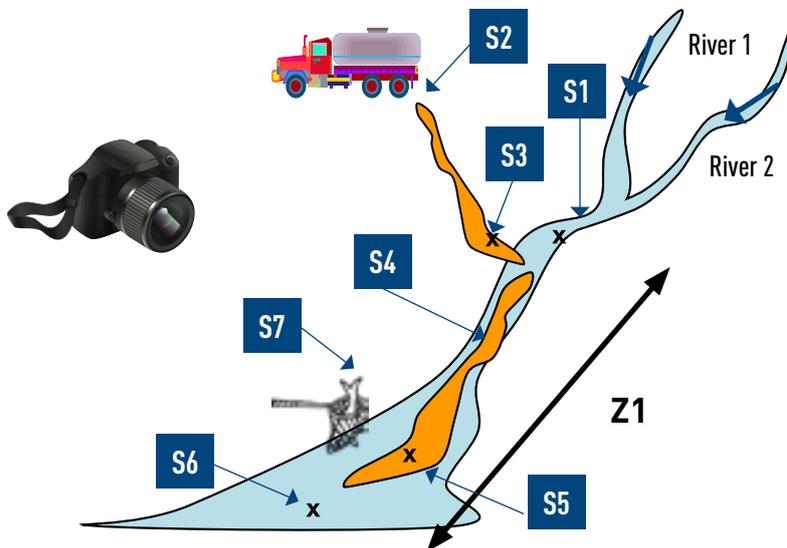
WATER 1: IMPROPER DISPOSAL OF SEWAGE THROUGH RUNOFF TO WATER BODY

INVESTIGATIVE STRATEGY

1. Test temperature, pH, dissolved oxygen, conductivity, odour, turbidity, nitrates, phosphates and coliform, metals and Biochemical Oxygen Demand (BOD₅).
2. Whenever possible, to reduce risk of cross contamination of samples, collect samples in order from the least contaminated to the most highly contaminated. Samples are collected in order S1, S6, S5, S4, S3, S2, S7.

EQUIPMENT NEEDED

- Safety glasses
 - Protective gloves
 - Notebook
 - Thermometer, pH paper, or multiparameter probes
 - Bottles
 - Coliform - 100 ml glass jars
 - Metals - 100 ml plastic jars
 - BOD₅ - 1.0 litre glass or plastic jars
 - Preservative – nitric acid
 - Camera
- See **SECTION 2.0 TO 2.6** for Safety and Equipment Details



- S1** - Collect/Test from upstream site
- S6** - Collect/Test farther downstream until field analyses reflect S1 background
- S5** - Test farther from downstream of site
- S4** - Test from mixed downstream site
- S3** - Test from point of discharge
- S2** - Test from suspected source of discharge, if known
- S7** - Collect and/or photograph evidence of dead fish or animals or damaged plants
- Z1** - Measure the Zone of Impact

3. GPS mark and photograph all sample sites from at least four directions and an elevated view if possible.
4. Obtain copies of all available records.
5. Interview responsible people and all witnesses.
6. Write a report and submit it to the prosecutor or judge.



INSPECTOR'S REPORT

- 1) Name, title and address of the inspector(s)
- 2) Introduction: Write what this case is about
- 3) Information about the site: The who, what, when, where and how.
Detail observations, sights, sounds, odors, locations of sample sites, evidence, dead fish/birds/biota, location, address, street signs etc., especially anything relevant to whom may be responsible.
- 4) Evidence of the offences
 - > Is a responsible party identified or suspected. If so, provide all information.
 - > Temperature recorded at the sample site(s).
 - > Chemistry or biological data in the form of tables and/or illustrated graphs and diagrams. See example charts.
 - > Photographs of the sample sites. Site should be viewed from all four directions and an elevated level if possible to provide perspective and context of the site(s). See the following example using "Google Earth".
 - > Photos of dead fish, aquatic life, animals, plants.
 - > Company delivery documents, or process effluent or disposal records.
 - > Statement from the plant foreman or witnesses.
- 5) Reports by expert witnesses, such as engineers, chemists, or biologists, concerning the evidence and an estimate of damage caused and cost to repair, but only if reasonably known.
- 6) List of witnesses - statement of witness #1, etc.
- 7) Copies of the documents, if obtained, including manifests, shipping records, correspondence, lab reports, etc.
- 8) Copy of the legislation
 - > Copy of the act
 - > Copy of the regulation
 - > Copy of the permit
- 9) Copy of the suggested charges

ANALYTICAL DATA SHOULD BE PRESENTED IN AN UNDERSTANDABLE FORM

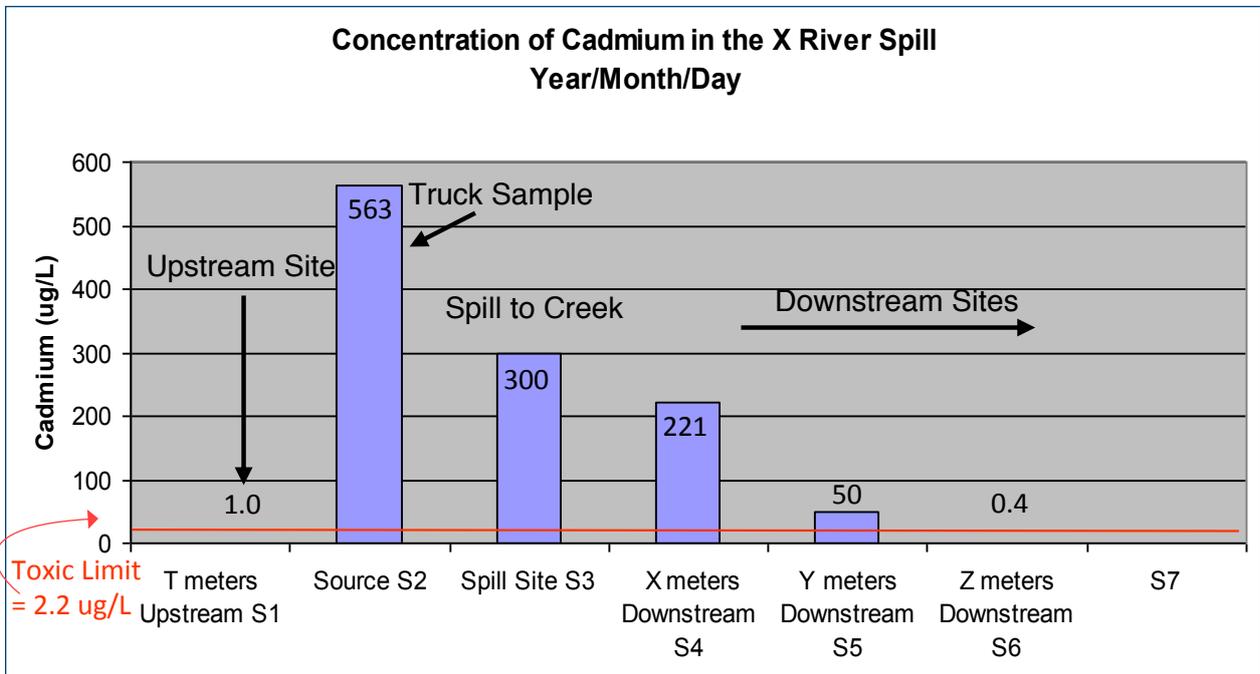
1. Pre-numbering the samples, i.e. from upstream to downstream (S1 to S6) allows the analytical data to be compared in a table and/or a graph.
2. Original laboratory data reports should be maintained as part of the file.
3. Chemistry data should be presented as a whole number in the units where it is toxic. For example, if sites S1 to S6 have cadmium in water samples, often a laboratory will report the values in milligrams/litre (mg/L) or parts per million and the data in the simulated case may be reported as follows:

SITE	TOXIC LIMIT	S1	S2	S3	S4	S5	S6
Cadmium <small>(dissolved) mg/L</small>	0.0022	0.001	0.563	0.300	0.221	0.050	0.0004

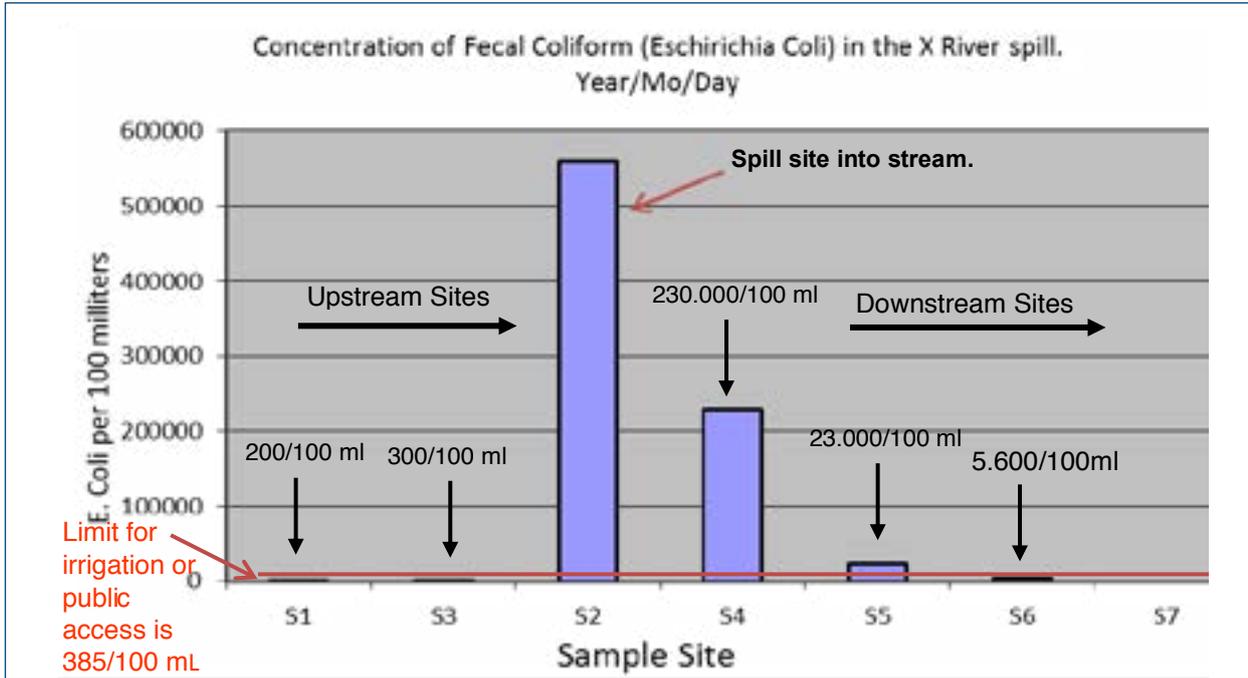
4. Cadmium is acutely toxic to sensitive fish at 2.2 micrograms/litre ($\mu\text{g/l}$) or parts per billion. Therefore the laboratory report can be converted from mg/L to $\mu\text{g/L}$ to make the numbers whole numbers which are more easily understood by non-technical people.

Analytical data can be presented as a table. However, scale and order of magnitude are easier for a prosecutor or judge to comprehend when presented as a graph where levels are compared to regulated limits.

SITE	TOXIC LIMIT	S1	S2	S3	S4	S5	S6
Cadmium (dissolved) $\mu\text{g/L}$	2.2	1.0	563	300	221	50	0.4



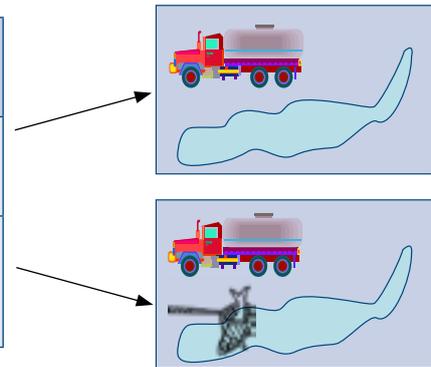
5. If sewage is the issue, results are usually reported as number of organisms per 100 millilitres. While a table can provide the laboratory results directly, the conversion into a graph with some explanatory text will help illustrate the order of magnitude of the impact in a much clearer format.



SITE	PUBLIC ACCESS	UPSTREAM		SPILL SITE S2	DOWNSTREAM		
		S1	S3		S4	S5	S6
Limit org/100 mL	385	200	300	560,000	230,000	23,000	5,600

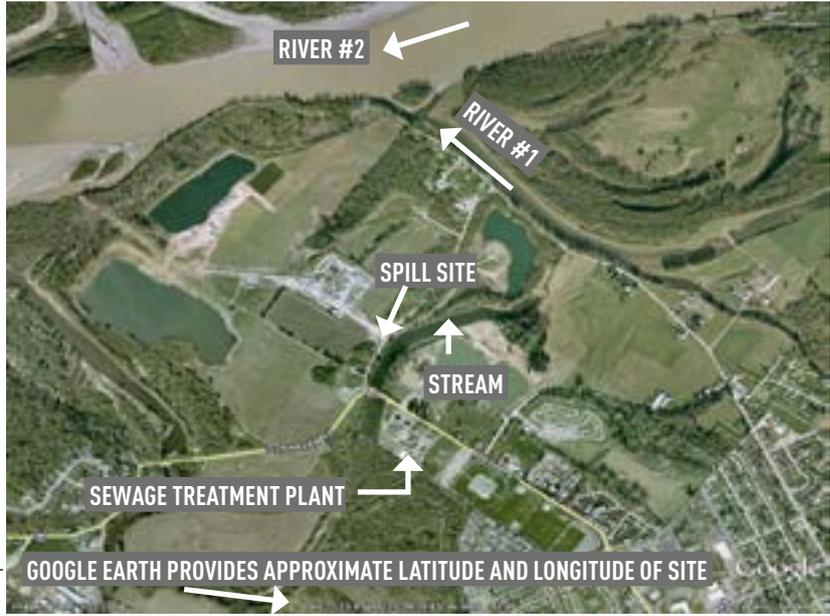
6. Photography should also be used to explain and illustrate the case.

DATE (YR/MO/DAY)	PHOTOGRAPHER	PHOTO #	SIGNIFICANT ISSUES IN THE PHOTOGRAPH
2011-11-04	Inspector 1	001	Photo of Sewage truck parked by the stream
2011-11-04	Inspector 2	010	Photo of dead fish collected downstream of the sewage spill



- An inventory of all photographs and what is significant about them should form part of the file.
- Starting from large views to progressively smaller views brings the reader into the context of the case. The photos should include reference points which link one photo to the next. Note the position of the truck in the first photo and the downstream sampling site in the second photo. The photos can be copied into a simple graphics program (such as Microsoft PowerPoint) and details of the case can be added to the photographs to help explain significant evidence.
- Aerial photographs which illustrate the context of the case can be generated by using geographical programs such as "Google Earth".

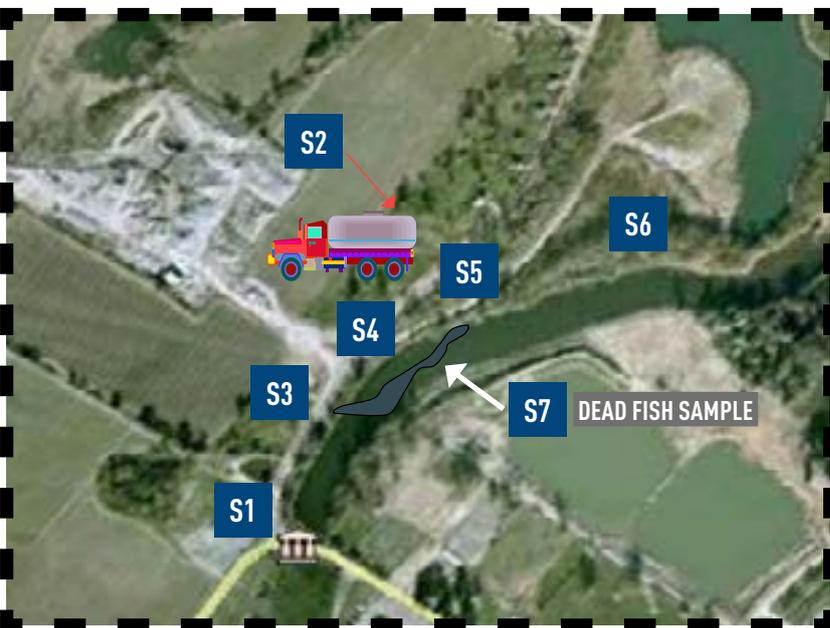
10. Google Earth can assist in providing an elevated view of the crime scene and provide context for the evidence which has been collected. In this simulated case, a septic tank pumper truck bypassed a sewage treatment plant and illegally dumped the septic waste into a nearby stream.



11. Google Earth can assist in providing distance measurements using the "Tools" menu and selecting "Ruler Function".

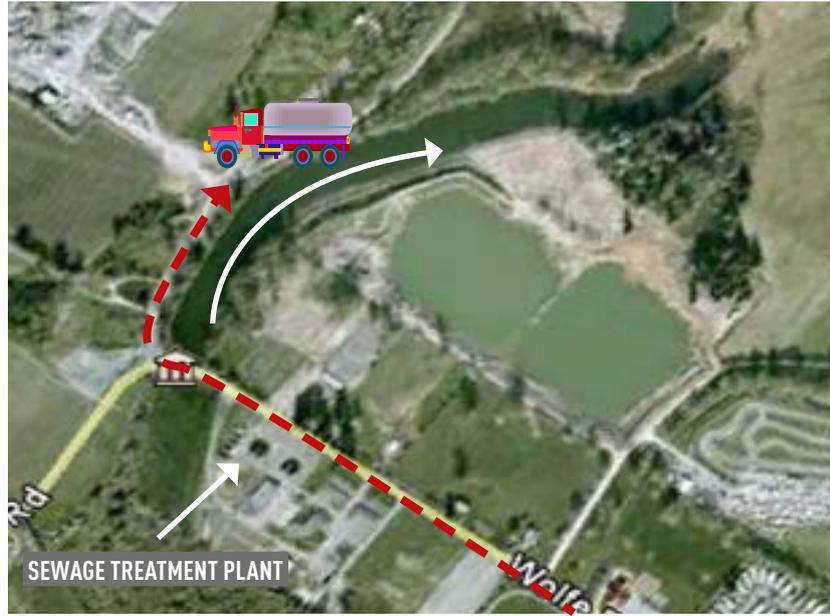


12. Zooming into the site allows the detail to be seen. Sample sites and other details can be added by inserting the Google photo into a graphics program like "Microsoft PowerPoint".





13. Details of the case can be added to support the explanation of the case evidence. In this simulated case, the septic truck bypassed the sewage treatment plant and dumped directly into the stream to avoid tipping costs and reap a greater profit.



- 14. Documentary evidence should also be used to explain and illustrate the case.
- 15. An inventory of all documents and what is significant about them should form part of the file.

DATE (YR/MO/DAY)	INSPECTOR WHO SEIZED INFORMATION	DOCUMENT #	SIGNIFICANT ISSUES IN THE DOCUMENT
2011-11-04	Inspector 1	001	Log book from Truck X Septic Disposal truck containing pick up locations and volumes of sewage
2011-11-04	Inspector 2	010	Receipt inventory from Sewage Treatment Plant, indicating the number and dates of disposal of sewage from Truck X

- 16. Statement evidence should also be used to explain and illustrate the case.
- 17. An inventory of all statements and what is significant about them should form part of the file.

DATE (YR/MO/DAY)	INSPECTOR WHO TOOK THE STATEMENT	DOCUMENT #	SIGNIFICANT ISSUES IN THE DOCUMENT
2011-11-04	Inspector 1	001	Statement from Truck X septic driver saying the company manager told him to short dump the loads
2011-11-04	Inspector 2	010	Statement from sewage treatment plant operator saying he saw Truck X bypass the sewage treatment plant on the day in question

WATER 2: SPILL OF CHEMICAL/WASTE OIL TO SURFACE WATER AND/OR SURFACE SOIL

INVESTIGATIVE STRATEGY

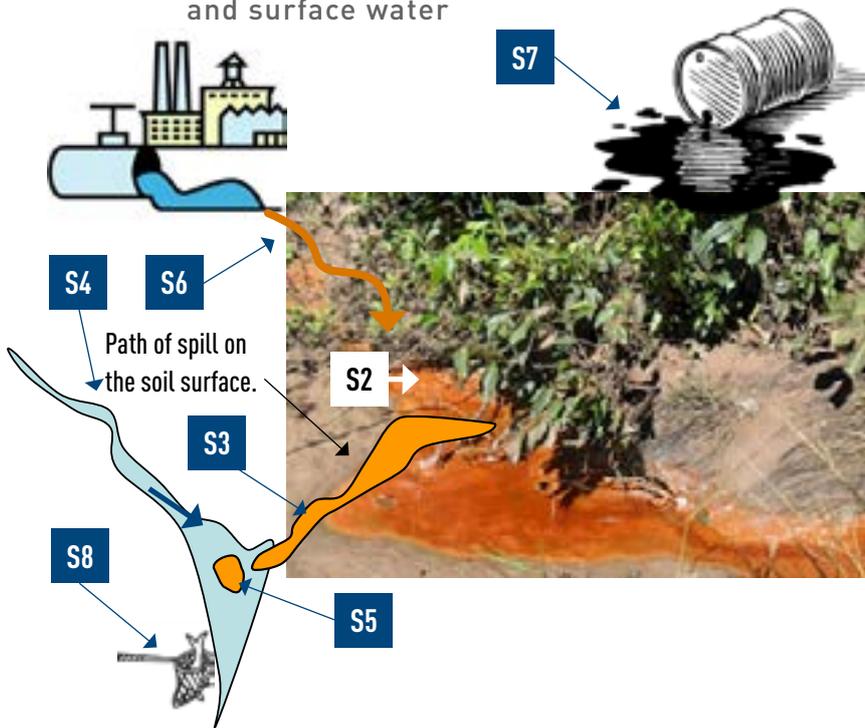
- Determine the type of chemical/oil/waste contamination.
- Determine the source of contamination, its scale and health risks.
- Define a sampling plan with objectives to minimize health risks and collect at least one background sample (S1 or S4), one source sample (S2, S6 or S7) and one receiving environment sample (S3 or S5), and impacted wildlife (S8).

1. Select a representative sampling procedure depending on:

Option 1 - chemical/oil only contaminates surface soil and surface water.

Option 2 - chemical/oil contaminates shallow soil and/or groundwater.

Option 1 Chemical/oil only contaminates surface soil and surface water



Use a clean stainless steel scoop at each site to collect samples at:

- S1** - Surface soil background sample. If possible, collect first to avoid cross-contamination from other samples.
- S2** - Surface soil to determine contamination at the spill site.
- S3** - Additional soil sample to illustrate impact on receiving environment surface soils.
- S4** - Grab sample of surface water column composite background sample.
- S5** - Grab sample of surface water column composite downstream sample.
- S6 and S7** - Possible source comparison for analytical fingerprinting. If possible, collect last to avoid cross contamination of other samples.
- S8** - Dead or dying fish and wildlife impacted by the spill.

EQUIPMENT NEEDED

- Safety glasses (See SECTION 2.6)
- Protective gloves, clothes, boots
- Notebook
- Sampling dark brown glass bottles/cans, seals (See SECTION 2.9.2)
- Soil auger, scoop, shovel, bucket
- Stop watch
- Transportable cool box
- Camera

For water contamination (See SECTION 3)

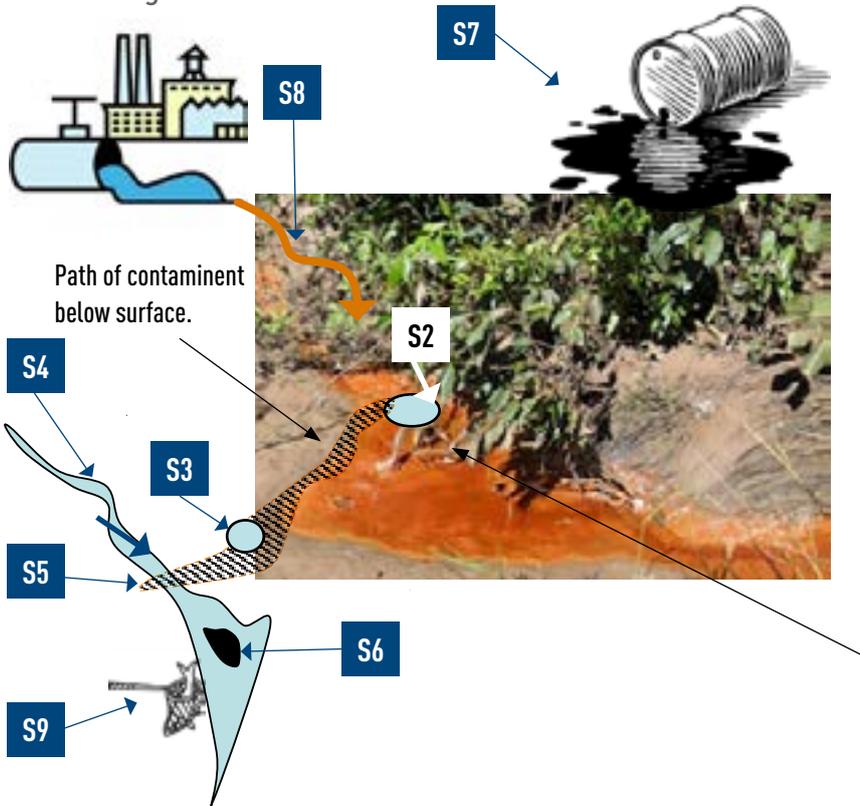
- pH strips or meter
- Thermometer or temperature meter
- Dissolved oxygen kit or meter
- For metals/salts: conductivity meter

S1 Background sample from a field not impacted by the discharge

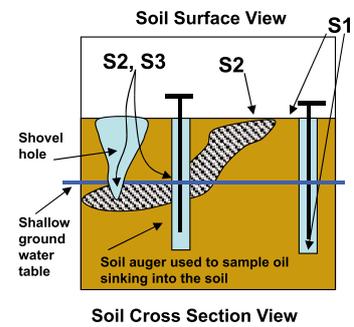




OPTION 2 Chemical/oil contaminates shallow soil and/or groundwater



S1 Background sample from a field not impacted by the discharge



Use a clean stainless steel scoop, soil auger and/or shovel at each site to collect:

- S1** – Use a scoop and soil auger to determine background contamination at the surface and at depth similar to the depth the waste has penetrated. Collect first if possible.
- S2** – Use a scoop to determine surface soil contamination.
- S2 and S3** – Use a soil auger or shovel to determine at least one subsurface sample along the path of the waste.
- S4** – At least one background composite water sample.
- S5** – At least one upwelling seepage water sample (see **WATER 7** for shallow groundwater techniques).
- S6** – At least one depth composite water sample if dissolved or one surface sample if the waste is floating on the stream to illustrate impact on receiving environment surface water.
- S7 and S8** – At least one sample from the source for analytical fingerprint comparison between the possible source and receiving environment samples. If possible, sample last to avoid cross-contamination of other samples.
- S9** – Dead or dying fish and wildlife impacted by the spill.



2. Photograph crime scene and contaminated area, in relation to the source if possible. Photograph all sample sites from at least four directions and an elevated view if possible.
3. Interview responsible people and all witnesses and examine any records.
4. Write a report and submit it to the prosecutor or judge. See **WATER 1**

WATER 3: SPILL OF CHEMICAL/WASTE OIL TO STORM DRAIN AND TO SURFACE WATER

INVESTIGATIVE STRATEGY

The environmental crime investigator will be called to the scene because some kind of damage (fish kill, oil slick) has been observed in/on the receiving water body. At the beginning of the investigation, it may not be obvious that the pollution originates from a storm drain system.

Therefore, it is always important to look out for drain pipes when working on water pollution scenes.

- Determine the type of waste contamination
- Determine the source of contamination - interview witnesses, present or former employees, and consult sewer mapping sources from local government or industry sources.
- Determine the scale of contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and collect at least one background sample, one source sample and one receiving environment sample.

PROBLEMS RELATED TO POLLUTION ORIGINATING FROM STORM DRAIN SYSTEMS

- If the pollution originates from a drain pipe, the place of the actual spill/discharge differs from the place where the pollution is observed. It may be very difficult to find the original source/site of the pollution, especially if the storm drain system is not constructed as an open channel, but a subsurface installation.
- Often, the inlets of the drain into the receiving water body are hidden, e.g. under a bridge. It is possible that the efflux from the drain pipe has already stopped when the inspector arrives on the scene. If the original source discharge has stopped, residual samples may have to be collected from deeper wells in manholes or other areas in the system where liquid could form pools.
- Storm drains serve as a buffer, resulting in time lags between the actual spill/discharge and the observation of the pollution. Depending on the length of the storm drain system, the retention time before the pollution enters the receiving water body may be several minutes to several hours.
- Under certain circumstances (depending on the architecture of the storm drain system), the pollution may be retained within the storm drain system until the next rain storm occurs. In these cases, it will more difficult to establish the actual time when the spill/discharge took place.
- Heavy rainstorms generally transport a lot of organic material into the receiving water bodies (e.g. street wash-off, sediments from the drain pipe system), therefore oxygen demand of water bodies is generally elevated after rain storms. In extreme situations, it is possible that water inputs from storm drain systems cause fish



kills even though no illegal substance was spilled/discharged. This may occur during a heavy rain storm after a prolonged dry period. Contributing factors include high water temperatures and poorly mixed water bodies.

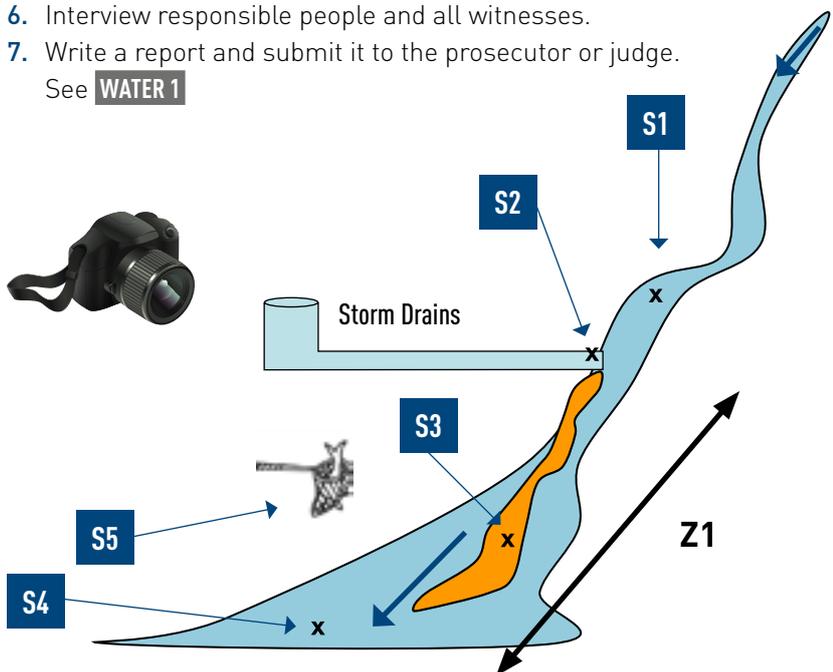
- Fast currents in the receiving water body may cause the scene to change rapidly. Evidence at the discharge to the stream may be washed away; therefore, samples may have to be collected in the stream before the investigation of the origin/source of the pollution is initiated. To preserve evidence, sampling must be done as quickly as possible.

SAMPLING THE RECEIVING WATER BODY

1. If possible, try to stop further spreading of the pollution (e.g. installation of oil absorption barriers; ask for support by fire brigades and other first responders).
2. Evaluate alternative sources of contamination (inlets from factories, discharge from ships, spill from riverbank, etc.).
3. If possible, collect the samples in order of least contaminated to most contaminated

- S1** - Upstream reference sample
 - S2** - Outlet of the drain pipe (water and, if present, sediment from the bottom of the pipe)
 - S3** - Mixed downstream site
 - S4** - Farther downstream until field analyses reflect S1 background
 - S5** - Collect and/or photograph evidence of dead fish or animals or damaged plants
 - Z1** - Measure the Zone of Impact, that is: S2 to S4
4. GPS mark and photograph all sample sites from at least four directions and an elevated view if possible.
 5. Obtain copies of all available records.
 6. Interview responsible people and all witnesses.
 7. Write a report and submit it to the prosecutor or judge.

See **WATER 1**



With open channel storm drains, all sources are visible. With subsurface systems, the source of the pollution will need to be traced back.

TRACING BACK THE SOURCE OF POLLUTION

1. If available, contact the city or municipal engineering department and check maps of the sewage system to find out about the catchment area of the storm drain.



Open channel storm drain

2. Determine if any suspicious activities occurred within the collecting area. Are there reported spills, accidents, illegal workshops or factories?



Subsurface storm drain (concrete pipe)

3. If no source of contamination is obvious, open the inlets/manholes ● of the storm drain starting from the water body where the pollution was observed and work upstream in order to trace back the origin of the contamination. Check smell, colour, or use simple field devices, e.g. pH-paper, oil indicator paper, conductivity meter, dissolved oxygen meter.

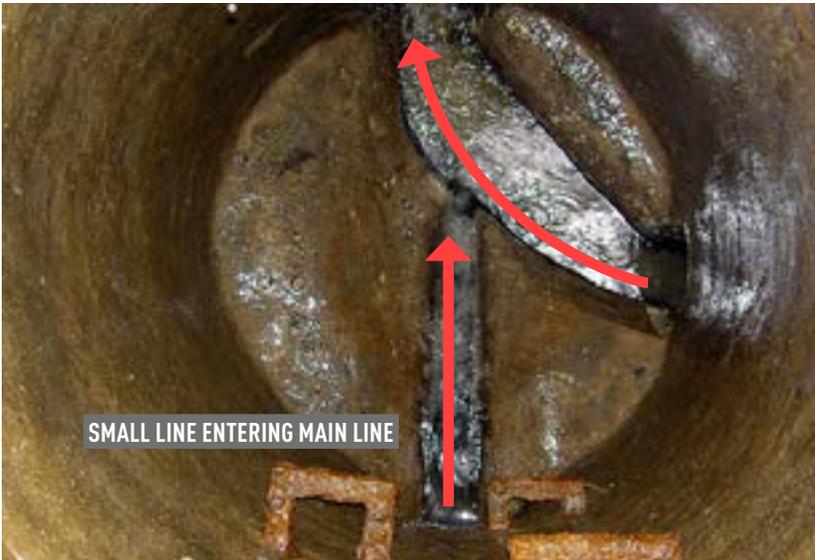


Note: Manholes can be confined spaces devoid of oxygen. They should not be entered unless you have confined entry training, an oxygen supply, and supervising help.



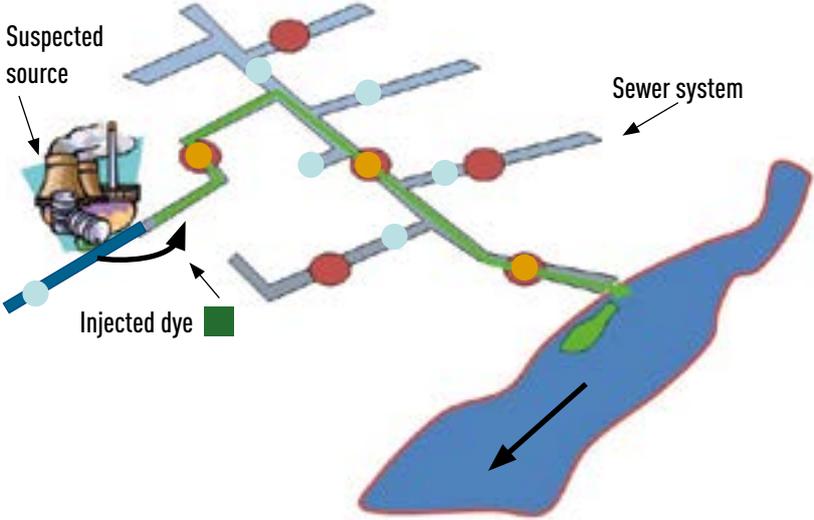
Open manhole of a sewage system

- To prove deposit, if possible, collect samples ● and isolate the potential source . If possible collect samples ● along the potential spill path prior to doing a dye test to prove the path from the source to the receptor stream.



Converging sewer lines (as seen from the top of a manhole)

- Conduct a dye test to prove the pathway by injecting dilute solution of Rhodamine or Fluorescence dye ■ into the source drain and visually track its path through the storm sewer system. Dilute salt solutions can be used instead of dye and be tracked using conductivity meters.
- This procedure should either lead you directly to source of the contamination, or you will be able to identify the two inlets between which the contamination entered the storm drain. In the latter case, there must be a subsurface connection leading from neighboring premises into the main storm drain somewhere between the last "clean" and the first "contaminated" inlet.



Conduct a dye test to determine the pathway of the contaminant.

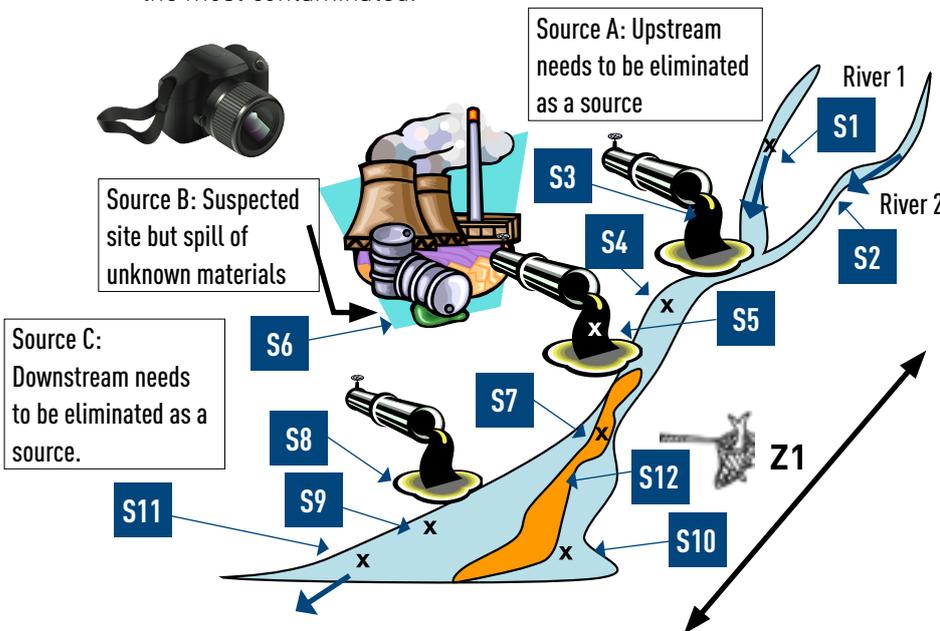


WATER 4: DISCHARGE OF CONTAMINATED PROCESS EFFLUENT FROM AN ESTABLISHED OUTFALL

INVESTIGATIVE STRATEGY

When there are multiple sources of discharge, the sampling plan must try to prove the actual source. The plan should establish the contribution from each source. Upstream samples of all tributary streams must also be sampled to confirm that they are not contributing to the pollution. Establish an upstream to downstream sample numbering system.

1. Test temperature, pH, conductivity, dissolved oxygen of upstream, downstream and Sources A,B and C to estimate suspected source of contamination.
2. If possible, collect samples in order from the least contaminated to the most contaminated.



- S1 and S2** - Collect/Test from upstream to establish if contaminated
- S9, S10 and S11** - Collect/Test farther downstream to establish if contaminated
- S4 and S7** - Collect/Test between potential sources to establish if contaminated
- S3, S5 and S8** - Collect/Test from points of discharge
- S6** - Collect samples directly from suspected site
- S12** - Collect and/or photograph evidence of dead fish or animals or damaged plants
- Z1** - Measure the Zone of Impact, that is: **S5 to S11**

3. GPS mark and photograph all sample sites from at least four directions and an elevated view if possible.
4. Obtain copies of all available records.
5. Interview responsible people and all witnesses.
6. Write a report and submit it to the prosecutor or judge.

See **WATER 1**

EQUIPMENT NEEDED

- Safety glasses
- Protective gloves
- Notebook
- Thermometer, pH paper or multiparameter probe (pH, temperature, dissolved oxygen)
- Bottles
 - Coliform - 100 mL glass jars
 - Metals - 100 mL plastic jars
 - Oil/grease - 100mL glass jars
- Metal preservative - Nitric Acid
- Transportable cool box
- Camera

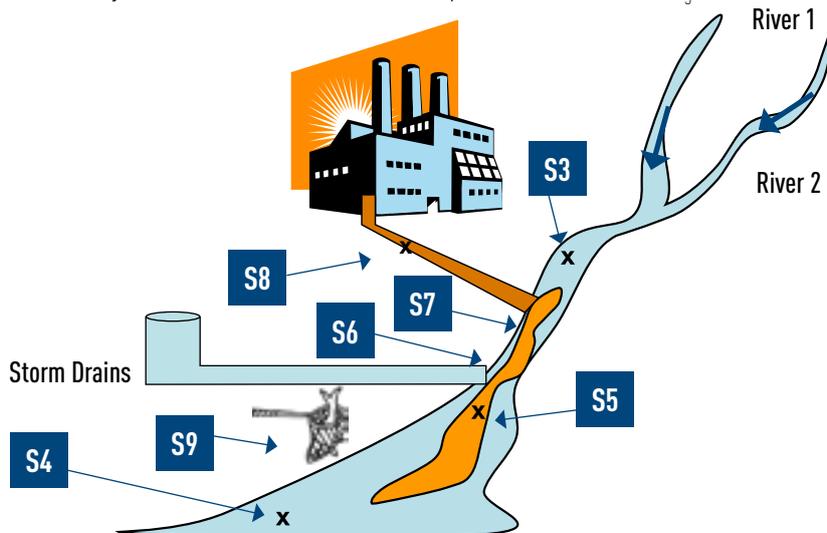
See page **SECTION 2.0 TO 2.6** for Safety and Equipment Details

WATER 5: DISCHARGE OF PROCESS EFFLUENT CONTAINING HIGH BOD₅ OR HIGH COD

Effluent from a plant may contain high biochemical oxygen demand (BOD₅) or high chemical oxygen demand (COD).

INVESTIGATIVE STRATEGY

- Determine the source of contamination.
 - Determine scale of contamination and health risks.
 - Define a sampling plan with objectives to minimize health risks and collect at least one background sample (S3), one source sample (S8) and one receiving environment sample (S7).
1. If material is highly visible, photographic evidence is the minimum evidence which should be collected. Photograph all sample sites from at least four directions and an elevated view, if possible. (See **SECTION 2.7.4** on Photography)
 2. Test each site for temperature, dissolved oxygen, pH and conductivity. Use clean jars at each site to collect samples and test for BOD₅ and COD at:



S3 - Background composite level samples to determine receiving water background contamination. If possible, collect first to avoid cross contamination from other samples.

S4 and S5 - Distant sites. Collect composite level receiving water samples to illustrate impact of contamination.

S7 and S8 - Source site composite effluent samples to test COD and BOD₅.

S6 - Composite effluent from the storm drains which may contribute to the impact zone.

S9 - Photograph and/or collect samples of dead organisms (fish) likely killed by low dissolved oxygen (caused by high BOD₅ and/or high COD).

3. Obtain plant operating records.
4. Interview factory engineers or foremen and ask questions about how the plant process works.
5. Write a report and submit it to the prosecutor or judge. See **WATER 1**

EQUIPMENT NEEDED

- Safety glasses
- Protective gloves/clothes
- Notebook
- Thermometer, pH paper or multiparameter probe (pH, temperature, dissolved oxygen)
- Bottles
 - 1.0 L dark brown glass bottles
 - Seals
- Transportable cool box
- Camera

See **SECTION 2.0 TO 2.6** for Safety and Equipment Details

See also **SECTION 2.9.2** for Bottles and Preservatives



WATER 6: DISCHARGE OF BLOOD AND SLAUGHTER WASTE FROM ABATTOIR TO SURFACE WATER

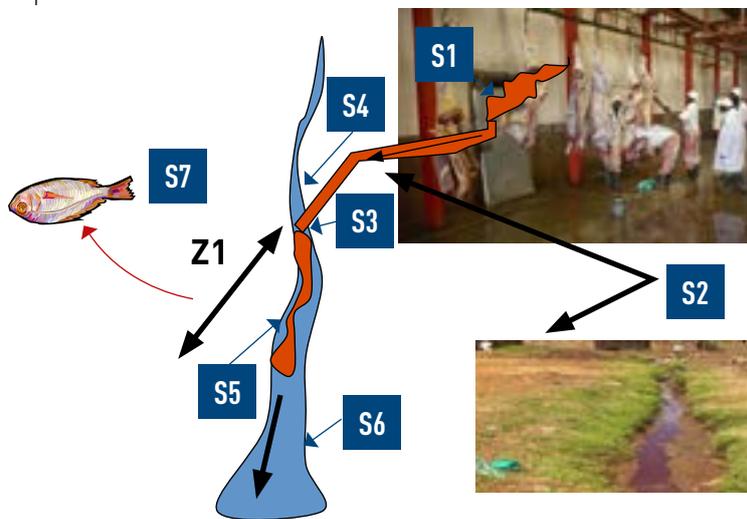
29

The major risks are depletion of oxygen (high biochemical oxygen demand BOD) and spread of blood-borne bacteria and viruses in the receiving water.

INVESTIGATIVE STRATEGY

- Determine the type of contamination.
- Determine the sampling points
- Determine the magnitude of contamination and any health risks.

1. Sample from least contaminated to most contaminated site.



S4 - Take samples of the stream at a point upstream of discharge.

S6 - Take at least one sample of the river at a point downstream at the contaminated zone.

S5 - Take at least one sample of the river/stream/water body at a point in the contaminated plume downstream of discharge.

S3 - Take samples from the drainage pipe or open ditch as it discharges to the to the river/stream/water body.

S2 - Sample at the drainage connecting the abattoir and the effluents /sludge into the drainage pipe or open ditch leading to the river/stream/water body.

S1 - Sample from source of contamination just prior to entry into the floor drain(s).

S7 - Collect samples or dead fish/wildlife.

Z1 - Measure the Zone of Impact.

2. At each site, collect samples for Biochemical Oxygen Demand (BOD₅).
3. At each site, test for temperature, pH, conductivity and dissolved oxygen.
4. Estimate flow rates of the discharge and the stream.
5. Make notes regarding discoloration, odours, and evidence of dead fish, frogs, etc. likely due to depletion of oxygen. Map out Zone of Impact "Z1".
6. GPS mark and photograph all sample sites from at least four directions and an elevated view, if possible.
7. Obtain copies of all available records.
8. Interview responsible people and all witnesses.
9. Write a report and submit it to the prosecutor or judge. See **WATER 1**

EQUIPMENT NEEDED

- Safety glasses
 - Protective gloves
 - Notebook
 - Thermometer, pH paper or multiparameter probes (pH, temperature, dissolved oxygen)
 - Coliform - 100 mL glass jars
 - BOD₅ - 1.0 L glass or plastic jars
 - COD - 1.0 L glass or plastic jars
 - Metals - 100 mL plastic jars
 - Preservative - nitric acid
 - Transportable cool box
 - Camera
- See **SECTION 2.0 TO 2.6** for Safety and Equipment Details

WATER 7: SPILL OF CHEMICAL INTO SOILS WHICH ENTERS GROUNDWATER

INVESTIGATIVE STRATEGY

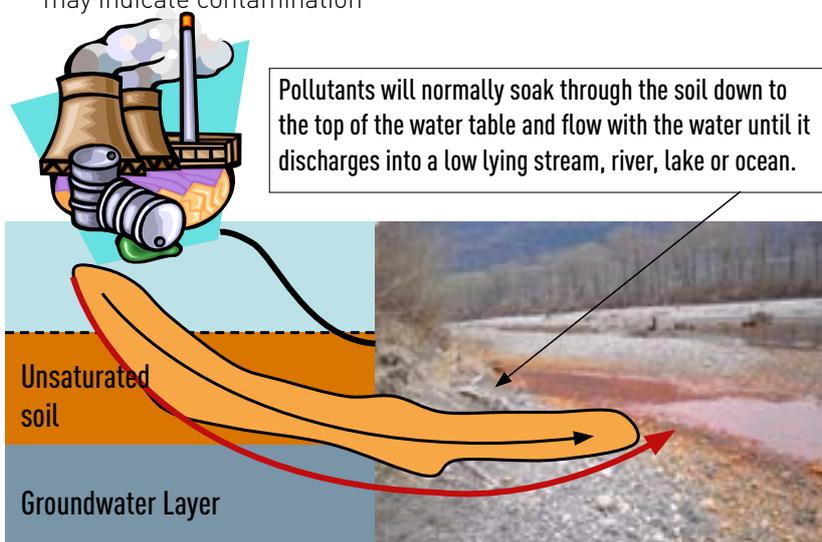
Safety: Wear protective gear - disposable coveralls, gloves, and boots suitable for protection against hazardous materials, and personal floatation devices when working near water. See **SECTION 2.6**

1. Define sampling case criteria and environmental risk and objectives.
2. Photograph crime scene and contaminated area in relation with source, if possible. Photograph all sample sites from at least four directions and an elevated view, if possible.
3. If acid generating waste is suspected, inspect the near-shore area. Look for staining (often red from iron or white from aluminum, manganese or zinc caused by precipitation of heavy metals). Look for excessive growth of algae due to nutrients from sewage or low oxygen.



Ferric iron staining caused by illegal burial of wood waste and organic debris. Decomposition of the wood waste forms carbonic acid, which leaches iron from the soils and deposits it into the river bed as red iron ferric solids. The solids cover the gravel bottom, destroying fish habitat, and deplete oxygen from the water resulting in the formation of low oxygen algae. (Courtesy of Genesis Environmental Sciences Ltd.)

4. Test the shallow water near the bottom sediments (epibenthic zone) for pH, dissolved oxygen, temperature and conductivity. Extreme pH ranges, high temperature, low dissolved oxygen and high conductivity may indicate contamination



(Courtesy of Genesis Environmental Sciences Ltd.)



5. Select a representative sampling procedure:

SHALLOW GROUNDWATER - Inspection determines that the type of waste or chemical may be entering the shallow near-shore area of a receiving body of water.

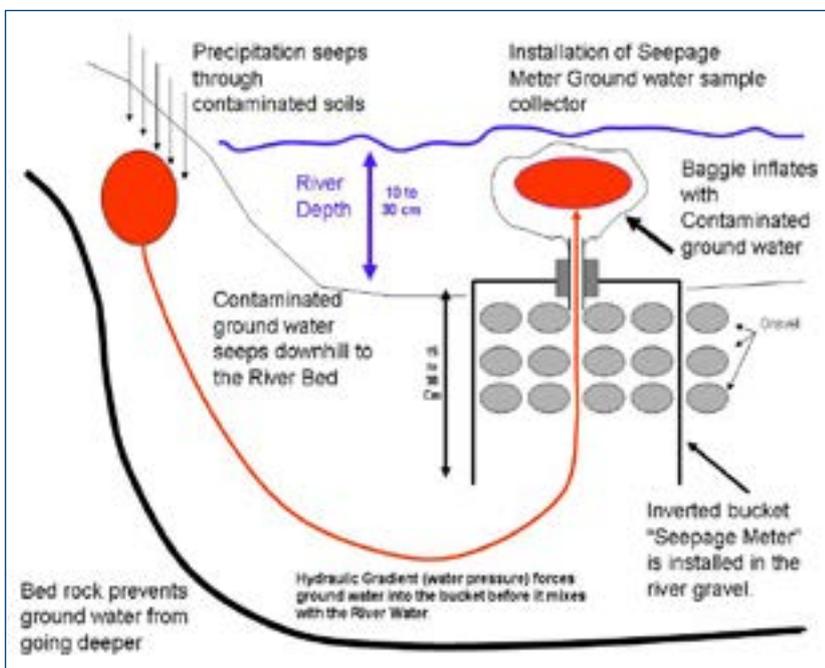
Option 1: Sampling using seepage meters

Option 2: Sampling using shallow piezometers

DEEP GROUNDWATER - Inspection determines that the type of waste or chemical may be entering the deeper groundwater or deep off-shore area of a receiving body of water.

Option 3: Sampling using deep wells and piezometers

Option 4: Sampling using offshore deployable piezometers



(Courtesy of Genesis Environmental Sciences Ltd.)

Option 1 Sampling using seepage meters

Seepage meters are inverted buckets with holes drilled in the bottom that are used to collect upwelling groundwater.

- a. Drill the bottom of a bucket to accept a rubber bung.
- b. Tube and baggie assembly: Using a rubber band, attach a plastic baggie to the rubber bung/stopper with a tube through its center.
- c. Push the inverted bucket in the top into the sand/gravel stream bed until the top of the bucket is submerged at least 10 cm.
- d. Compress the air out of the plastic bag to exclude air or water from entering, and insert the bung into the hole of the bucket.
- e. Upwelling groundwater flows into the bucket, through the tube and is captured in the plastic baggie. Sample collection is made just prior to full inflation of the baggie. The water is poured into a container suitable for the type of chemical.
- f. The time from attachment of the baggie to collection of the water sample is recorded. The volume of the sample in the baggie is recorded. The multiplication or "volume x time" of collection allows an estimate of the volume flow rate of contaminated water from the groundwater into the river.



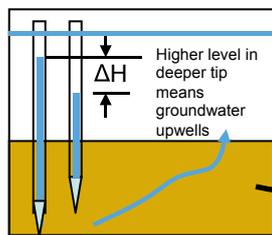
Option 2 Sampling using shallow piezometers

Shallow piezometers are tubes with well points that are driven into the river bed with slide hammers or sledge hammers. When two or more piezometer tips are inserted close to each other, one is pounded deeper than the other. These are called nested piezometers.

- a. Groundwater levels in each piezometer are measured using an electric tape measure.
- b. When the water level in the deepest piezometer is higher than in the shallower piezometer, it means that groundwater pressure is higher in the deeper piezometer and is upwelling into the bottom of the stream.
- c. After the shallow piezometer has been in place, it can be carefully pumped out using a variable rate peristaltic pump to remove water and sediment from the initial insertion. After the piezometer has been allowed to stabilize for several hours or days, a sample should be collected. The sample container should be pre-labeled and the sample collected and preserved according to the type of test required. See **SECTION 2.9.2**

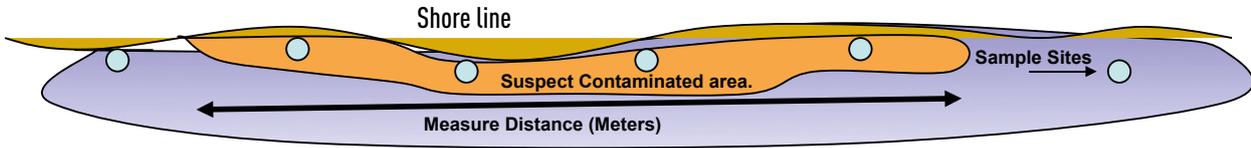
(Courtesy of Canada-DOE)

- Piezometers tips
- Slide Hammer





- d. Samples and water quality tests should be collected along the shoreline to determine the “Zone of Impact” where the boundaries of the contamination are determined. Sample locations should be logged in with a Global Positioning System.



Option 3 Sampling using deep wells and piezometers

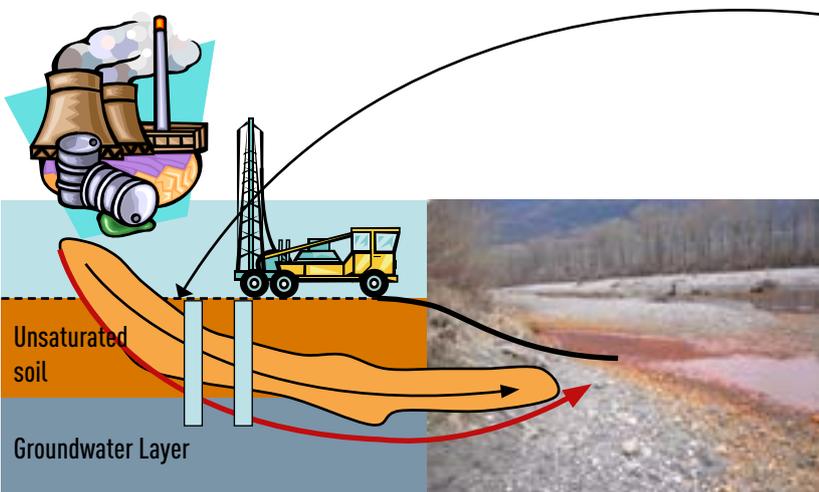
Deep well piezometers are different from shallow piezometers in that the well tubes are longer and require heavier equipment to drive in by pneumatic punches or drilling into the ground. In very deep wells, special casings may need to be cemented in place and multiple wells may need to be inserted in a single bore hole to collect groundwater from different depths/zones.

(Courtesy of Genesis Environmental Sciences Ltd)

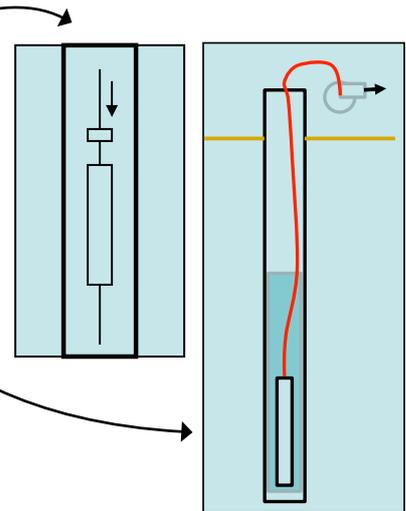
A qualified hydrogeologist and well-sampling specialist may have to be retained to collect samples from deep wells. The sampler may have to take precautions if the contaminant has vapors (such as spilled fuels) which can escape into the overlying soils or evaporate when being pumped up the well and into the sample container. Other considerations include the types of pumps being used and whether the well must be purged before collecting samples. If excess contaminated well water is withdrawn during purging, then arrangements may have to be made for proper disposal of excess contaminated water.

- a. A collapsible plastic tube sampler with a stainless steel weight is one non-purge method of collecting a sample from a well.

(Courtesy of Genesis Environmental Sciences Ltd)



- b. A tube sampler with a trigger and plug mechanism is one non-purge method of collecting a sample from a well.
- c. Hand operated or electrical narrow diameter pumps may be lowered into wells to pump up groundwater samples.

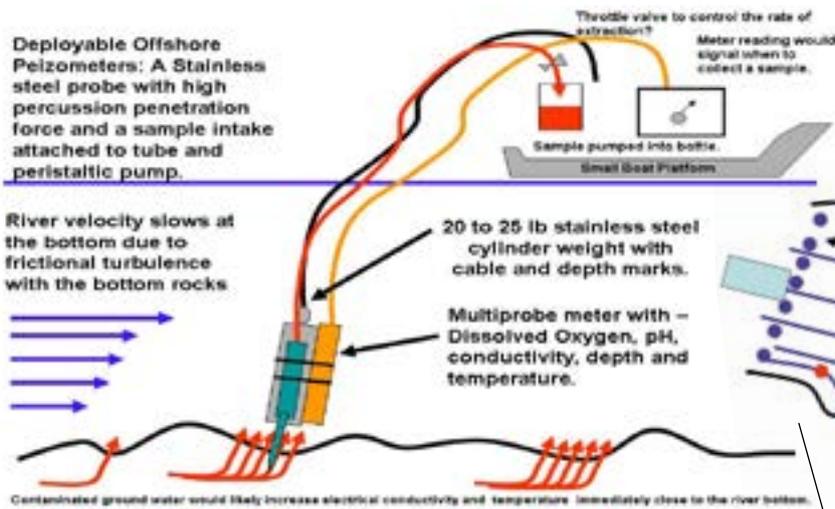


Option 4 Sampling using offshore deployable piezometers

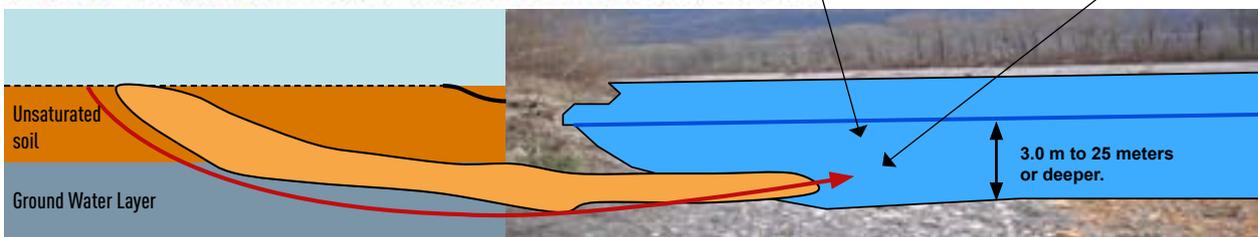
Contaminated groundwater upwelling into surface water which is 3 to 25+ metres deep can be sampled by offshore deployable piezometers and split spoons. The zone of upwelling can be detected by testing the epibenthic zone (layer of water just above the bottom sediment) using multi-meter probes to test for pH, temperature, conductivity and dissolved oxygen.

A series of transects of water quality measurements followed by sampling probes can collect samples where coarse sands and gravels allow extraction of groundwater. Where sediments are too fine, a split spoon sampler can be deployed and pore water can be extracted from the sediment and sediment analysis can be conducted.

(Courtesy of Genesis Environmental Sciences Ltd)



(Courtesy of Genesis Environmental Sciences Ltd)



- a. Multimeter probe is attached to deployable probe to survey water quality.
- b. Probe deployment is monitored and recorded.
- c. Underwater camera allows viewing of bottom conditions and deployment of probes.



6. Choose a method for illustrating the data.

(Courtesy of Genesis Environmental Sciences Ltd)

Option 1 Concentration of contaminants

A hydrogeologist can plot concentrations of contaminants in the various samples on a map showing inferred concentric zones of contamination. The Site Identifier is a unique combination of letters and numbers that identifies the site, for example:

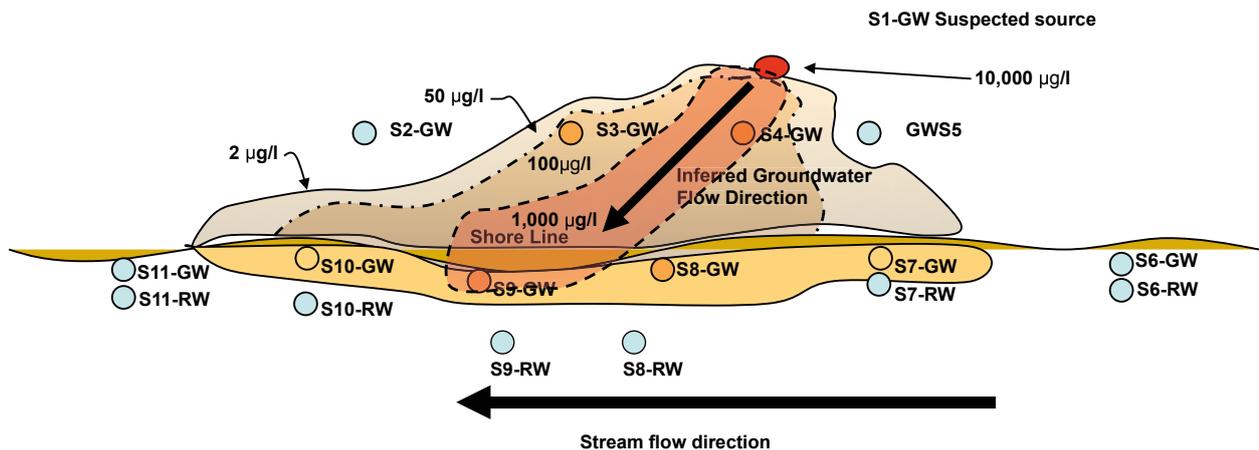
- GW = Groundwater sample**
- RW = River water sample**
- GWS1 or S1- GW = Groundwater Source Sample Site #1.**

Concentrations of contaminants may be expressed in text, (e.g. parts per million) or units of weight, (e.g. mg/L or $\mu\text{g/L}$)

Chemical concentration may be labeled in abbreviated form, for example:

- One part per million in water = 1.0 ppm = 1.0 milligram per litre = 1.0 mg/L**
- One part per billion in water = 1.0 ppb = 1.0 microgram per litre = 1.0 $\mu\text{g/L}$**
- One part per million in soil = 1.0 ppm = 1.0 milligram per kilogram = 1.0 mg/kg**
- One part per billion in soil = 1.0 ppb = 1.0 microgram per kilogram = 1.0 $\mu\text{g/kg}$**

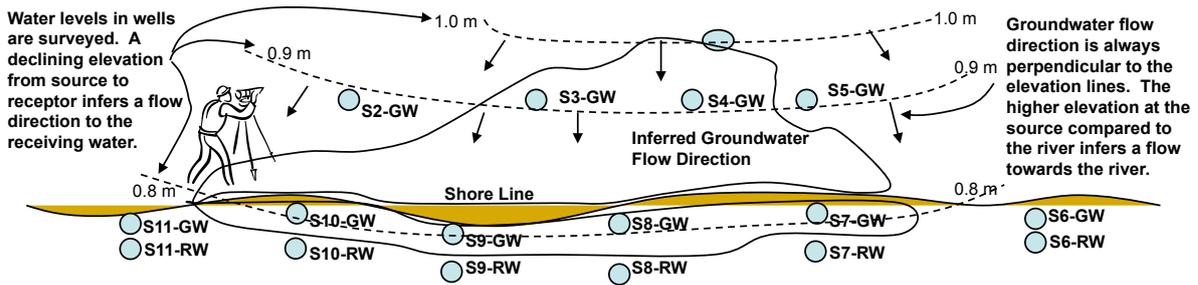
(Courtesy of Genesis Environmental Sciences Ltd)



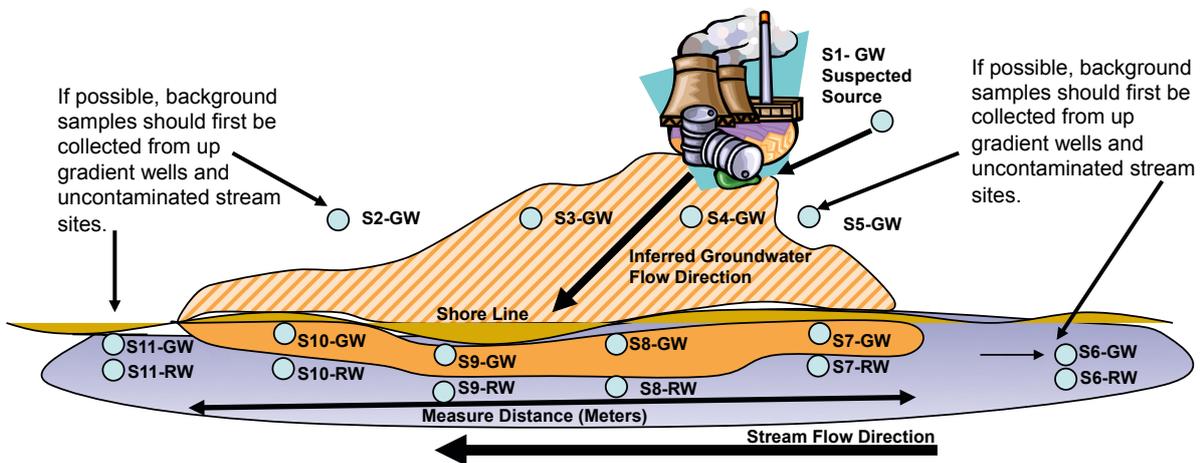
The concentration data can be plotted on a chart or a photograph of the site to help illustrate the context and order of magnitude of the contamination and the relative toxicity to aquatic organisms such as fish.

Option 2 Water elevation

Using survey methods a hydrogeologist can plot water elevations on a map showing an inferred flow direction as part of the evidence that what was spilled is flowing towards the receiving water.



Note: Samples and water quality tests should be collected from least contaminated towards the closest to the source in an up-gradient direction. If possible, the background sites at the shoreline wells should be collected first followed by background up-gradient sites, then from the plume center and lastly from the source itself. This is to minimize the risk of cross contamination.



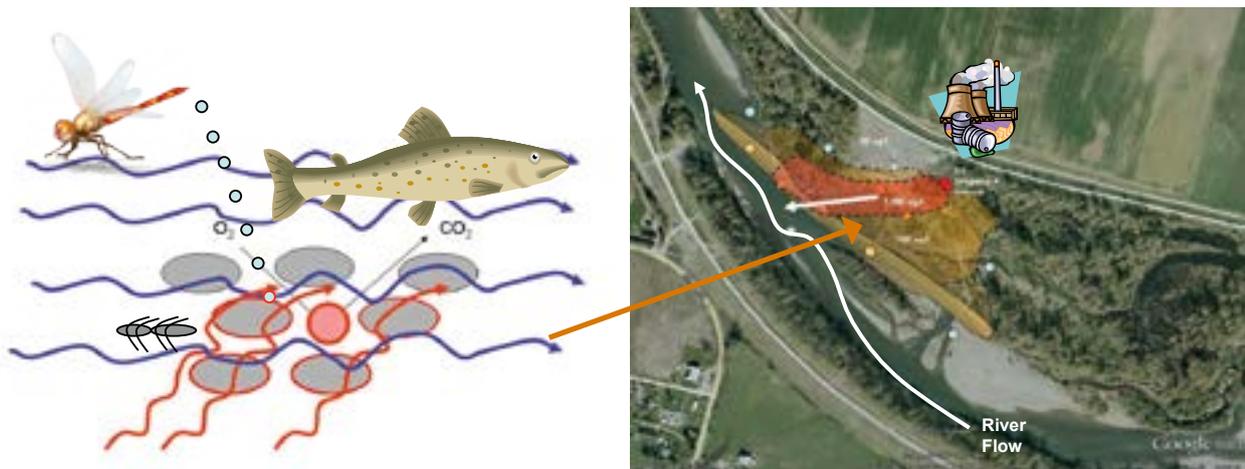
Option 3 Overhead map

Overhead maps utilizing surveys of the site or geo-referencing programs such as Google Earth can be used to generate illustrative diagrams to show the context of contaminated groundwater impacting receiving waters.

(Courtesy of Genesis Environmental Sciences Ltd)



IMPACTS OF CONTAMINATED GROUNDWATER



Upwelling groundwater contaminated with heavy metals or calcium/magnesium salts can precipitate out and smother the eggs, larvae and juveniles of fish and benthic invertebrates.

Upwelling groundwater contaminated with heavy metals or calcium/magnesium salts can precipitate out and consolidate bottom sediments or form terraces to harden stream beds to prevent spawning.



(Courtesy of Genesis Environmental Sciences Ltd)

Low dissolved oxygen can suffocate eggs and larvae, and prohibit juvenile benthic invertebrates and fish from living within the interstitial spaces of the river gravel.

7. Obtain copies of all available records.
8. Interview responsible people and all witnesses.
9. Write a report and submit it to the prosecutor or judge.

See **WATER 1**

WATER 8: ILLEGAL FISHING USING CYANIDE

Cyanide fishing is a common method used to collect coral-dwelling fish for the live aquarium fish or food fish trades. Perpetrators use solutions of sodium cyanide to stun fish, which are then collected alive. The cyanide disorients the fish, making them easier to net. Cyanide fishing most often occurs on a small scale, where the perpetrator uses a squirt bottle to dispense the cyanide solution at a particular target fish or disperses it in the reef to stun all the fish and collect the ones of interest. Dead fish may also be sold in the market place. Cyanide does not remain long in the environment and is metabolized quickly by organisms, meaning that time is critical when collecting samples from this type of event.

INVESTIGATIVE STRATEGY

- > Cyanide would not be used for any other purpose out on a coral reef so the presence of the chemical in a small vessel would be significant evidence towards supporting a conviction.
- > Supporting evidence of cyanide dispersion tools, such as plastic squirt bottles with dissolved liquid cyanide and solid sodium cyanide crystals which can be obtained from mining (particularly gold mining operations), is critical evidence.
- > The presence of larger than normal dead/dying fish (and sea organisms) and bleached coral reefs should be documented by collecting samples and photographing the extent of the impact as critical evidence.

SAFETY

- > Due to the highly toxic nature of sodium cyanide, the appropriate health and safety precautions must be taken. See **SECTION 2.6**
- > **Sodium cyanide can be absorbed through the skin, eyes, orally or the respiratory system. Therefore, safety glasses, dust filter masks, protective rubber gloves and boots, and protective (Tyvek/plasticised paper) type coveralls are recommended.**
- > Snorkel diving to collect water samples and evidence of dead fish (marine life) in an area where sodium cyanide has been dispersed **is not recommended** due to absorbance through the skin, eye or mouth contact, or accidental ingestion or breathing while swimming in the water.

PHYSICAL EVIDENCE COLLECTION

Time is critical as dispersal and degradation of the sodium cyanide in the environment may be rapid. The priority is to collect evidence which will be lost first, usually this consists of water samples and dead or impacted fish from the impacted scene followed by physical evidence in the boat. Since water samples will dilute the quickest, this is normally the first sample to be collected.

EQUIPMENT NEEDED

- Safety glasses
- Protective gloves, clothes and boots
- Protective dust filter mask
- Notebook
- Bottles
 - Sampling dark brown glass bottles/cans
 - Seals
- Preservatives. See **SECTION 2.9.2**
- Long handled small mesh fish net
- Extendable sampling pole with sampler clamp
- Waterproof digital/video camera
- Submersible water sampler with trigger device. See **SECTION 4.4** for depth samplers
- Weighted sampling hose with peristaltic pump
- For water contamination
 - pH strips or meter
 - Thermometer or temperature meter
 - Dissolved oxygen kit or meter
 - Conductivity meter
- Transportable cool box



1. Select a water sampling procedure:

Method 1: Weighted bottle

- a. Use a weighted bottle holder with a rope and insert a 1.0 litre bottle in the holder.
- b. Lower the bottle from the surface to the bottom of the reef as soon as possible so that the majority of the sample is collected at the area of potentially highest concentration.
- c. Raise bottle after bubbles have stopped exiting.
- d. Preserve the sample as indicated below.



(Courtesy of Canada - DOE)



Note: This method will collect water from the entire water column and is likely to dilute the sample and underestimate the concentration of cyanide in the water. However, it may only be necessary to show the presence of cyanide relative to the control site. Therefore concentration is critical to proving impact but proving deposit of cyanide is done by showing it is present in the reef environment in excess of background concentrations.

Method 2: Extended Pole Sampler

- a. If the reef is shallow enough, attach the 1.0 litre bottle to an extended pole sampler.
- b. Insert a cork plug with string attached into the neck of the bottle.
- c. Lower the bottle to the depth required and pull the string to extract the cork.
- d. Raise bottle after bubbles have stopped exiting.
- e. Preserve the sample as indicated below.



Camera can be set to "video" mode to capture the condition of the reef and photograph evidence of dead fish and sea life.

Converted paint roller used to hold clamp, camera and bottle. (Courtesy of Canada-DOE)

Extended pole and clamp with sample bottle and camera (Courtesy of Canada-DOE)

Method 3: Peristaltic pump and weighted hose

- a. Cut sufficient polyethylene hose of suitable diameter and attach a lead or brass weight to one end.
- b. Attach the other end of the hose to the silicone section of the peristaltic pump and connect the pump to the battery (usually 12Volt).
- c. Attach sufficient polyethylene hose on the discharge side of the pump so that excess water can be discharged overboard or into a waste water collection jug.
- d. Lower the weighted hose from the surface to the bottom of the reef as to the area of potentially highest cyanide concentration.
- e. Turn on the pump for sufficient time to clear the hose of any water which may have entered the hose during the lowering process. Flush the hose with at least 3 times the volume of the volume of the hose. Take care to discharge the potentially cyanide-contaminated water into the holding container or back overboard.
- f. Collect the 1.0 litre sample and preserve as indicated below.





Method 4: KIST Sampler

The KIST sampler uses a weighted probe with a polyethylene collection tube to which an underwater camera can be attached.

- a. Assemble the sampler as described in the operational manual.
- b. Cut sufficient polyethylene hose of suitable diameter and insert into the KIST sampler as per the instructions for the sampler.
Note: insert the tube so that it just exists the bottom of the sampler. No additional tip is required as the sampler will only be used to collect sample from the water column.
- c. Attach the other end of the polyethylene collection tube to the silicone section of the peristaltic pump and connect the pump to the battery (usually 12Volt).
- d. Attach sufficient polyethylene hose on the discharge side of the pump so that excess water can be discharged overboard or into a waste water collection jug.
- e. Lower the KIST sampler from the surface to the bottom of the reef as soon as possible so that the majority of the sample is collected at the area of potentially highest concentration.
- f. Turn on the pump for sufficient time to clear the hose of any water which may have entered the hose during the lowering process. Take care to discharge the potentially cyanide contaminated water into the holding container or back overboard.
- g. Collect the 1.0 litre sample and preserve as indicated below.



2. Sample preservation: Immediately after the samples have been collected, analyse them for the presence of oxidizing agents (mainly sulfide), which can destroy cyanide and thus affect the reading. See **TABLE 2.9.3.9** for iodide-starch paper test and preservation of sample.



3. Collection of concentrated liquid cyanide: Collect/seize samples of dissolved sodium cyanide in squirt bottles if present. The water found in squirt bottles aboard may also be analysed for cyanide. Follow the analyte fixing protocol above. Store all water and cyanide samples in a cooler with freezer packs. **Avoid the use of ice as meltwater can contaminate the samples.**



(Courtesy of Canada-DOE)

4. Collection of concentrated solid cyanide crystals: Collect/seize sample of solid sodium cyanide crystals if present. Store in a 100 mL clear or amber glass bottle.



5. Collection of live or dead fish:
 - a. Collect/seize any live or dead fish in the water and in possession of the alleged accused.
 - b. Use an extended pole with fish net to collect samples of the fish.
 - c. To preserve the fish wrap them in aluminum foil.
 - d. Seal them in a plastic bag, excluding as much air as possible.
 - e. Label the sample with indication as to site location and case.
 - f. The fish samples should be packed on freezer packs immediately and frozen as soon as possible. **Note:** Freezing the fish will not impact future analysis.

6. GPS mark and photograph the scene from all angles. Underwater photography may use low cost waterproof digital cameras. The simplest is to attach the camera to an extendable sampling pole and set it to video or to collect single frames on a timed interval. Lower the camera and collect 360 degree views of the dead/dying fish and the site.

Cyanide may also damage the surrounding coral, causing it to take on a white appearance (bleaching). Take photos from the control site and the damaged site for comparison. Photograph related paraphernalia that may be present in the boat.

7. Interview responsible people and all witnesses.
8. Write a report and submit it to the prosecutor or judge.

See **WATER 1**

WATER 9: ILLEGAL FISHING USING BLASTING AGENTS

Blast fishing is a method used to kill or stun fish by detonating explosives underwater, so that the fish may be collected and sold in the market place. These bombs are made from dynamite or homemade explosives made from ammonium nitrate, ammonium sulfate, potassium nitrate, nitroglycerine and trinitrotoluene (TNT). Blast fishing is a short time frame event and dead or stunned fish can be quickly collected by the perpetrators, or be lost due to scavengers in the reef. Blast residues can be quickly dispersed by water currents. Therefore, time is critical when collecting evidence and samples from this type of event.

INVESTIGATIVE STRATEGY

- > Blasting materials would not be used for any other purpose out on a coral reef where there are no permits for marine construction projects so the presence of the raw materials or finished blasting devices in a small vessel would be significant evidence towards supporting a conviction.
- > Supporting evidence of blast tools such as detonation devices such as blasting caps, homemade bombs or dynamite which can be obtained from mining operations is critical evidence.
- > The presence of larger than normal dead/dying fish (and sea organisms) and blasted/damaged coral reefs should be documented by collecting samples and photographing the extent of the impact as critical evidence.

SAFETY

- > Due to the highly reactive and potentially unstable nature of homemade blasting agents the appropriate health and safety precautions must be taken. See **SECTION 2.6**
- > **Explosive devices must only be handled by officers trained in explosives and demolition materials handling. If you are unfamiliar with handling these materials contact trained police or military experts.**
- > Snorkel diving to collect water samples and evidence of dead fish (marine life) in an area where blasting has occurred **is not recommended** unless trained to do so and the appropriate safety supervisor is present.

PHYSICAL EVIDENCE COLLECTION

Time is critical as dispersal of the blast residue and dead marine animals in the environment may be rapid. The priority is to collect evidence which will be lost first, usually this consists of water samples and dead or impacted fish from the impacted scene followed by physical evidence in the boat. Since water samples will dilute the quickest, this is normally the first sample to be collected.

EQUIPMENT NEEDED

- Protective gloves, clothes, boots, glasses and protective dust filter mask, hearing protection.
- Notebook
- Long-handled small mesh fish net
- Extendable sampling pole
- Transportable cool box
- Waterproof digital/video camera
- Submersible water sampler with trigger device

See **WATER 8**

- Weighted sampling hose with peristaltic pump

See **WATER 8**

For water contamination and physical samples:

- Ammonia field test kit
- Metals sample bottle, 0.45 µm filter, 50 cc syringe, 250 mL bottle, 1.0 L nutrients bottle, cans
- Legal seals
- Preservatives - nitric acid

See **TABLE 2.9.3.13**

- Thermometer or temperature meter
- Dissolved oxygen kit or meter
- Conductivity meter



1. Select a water sampling procedure:

Water Sample Method 1: Weighted bottle

- a. Use a weighted bottle holder with a rope and insert a 1.0 litre bottle in the holder.
- b. Lower the bottle from the surface to the bottom of the reef as soon as possible so that the majority of the sample is collected at the area of potentially highest concentration.
- c. Raise bottle after bubbles have stopped exiting.
- d. Preserve the sample as indicated below.

Note: This method will collect water from the entire water column and is likely to dilute the sample and underestimate the concentration of blasting agent in the water. However, it may only be necessary to show the presence of these chemicals relative to the control site.

For image, see **WATER 8**

Water Sample Method 2: Extended Pole Sampler

- a. If the reef is shallow enough, attach the 1.0 litre bottle to an extended pole sampler.
- b. Insert a cork plug with string attached into the neck of the bottle.
- c. Lower the bottle to the depth required and pull the string to extract the cork.
- d. Raise bottle after bubbles have stopped exiting.
- e. Preserve the sample as indicated below.

For image, see **WATER 8**

2. Field test for the presence of ammonium and nitrogen compounds.
 - a. Rinse a 250 mL high density polyethylene (HDPE) container three times with sample water. Note that ammonia will volatilize therefore care should be taken to minimize the introduction of air bubbles during sampling and the field test should be conducted as soon as the sample has been collected.
 - b. To determine the presence of ammonium, conduct a field test using a color-changing strip. Collect a 250 mL samples in an HDPE container to allow for further analysis. Little head space should be kept in the sample bottle to prevent dissolved ammonia



Colorimetric ammonia test kit
(Courtesy of Canada - DOE)



from evaporating into a gas, which will affect the analysis.

3. Test for the presence of potassium (metals). This is the same procedure as for collecting a metals sample.
 - a. For a dissolved metals sample, use a 0.45 micron filter on a 50 mL new plastic syringe and extract a water sample by either: (1) sucking the water through the filter into the syringe; or, (2) filling the syringe and then pushing the water through the filter.
 - b. Deposit sample into a new 250 mL high density polyethylene (HDPE) bottle and preserve using a few drops of nitric acid (1 mL, 35% nitric acid per 100 mL sample) to pH 2.0. The sample must be kept cool (4 °C) and transported to the laboratory as soon as possible for analysis.



See **TABLE 2.9.3.13**

(Courtesy of Canada - DOE)

4. Collect live or dead fish. Time is critical as dispersal and loss of dead or injured fish in the reef environment may be rapid. Evidence of damaged coral may have a longer time frame for the collection of evidence.

Collect/seize any live or dead fish/animals in the water and in possession of the alleged accused. Use an extended pole with fish net to collect samples of the fish. To preserve the fish wrap seal them in aluminum foil and/or sealable plastic bags, excluding as much air as possible. Label



(Courtesy of Canada - DOE)

the sample with identification as to site location and case.

ISSUES RELATED TO BLAST ANALYSIS OF FISH/WILDLIFE TISSUE

Freeze the fish if they are required only for visual confirmation of damage due to blasting.

Note: If tissue structure analysis of the fish is required, they cannot be frozen as the ice crystals will damage the cells. Therefore short term storage at 4°C and examination of cell structure is required as soon as possible. For long term storage, they must be first preserved in a solution of formalin which is then drained off and replaced with a solution of ethanol. Fish should be collected from impacted and non-impacted areas and the tissue structure can be used to show that fish from the non-impacted area do not have damaged cells and fish from the blast impacted area have damaged cells.



5. Collect blast materials.

It is critical to recognize and collect evidence of blast materials. If no other evidence (fish or water) is available to be collected, then collection and documentation of blast materials may be sufficient evidence for conviction as there are no other reasons to be in possession of blast materials when out on an ocean reef if there are no authorized construction projects in the area for which blast materials would be necessary.

Improvised explosive devices for blast fishing may take many forms, two common ones are plastic bottles and bags filled with an oxidizer (ammonium nitrate or ammonium phosphate fertilizers), carbon fuel



agent (usually diesel fuel), and a blasting cap connected to a safety fuse. Two examples are provided above.

- Containers of ammonium nitrate/phosphate pellets/prills.
- Diesel/fuel oil, blasting caps and fuses, improvised explosive devices.
- **Safety:** Do not handle unless trained to do so.
- Hookah breather/compressor, used to provide air to the fishermen



(Courtesy of Canada-DOE)

while they are underwater collecting fish.

- Snorkel gear used for diving.
6. GPS mark and photograph the scene from all angles. Underwater photography may use low cost waterproof digital cameras. The simplest is to attach the camera to an extendable sampling pole and set it to video or to collecting single frames on a timed interval. Lower the camera and collect 360 degree views of the dead/dying fish and the site.

Blast fishing may also damage the surrounding coral, causing it to be broken or have blast craters. Take photos from the control site and the damaged site for comparison. Photograph related paraphernalia that may be present in the boat.

7. Interview responsible people and all witnesses.
8. Write a report and submit it to the prosecutor or judge.

See **WATER 1**

HAZARDOUS WASTE 1: HAZARDOUS WASTES/PRODUCTS ILLEGALLY DUMPED ON THE SURFACE AT A LANDFILL

INVESTIGATIVE STRATEGY

- Determine the type of hazardous waste contamination
- Determine the source of contamination. Interview witnesses, present or former employees, consult historical aerial mapping sources from government or university departments of geography or land registries, or municipal offices and local community.
- Determine the scale of contamination and health risks and damage to the ambient environment (vegetation, crops, soil, wildlife, water ways).
- Define a sampling plan with objectives to minimize health risks and collect at least one background sample, one source sample and one receiving environment sample.

WARNING: Hazardous waste sites require special precautions. For Health and Safety Gear, see SECTION 2.6.

The following scenarios assume that a properly trained and equipped hazardous materials response and specialized sampling team is available.

- > **Case 1:** An informant complains about pollution originating from the suspected or known dumping of hazardous wastes at a permitted facility. Surface water is not at risk, groundwater is not at risk.
- > **Case 2:** An informant complains about a hazardous waste landfill or burial of hazardous waste at a non-permitted facility. Surface water is at risk.
- > **Case 3:** An informant complains about a hazardous waste landfill or burial of hazardous waste at a non-permitted facility. Surface water and groundwater are at risk.
- > **Case 4:** Radioactive wastes are suspected or known to be involved in a hazardous waste landfill or burial of hazardous waste at a permitted or non-permitted facility. Surface water and deeper groundwater may be at risk.

In all cases:

1. Contact a Hazardous Materials Emergency Response Team. In some jurisdictions, the local Fire Department may have a Hazardous Materials Emergency Response Team. If the local fire department and the environmental enforcement agency does not have a hazardous materials emergency response team, call the national organization responsible for such matters.

For **Case 4:** Contact the national agency responsible for the management of radioactive wastes.

2. Secure the site.

BASIC EQUIPMENT NEEDED

- Protective helmet
- Safety glasses
- Protective gloves
- Protective boots/shoes
- Protective breathing apparatus appropriate to the type of waste
- Protective suit appropriate to the type of waste
- Notebook
- Pen
- Camera

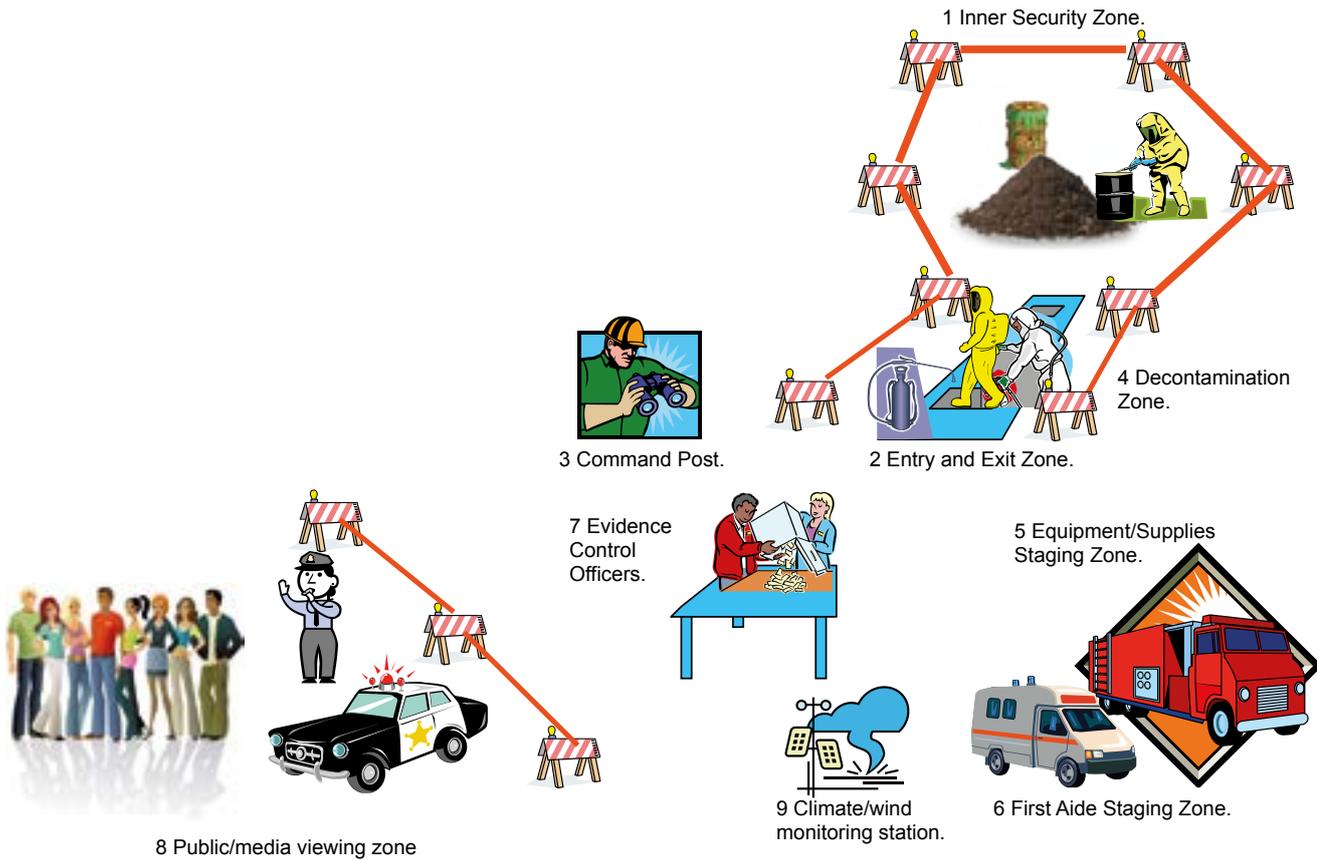
ANALYTICAL FIELD EQUIPMENT NEEDED

- If water is involved: pH, conductivity, dissolved oxygen, temperature, turbidity.
 - If gases are involved: gas sampling tubes or photoionization detectors.
 - For solids: various containers depending on the type of waste.
- See **SECTION 2.9**



Take all necessary steps to secure the site to protect the evidence and prevent the trespass of the public and animals.

Depending on the scale/size/type of hazardous waste the safety precautions will need to be adjusted accordingly. The following minimum criteria need to be established by the environmental enforcement officer or the specialized sampling team responding to the situation:



1. Secure the area with barriers warning signs and/or warning tape.
2. Establish a safe entry and exit zone. If this is a major situation putting public safety at risk then the following may be required.
3. Establish a command post. (Depending on scale of site, this can be a single vehicle to a full scale response unit.)
4. Establish a decontamination zone.
5. Establish an equipment/supplies zone.
6. Establish a first aid post.
7. Establish an evidence control zone.
8. Establish a public/media viewing zone.
9. Establish a climate/wind monitoring station.

(Courtesy of Genesis Environmental Sciences Ltd)

3. Select a representative sampling procedure depending on site conditions and type of waste.

Case 1 Pollution originating from the suspected or known dumping of hazardous wastes at a permitted facility. Surface water is not at risk, groundwater is not at risk.

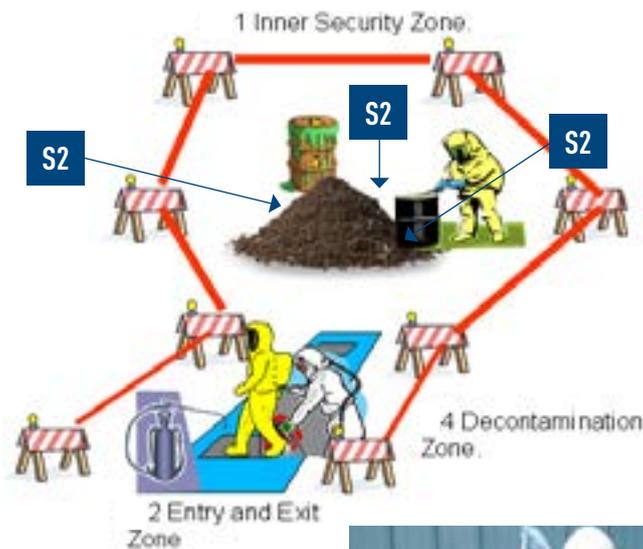
After the site has been secured:

- a. Obtain all records relevant to the waste and identify the type of waste.
- b. Identify the types of sample equipment and sample bottles required. See **SECTION 10 AND 2.9**
- c. Instruct the person sampling on how and where to sample.
- d. Collect samples. Consult with the laboratory for specific protocol or see **SECTION 2.9**

S1 - Background sample from un-contaminated soil near the site. If possible, collect first to avoid cross contamination.

- S2** - Composite sample from each type of hazardous waste.
 - use a composite "Barrel Thief" for unknown liquids in barrels
 - use stainless steel scoops for collection of solids and semi-solids

(Courtesy of Genesis Environmental Sciences Ltd)



S1 Background sample from a street or a field not impacted by hazardous waste

NOTE : Some jurisdictions require up to 3 samples per sample site, one for the enforcement agency, one for the defence and one for the court. Ensure that the correct number of samples per site are collected as per local regulations.



Fritted glass "Barrel Thief" can collect a composite sample from a barrel which may contain layers of different liquid wastes.



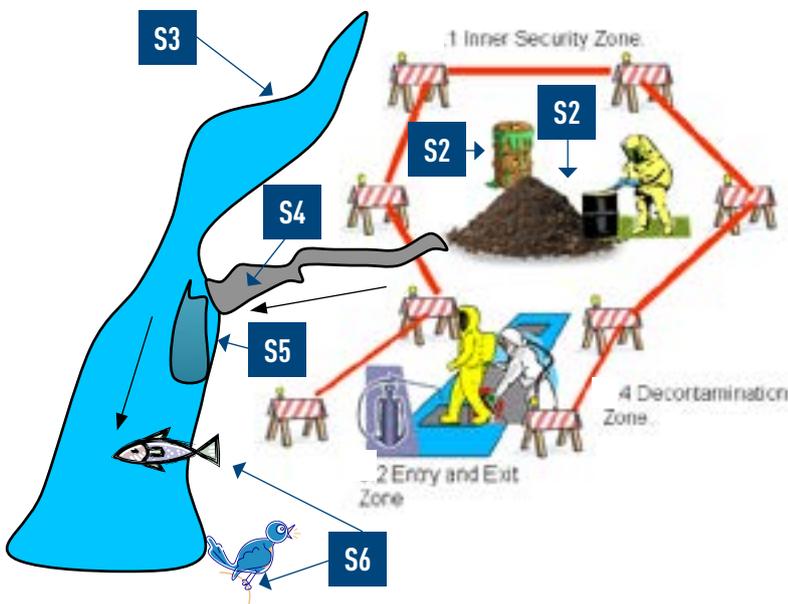
Sampler should wear appropriate safety equipment such as hard hat, respirator, safety glasses, gloves and chemical resistant suit.



Case 2 Hazardous waste landfill or burial of hazardous waste at a non-permitted facility.

Surface water is at risk.

- a. Obtain all records relevant to the waste and identify the type of waste.
- b. Identify the types of sample equipment and sample bottles required. See also **SECTION 2.9**
- c. Instruct the person sampling Hazardous Materials (HAZMAT) responder on how and where to sample.
- d. Collect samples. Consult with the laboratory for country specific protocol or see **SECTION 2.9**



S1 Background sample from a street or a field not impacted by hazardous waste

(Courtesy of Genesis Environmental Sciences Ltd)

- S1** - Background sample from un-contaminated soil near the site. If possible, collect first to avoid cross contamination.
- S2** - Composite sample from each type of hazardous waste.
 - use a composite "Barrel Thief" for unknown liquids in barrels
 - use stainless steel scoops for collection of solids and semi-solids
- S3** - If other critical evidence will not be lost, collect a composite water sample upstream first to avoid cross contamination.
- S4** - Collect a composite water sample prior to stream entry.
- S5** - Collect a composite water just after stream entry.
- S6** - Collect or photograph dead or dying fish and animals that may be impacted by the waste.

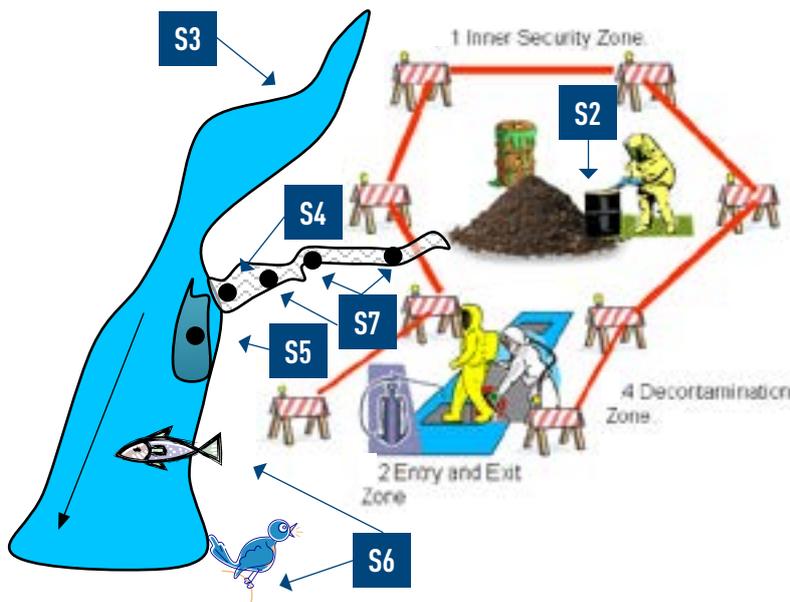


Courtesy of United States - EPA

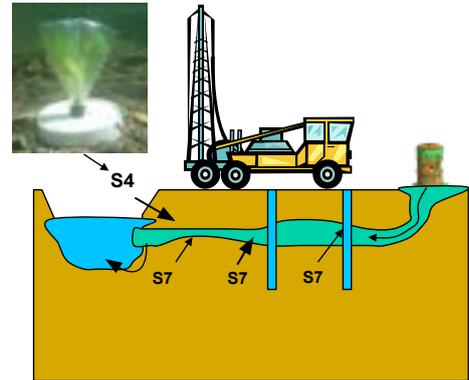
Case 3 An informant complains about a hazardous waste landfill or burial of hazardous waste at a non-permitted facility.

Surface water is not at risk, groundwater is not at risk.

- a. Obtain records relevant to the waste and identify the type of waste.
- b. Identify the types of sample equipment and sample bottles required. See also **SECTION 2.9**
- c. Instruct the person sampling on how and where to sample.
- d. Collect samples. Consult with the laboratory country specific protocol or see **SECTION 2.9**



S1 Background sample from a street or a field not impacted by hazardous waste



(Courtesy of Genesis Environmental Sciences Ltd)

S1 - Background sample from un-contaminated soil near the site. If possible, collect first to avoid cross contamination.

S2 - Composite sample from each type of hazardous waste.
 - use a composite "Barrel Thief" for unknown liquids in barrels
 - use stainless steel scoops for collection of solids and semi-solids

S3 - Collect a composite water sample for chemistry and fish bioassay upstream if possible, collect first to avoid cross contamination.

S4 - Collect a composite groundwater sample for chemistry (and fish bioassay if possible) prior to stream entry - Use seepage meter or shallow piezometer. See **SECTION 6.7.1 AND 6.7.2**

S5 - Collect a composite water sample for chemistry (and fish bioassay if possible) just after stream entry.

S6 - Collect or photograph dead or dying fish and animals that may be impacted by the waste.

S7 - Collect soil and groundwater samples utilising a drill rig to establish the path of the hazardous waste in the groundwater to the surface water. Utilise a groundwater expert.

Case 4 Radioactive wastes are suspected or known to be involved in a hazardous waste landfill or burial of hazardous waste at a permitted or non-permitted facility.

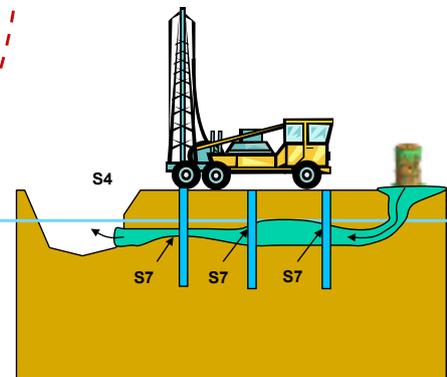
Surface Water and deeper groundwater may be at risk.

- a. Increase the security, Ensure wide margin in exclusion zone with no admittance to the area except for essential sampling and clean up personnel.
- b. Contact the national institution in charge of collecting and processing nuclear wastes. If there is no national institution for the collecting and processing of nuclear wastes contact INTERPOL.
- c. Ensure a high level of safety, and conduct a survey for radioactivity by trained technicians to establish safety zones and decontamination areas. Implement medical monitoring of staff involved in evidence collection.
- d. Collect samples as required depending on the situation, see examples in **CASE 1, 2, 3.**
- e. Develop a cleanup strategy in consultation with the national institution for control of radioactive wastes or the agency referred to by INTERPOL.

Courtesy of United States - EPA

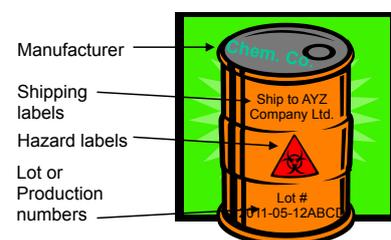


S1 Background sample from a street or a field not impacted by hazardous waste



(Courtesy of Genesis Environmental Sciences Ltd)

4. Submit waste, soil and water samples for specific analysis in the composition is known. Submit samples for scans for organics and heavy metals if composition is unknown. See **SECTION 2.9**
5. Submit liquid waste, contaminated groundwater and contaminated stream water samples for fish bioassay. See **SECTION 6.8**
6. Photograph the scene and any evidence on containers which could help identify the source of the waste or current or past owners.



7. GPS mark and photograph the scene and critical sample points from all four directions of the compass and an aerial view if possible.
8. Collect evidence of documents and papers that may have been left at the scene that may identify the contents of the waste or the ownership of the waste.
9. Determine if the owner was aware of the nature of the waste and potential hazards of disposal.
10. Determine financial responsibility, from the owner if possible, and issue instructions/orders according to local legislation for site assessment and cleanup.
11. Determine if financial profit was gained by inappropriate or illegal dumping.
12. Determine legal responsibility and charges and penalties which apply, based on local legislation.
13. Interview responsible people and all witnesses.
14. Write a report and submit it to the prosecutor or judge. See **WATER 1**



HAZARDOUS WASTE 2: HAZARDOUS TANNERY WASTE ILLEGALLY BURIED IN A LANDFILL

57

Tannery waste may be very high in organic matter which has been made very toxic by heavy metals including chromium. Therefore it can exert a high toxicity to fish, wildlife and humans. It may also have a very high chemical oxygen demand and therefore contaminate ground and surface water and deplete oxygen from those waters and kill aquatic organisms.

INVESTIGATIVE STRATEGY

- Confirm the type of contamination (if it is tannery waste derived or not).
- Determine the source of contamination. Interview witnesses, present or former employees and the local environmental agency. Consult historical aerial mapping sources, such as aerial photos from university departments of geography or government land registries.
- Determine the scale of contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and
- Collect at least one background sample, one source sample and one receiving environment sample.

Safety: Depending on the type of waste and environmental conditions H_2S (hydrogen sulphide gas) can be a safety issue related to tannery wastes. See **HAZARDOUS WASTE 1** for further information.

- Define the H_2S gas affected area using an appropriate gas detector.
- Refer to local health and safety legislation to establish a safe zone with respect to H_2S atmospheric concentration.
- Prevent the public and animals from entering the hazardous zone.
- Refer to local health and safety legislation to use appropriate safety equipment such as protective suits and self-contained breathing apparatus to enter the hazardous zone. If not trained in using protective suits and self-contained breathing apparatus, then obtain the assistance of a hazardous materials response team. See **HAZARDOUS WASTE 1**, **SECTION 2.6** Health and Safety Planning, and **SECTION 10** Sampling Hazardous Waste
- Before entering an H_2S contaminated area:
 - > Ambient air must be tested for the presence and concentration of H_2S by a qualified person using air monitoring equipment, such as H_2S detector tubes or a multi-gas meter.
 - > Testing should also determine if fire/explosion precautions are necessary using an explosive gas meter.
 - > If H_2S gas and/or explosive gas is present, the area must be ventilated continually to remove the gas. If the gas cannot be removed, use appropriate respiratory protection and any other necessary personal protective equipment (PPE), rescue and communication equipment.
- A level of H_2S gas at or above 100 parts per million (ppm) is Immediately Dangerous to Life and Health (IDLH). Entry into IDLH atmospheres can only be made using a full face-piece pressure

BASIC EQUIPMENT NEEDED

- Protective gloves
- Protective suit, shoes and eyewear
- Notebook
- Handheld GPS receiver
- Camera
- Binoculars
- Portable conductivity meter, dissolved oxygen meter and pH meter. Redox potential (Eh) would also be useful in some cases.
- Magnetometer
- Sampling equipment:
 - Augers
 - Groundwater samplers
 - Soil samplers
 - Drills
 - Peristaltic pumps and hoses and/or hand operated well samplers.
 - Extension sampling pole with sample bottle clamp or attachment mechanism
 - Bellows samplers
- Bottles for metals analysis, biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia and nitrates.
- Preservatives for metals analysis
- H_2S testing equipment
- Explosive atmosphere testing equipment
- Respiratory protection if H_2S is present



If H₂S levels are below 50 ppm, an air-purifying respirator may be used, assuming the filter cartridge/canister is appropriate for hydrogen sulfide.



If air concentrations are elevated, eye irritation may become a serious issue. At 50 to 70 ppm full face-piece respirator will prevent eye irritation.



A level of H₂S gas at or above 100 to 300 parts per million (ppm) is Immediately Dangerous to Life and Health (IDLH). Entry into IDLH atmospheres can only be made using a full face-piece pressure demand self-contained breathing apparatus (SCBA).



Gas specific pocket monitors may be worn to provide warning against elevated H₂S (or other gases) to provide audible warnings when thresholds are exceeded. (Courtesy of United States - EPA, Canada - DOE)

demand self-contained breathing apparatus (SCBA), or a combination full face-piece pressure demand supplied-air respirator with an auxiliary self-contained air supply.

- **Incompatibility:** Materials to avoid: concentrated nitric acid, sulfuric acid, and other strong oxidizers. Conditions to avoid: heat, flame, or other sources of ignition.
- Vapors will combust spontaneously when mixed with chlorine, nitrogen trifluoride, or oxygen trifluoride vapors. Distinct hydrogen sulfide odor can be masked by high concentrations of vapors or gases of other chemicals.

1. Select a representative sampling procedure depending on site conditions and type of waste.
 - > **CASE 1:** A landfill containing predominantly tannery waste is discharging leachate to surface water or surface soil. Streams, deep soil and groundwater are not at risk.
 - > **CASE 2:** A landfill containing Hazardous Waste (i.e. tannery waste) is discharging leachate to surface water and/or contaminating soil and/or groundwater due to inadequate landfill containment procedures. Surface water and groundwater are at risk.



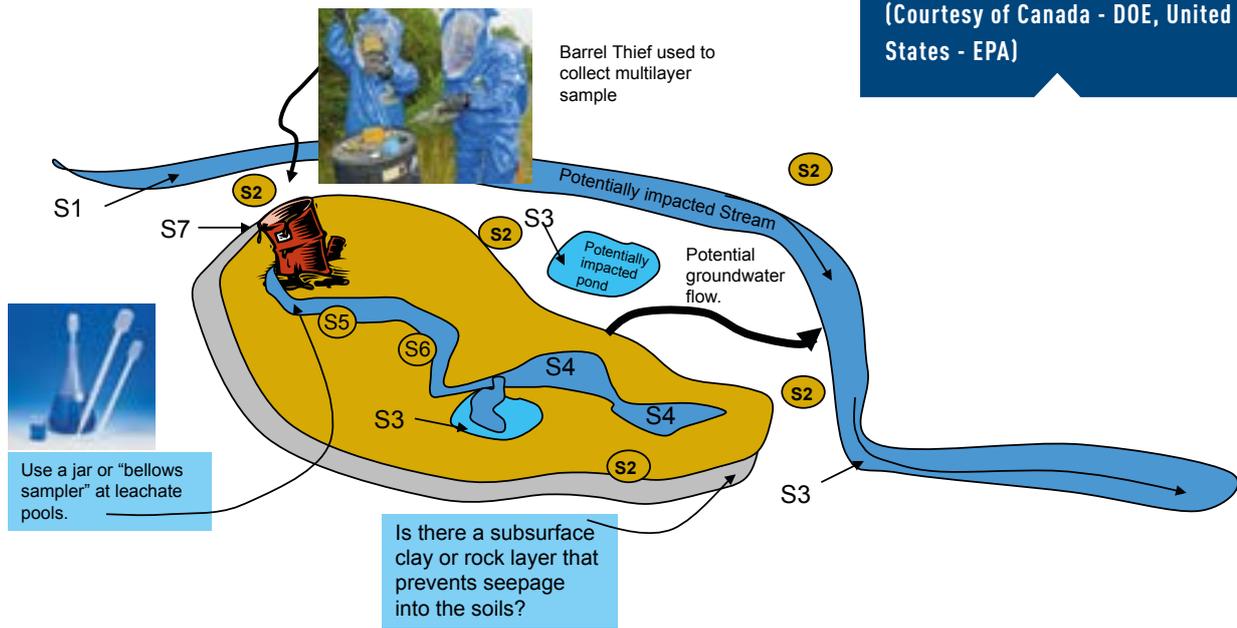
Case 1 A landfill containing predominantly tannery waste is discharging leachate. Surface water and shallow soil are at risk. Deeper soil and groundwater are not at risk.

After establishing that the site is safe regarding H₂S atmospheric concentration:

- a. Obtain permits and other documents that may help identify the type of waste and the legal status of the facility.



(Courtesy of Canada - DOE, United States - EPA)



- b. Perform an environmental assessment of the site with respect to;
 - Topography: Determine how the surface contours and type of soil may have caused the released liquids to flow over the surface of the land.
 - Hydrography: Are the soils permeable? i.e. if there is a lot of clay the liquids will not soak in, but if the soil is sandy or gravel the liquids may seep deeper.
 - Geology: Are there rock formations or layers of sandstone that may provide barriers to the liquids seeping into soil and groundwater?
- c. Measure the potentially impacted site by stepping out the distance by foot, tape measure or preferably a GPS unit.
- d. Hand-held X-ray fluorescence units are expensive but if available can quickly define the boundaries where metal contamination exists.
- e. Collect background samples first to minimize risk of cross contamination. **Note:** Multiple samples may be required to establish the boundaries of the contaminated zone¹. If possible, collect background samples first to avoid cross contamination.

- S1** - Background sample(s) from uncontaminated surface water near the site (choose an upstream point regarding the groundwater flow. Groundwater will generally flow from a high point of land to a low point towards a pond/stream/lake/river).
- S2** - Background sample(s) of soil from outside the contaminated zone.
- S3** - Surface water sample(s) collected downstream of the contaminant discharge point.
- S4** - Surface water sample(s) from the contaminated zone.

S5 - Sample(s) of the spilled tannery waste liquid close to the source.

S6 - Sample(s) of the tannery waste saturated soil.

S7 - Composite sample(s) from the contamination source(s), to characterize it as hazardous¹ (use a composite “Barrel Thief” for sampling containers of liquid waste or sludge) and other analyses²;

See also **HAZARDOUS WASTE 1** and **SECTION 10**

- f. Submit for priority analysis: Chromium (Cr), but may also include lead (Pb), cadmium (Cd), zinc (Zn) and copper (Cu).

¹Ancillary parameters such as electrical conductivity, dissolved oxygen, pH and redox potential must be measured in background and contaminated water sites prior to sampling to help understanding the analysis results.

²Other analyses may be included such as chemical oxygen demand (COD) and biochemical oxygen demand (BOD), ammonium and nitrate in water samples.

Case 2 A landfill containing hazardous waste (i.e. tannery waste) is discharging leachate to surface water and/or contaminating soil and/or groundwater due to inadequate landfill containment procedures. Surface water and groundwater are at risk.

After establishing that the site is safe regarding H₂S atmospheric concentration:

- a. Perform an environmental assessment of the site with respect to topography, hydrography, geology and pollutant sources recording the tracks and waypoints with GPS in order to draw a map of the affected or potentially impacted area.
- b. Use a “magnetometer” (hand-held metal detection device) to determine if there are buried metal canisters or spilled metallic compounds.
- c. Select groundwater and soil sampling sites regarding the groundwater flow. See **WATER 7**
- d. Identify the types of sample equipment and sample bottles required. See **SECTION 2.9** for metals, COD, BOD, ammonia and nitrates.
- e. Select sampling points and collect a minimum number of samples to delineate the contaminated zone. If possible, collect background samples first to avoid cross contamination:

S1 - Background soil and groundwater sample hydraulically upgradient of the discharge point.

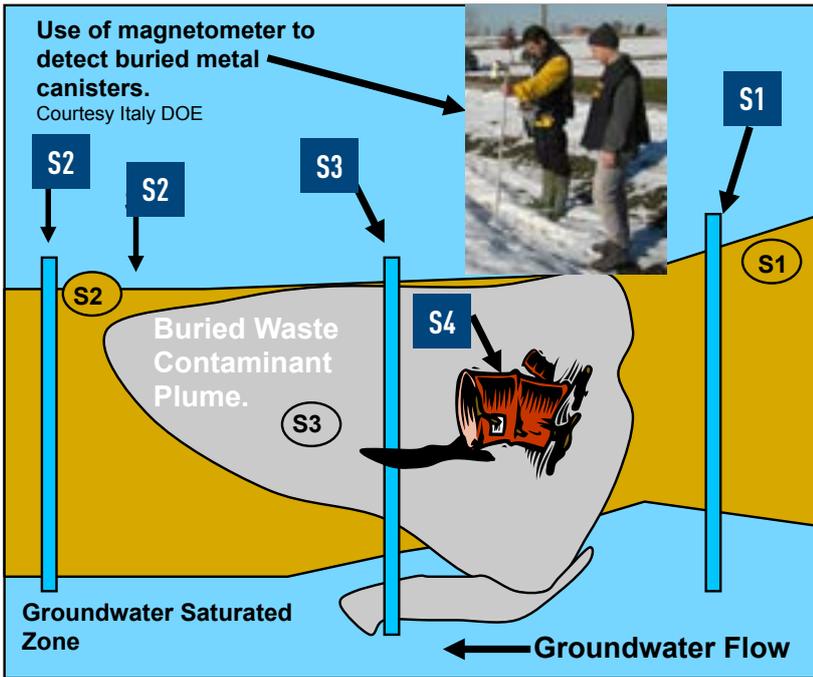
S2 - Soil and groundwater collected downstream of the contaminant discharge point.

S3 - Composite sample of contaminated groundwater and, composite sample of contaminated soils near the source.



Spot sampling with handheld X-ray fluorescence analysers can help quickly map out metal contaminated zones.

(Courtesy of United States - EPA)



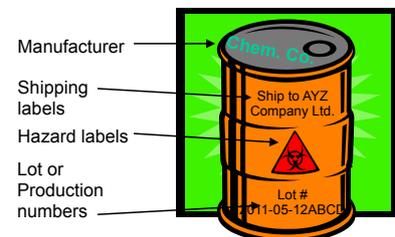
(Courtesy of Canada - DOE)

S4 - Composite sample from the contamination source, i.e. the tank, barrel or pooled liquid from the disposal site. Use a composite "Barrel Thief" for sampling any tanks or barrels or use a jar or "bellows sampler" at leachate pools.

- f. Submit for metals analysis, priority: chromium (Cr) as a priority, but may also include lead (Pb), cadmium (Cd), zinc (Zn) and copper (Cu), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia and nitrates.
 - g. Submit liquid waste, contaminated groundwater and contaminated stream water samples for fish bioassay.
- See **SECTION 6.8**

2. Photograph the scene and any evidence on containers which could help identify the source of the waste or current or past owners.
3. GPS mark and photograph the scene and critical sample points from all four directions of the compass and an aerial view if possible.
4. Collect evidence of documents and papers that may have been left at the scene that may identify the contents of the waste or the ownership of the waste.
5. Determine if the owner was aware of the nature of the waste and potential hazards of disposal.
6. Determine financial responsibility, from the owner if possible, and issue instructions/orders according to local legislation for site assessment and cleanup.
7. Determine if financial profit was gained by inappropriate or illegal dumping.
8. Determine legal responsibility and charges and penalties which apply, based on local legislation.
9. Interview responsible people and all witnesses.
10. Write a report and submit it to the prosecutor or judge.

See **WATER 1**



HAZARDOUS WASTE 3: HAZARDOUS WASTE ATTEMPTED TO BE EXPORTED ILLEGALLY

INVESTIGATIVE STRATEGY

- Identification of waste (categorization).
 - Determine waste volume.
 - Determine traceability (ownership, sources and destinations).
 - Determine illegal profits or cost savings.
 - Determine environmental damage if there has been a release.
1. When the suspected site is a “non-emergency situation” and immediate entry and sampling is not required:
 - It may be necessary to set up a surveillance unit to determine operations, sources and destinations of hazardous waste and identification of waste category.
 - Whenever possible, work with the local representative of the Ministry of Environment in charge of the waste disposal.
 - Initiate inquiries with border control agencies in charge of import and export especially in relation to records relating to the import and export of hazardous wastes and especially in regards to the company(s) and/or person(s) suspected.
 - Obtain copies of records relating to the company under surveillance from border control agencies in charge of import and export especially in relation to records relating to the import and export of hazardous wastes.
 - Identify the persons responsible for transport (conveyor/hauler), the waste owners, the wholesalers, traders and the classification of the alleged wastes.
 - Contact the authorities responsible for import and export in the potential receiving countries for information relating to historical records relating to the company in question.
 - Develop a premises, document and computer search plan with the assistance of local security (police, customs) forensics team.
 - Develop a sampling plan with the assistance of hazardous waste specialists such as local Hazardous Materials Team (Fire department), or Chemical-Biological-Radiological-Nuclear (CBRN) team or consult specialists contacted through INTERPOL, World Health Organization, or United Nations Environmental Program.
 - Ensure proper protective equipment and decontamination procedures are in place and in compliance with local health and safety requirements. See **SECTION 2.6** and **HAZARDOUS WASTE 1**
 - Consult with departmental legal counsel in regards to obtaining necessary legal site entry authorization documents or search warrants.
 - If public safety is at risk, inform local authorities of any actions. Maintain confidentiality.
 - Develop the roles for the various search, seizure and sampling teams.



Loading of waste for illegal export.
(Courtesy of the Netherlands - ILT)



Testing for toxic gas using a "photo ionization gas detector prior to opening shipping container. (Courtesy of the Netherlands - ILT)



Establish a decontamination site when exposure to toxic materials is possible. (Courtesy of United States - EPA)

Depending on the size of the facility and availability of staff, various teams may need to be formed with general duties as follows:

TEAM 1: SEARCHES (IN THE ADMINISTRATIVE PREMISES)

- > Accountability: Look for documents on traceability (waste tracking/delivery slip, consignment note), transit and destination, waste's origin.
- > Volume/Inventory: Look at the stocks and the registers in order to quantify the quantity of waste over a certain period of time.
- > Identification of the waste category: Inspect the firm's laboratory to determine if analysis have been done in order to classify the hazard(s) of the wastes.
- > Financial: When waste trafficking has been identified, have profits been generated? Compare the cost of properly recovered or recycled waste to costs incurred by the disposal company.
- > Computer: Rely on a computer analyst in order to copy the electronic files and e-mails. May have to go back to the firm weeks to months later in order to copy additional files issued during that time period.

TEAM 2: SECURITY (MONITORING OF ENTRANCES AND EXITS)

- > Surveillance may give an idea prior to site entry of what comes in and out of the firm.
- > Are the illegal wastes mixed with proper legal shipments?
- > Are the waste going out of the firm recovered/recycled wastes?

TEAM 3: INTERVIEWS AND STATEMENTS

- > Conduct interviews of the heads of the firm and employees about the process, how waste is treated, the destination and the accompanying documents.
- > Conduct interviews of the heads of the firm in relation to corporate

structure and any knowledge of the offences.

- > Obtain signed statements using hard copy statement forms or a tape recorder for later transcription to hard copy forms to be signed by the witness(s).

TEAM 4: SAFETY AND SAMPLING

See **SECTION 2.6** on Safety

See **HAZARDOUS WASTE 1** and **SECTION 10** for details regarding sampling

2. When an emergency situation has occurred and immediate entry and sampling and search for documentation is required:

- Initiate a search/seizure of documentation and witness statements simultaneously with the sampling plan.
- Utilize sufficient security staff to secure and monitor entry and exits from the premises, buildings and rooms where the search is to be conducted for the entire period of the search/sampling exercise.
- Assign at least one individual as an evidence control officer to receive and log in all legal evidence (documents, electronic media, samples).
- Establish an evidence control area for receiving, storing and logging in of evidence. Ensure that lock boxes for “dry evidence” and lockable coolers for “sample evidence” are available.
- Search for and collect documentation and evidence related to the types of waste, traceability and the volume of materials. Transport and register evidence with an evidence control officer.
- Establish a witness identification and interview area.
- Identify and interview witnesses.



(Courtesy of United States - EPA)



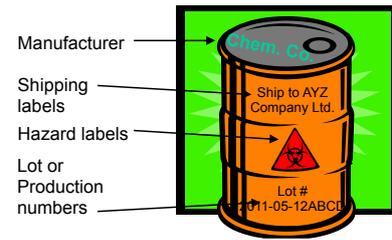
(Courtesy of United States - EPA)



3. Collect appropriate evidence to assess a violation and/or containment, storage and cleanup criteria. Obtain a records relevant to the waste and identify the type of waste.

- a. Identify the types of sample equipment and sample bottles required. See also **SECTION 2.9**
- b. Instruct the person sampling (hazardous materials responder) on how and where to sample.
- c. Collect samples:

- S1** - Background sample from un-contaminated soil near the site, If possible, collect first to avoid cross contamination.
- S2** - Composite sample from each type of hazardous waste.
 - use a composite "Barrel Thief" for unknown liquids in barrels.
 - use stainless steel scoops of solids and semi-solids.
- S3** - For sites near or impacting surface or groundwater, See **HAZARDOUS WASTE 2**



- d. Submit waste, soil and water samples for specific analysis if the composition of the waste is known. See **HAZARDOUS WASTE 1** and **SECTIONS 2.9 AND 10**
- e. Submit liquid waste, contaminated groundwater and contaminated stream water samples for fish bioassay. See **SECTIONS 6.7 AND 6.8**
- f. GPS mark and photograph the scene and any evidence on containers which could help identify the source of the waste or current or past owners.
- g. Collect evidence of documents and papers that may have been left at the scene that may identify the contents of the waste or the ownership of the waste.
- h. Obtain copies of plant operating records.



(Courtesy of United States - EPA)

4. In case of suspicion of an offense or in case of a stated offense:
- Initiate administrative controls or orders allowed by local legislation to properly store, dispose or export the wastes.
 - Establish a file review as soon as possible (within 24 hours) to determine if the case only involves local companies that sent or received the wastes. Or, establish whether the case involves foreign companies and additional checks have to be made abroad with the assistance of foreign governments and/or INTERPOL.
 - Assess the applicable local legislation for any legal options (such as prosecution) or penalties or administrative measures such as directions or civil penalties.

5. Conduct interviews.
 - Interview the site engineer or foreman and ask questions about how the plant process works.
 - Interview accounting staff on how the financial and billing transactions work.
 - Interview corporate/management staff on how the company is structured and ownership issues.
6. Write a report and submit it to the judge or prosecutor.

See **WATER 1**



SOIL 1: CONTAMINATED WITH CRUDE OIL, PROCESSED OR WASTE OIL, DIESEL OR GASOLINE

Fuel oil and waste oil can contaminate soil and groundwater and surface water supplies for drinking water and kill birds and aquatic life.

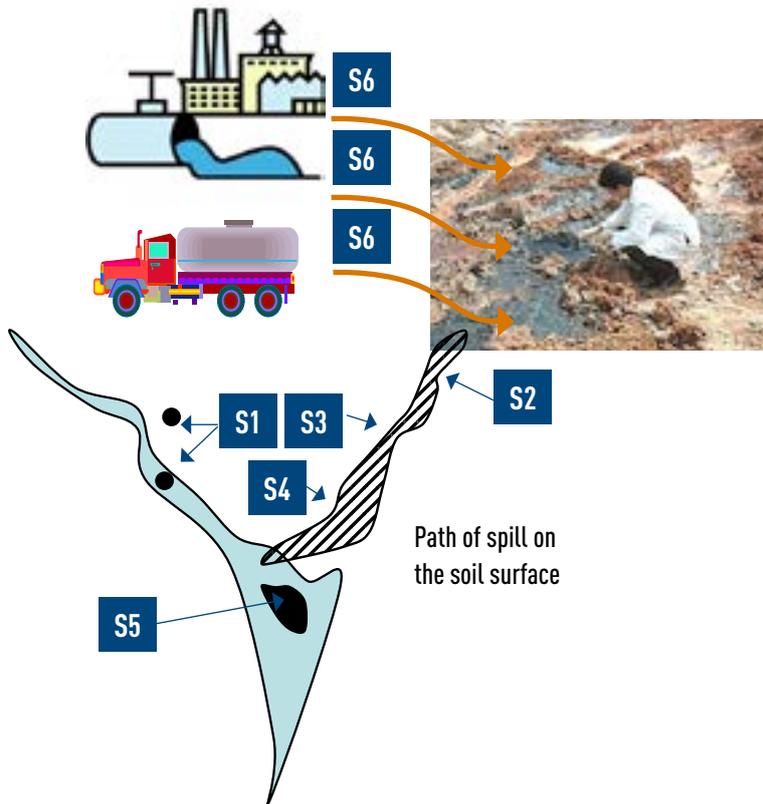
INVESTIGATIVE STRATEGY

- Determine the type of hydrocarbon contamination.
- Determine the source of contamination.
- Determine the scale of contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and collect at least one background sample, one source sample and one receiving environment sample.

1. Select the representative case

CASE 1: Oil only contaminates surface soil and water.

CASE 2: Oil contaminates deeper soil and/or groundwater.



Case 1 Oil only contaminates surface soil and water.

Use a clean stainless steel scoop at each site to collect samples. Collect background samples first to avoid contamination from other samples.

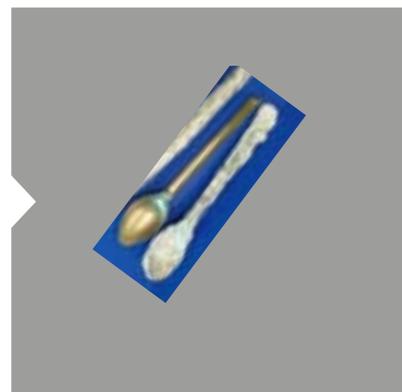
S1 - Background stream surface water sample and surface soil sample.

S2 - Contaminated surface soil sample at the source of the spill.

S3 and S4 - Additional contaminated surface soil samples to illustrate the impact on the receiving environment soils.

EQUIPMENT NEEDED

- Safety glasses
 - Protective gloves, clothes and boots
 - Note book
 - Sampling dark brown glass bottles/ cans.
- See **TABLE 2.9.3.35**
- Legal seals
 - Soil auger and scoop
- See **SECTION 4.6**
- Sampling pole
 - Transportable cool box
 - Camera



(Courtesy of Brazil Federal Police)

S5 - Contaminated receiving water surface sample.

S6 - Source sample for analytical fingerprinting. If possible, collect last to avoid cross contamination of other samples.

Fingerprinting spilled oil and petroleum products.

- a. Crude oil has a unique mixture of organic (carbon based) molecules and metals from each source where it is extracted. Refining may add unique molecules and the use of the oil in machinery may add additional metals fragments that give the oil a "unique chemical fingerprint".
- b. If the oil is spilled onto water or land it begins to age by being subjected to sunlight, wind, water/wave action, bacterial degradation and the addition of sediments. Therefore it is important to collect numerous samples, to link them to the suspect.
- c. As samples are collected further from the source there is more time for the oil to deteriorate and "peaks" are lost. However, there may be enough unique features in each sample to identify the source based on the number of unique chemical features which survive the aging process.

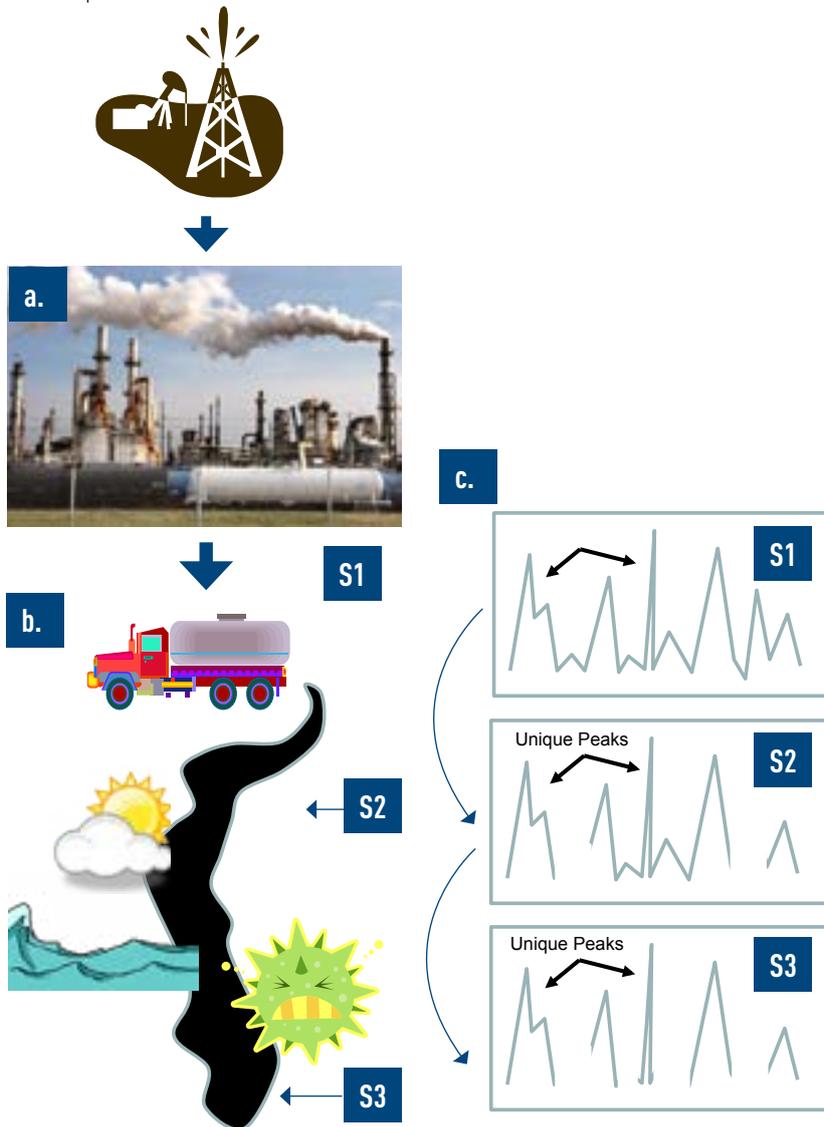
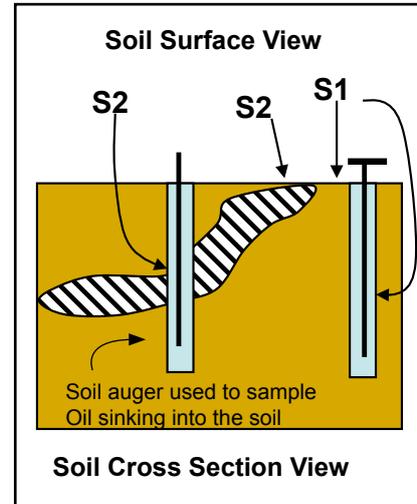
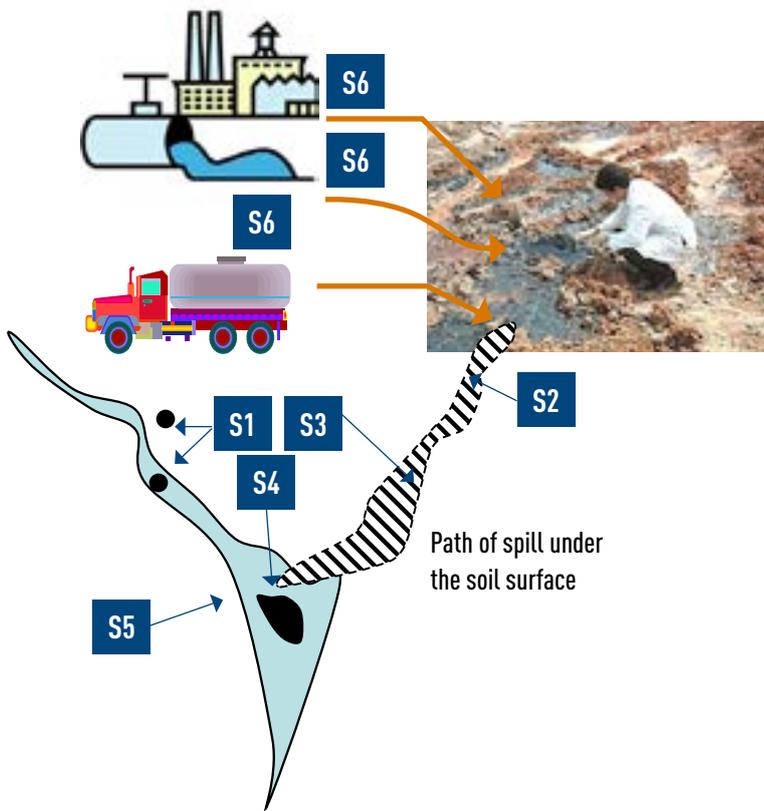


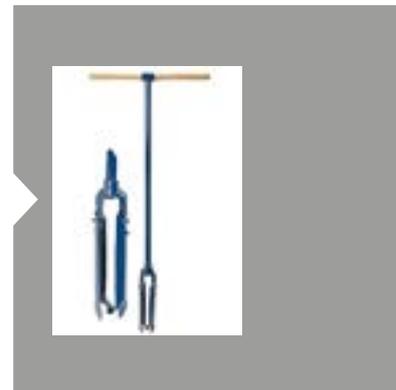
Photo: Courtesy of United States - EPA
 Diagram: Courtesy of Genesis Environmental Sciences Ltd.



Case 2 Oil contaminates deeper soil and/or groundwater



(Courtesy of Brazil Federal Police)



Use a clean stainless steel scoop and soil auger at each site to collect samples.

S1 - Background soil sample at the surface and at depth similar to the depth the oil has penetrated. Collect a background surface water sample.

S2 and S3 - Use a scoop to determine surface soil contamination.

S2 and S3 - Use a soil auger to determine at least one subsurface sample along the path of the oil.

S4 - At least one upwelling water sample. See **WATER 7**

S5 - At least one sample if the oil is floating on the stream to illustrate impact on receiving environment surface water.

S6 - At least one sample from the source for analytical fingerprint comparison between the possible source and receiving environment samples. If possible, sample last to avoid cross contamination of other samples.

2. Submit samples for hydrocarbon identification analysis.

See **TABLE 2.9.2.2**

3. Photograph crime scene and contaminated area, in relation with source if possible. Photograph all sample sites from at least four directions and an elevated view if possible.

4. Interview responsible people and all witnesses.

5. Write a report and submit it to the prosecutor or judge.

See **WATER 1**

SOIL 2: CONTAMINATED WITH AGRICULTURAL PESTICIDES

Pesticides and agrochemicals can contaminate soil, groundwater and surface water supplies, causing illness in humans and killing birds and aquatic life.

INVESTIGATIVE STRATEGY

- Determine the type of pesticide contamination.
- Determine the source of contamination. Read labels (use binoculars if necessary).
- Determine the scale of contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and collect at least one background sample, one source sample and one receiving environment sample.

1. Select a representative sampling procedure:

CASE 1: Pesticide only contaminates surface soil and water

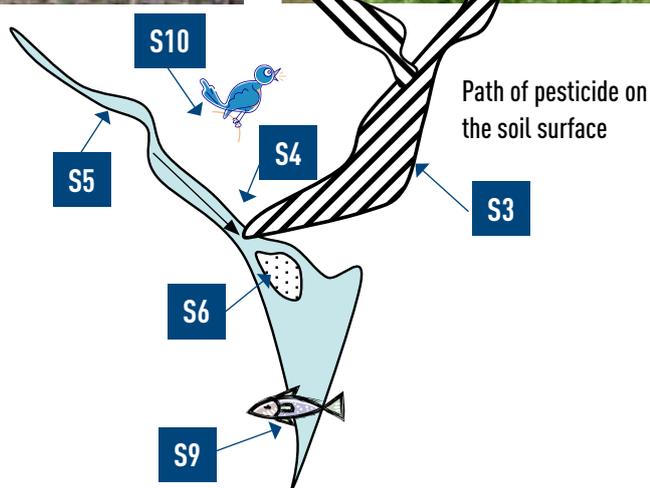
CASE 2: Pesticide contaminates deeper soil and/or groundwater

Case 1 Pesticide only contaminates surface soil and surface water

Abandoned pesticides, agrochemicals



Excessive/illegal spraying of pesticide/ agrochemicals



Use a clean stainless steel scoop at each site to collect samples at:

S1 - Background sample from field not impacted by spray or dumping to determine surface soil background contamination – If possible, collect first to avoid cross contamination from other samples.

S2 - To determine surface soil contamination at the spray or spill site.

BASIC EQUIPMENT NEEDED

- Safety glasses
- Protective gloves, clothes and boots
- Pesticide-grade filter masks
- Notebook
- Sampling dark brown glass bottles/ cans

See **SECTION 2.9.2**

- Soil auger, scoop or sampling thief

See **SECTION 4.6**

- Transportable cool box

- Camera

See **SECTION 2.6** for Safety and **SECTION 10** for Hazardous Waste Sampling

S1 Background sample from a street or a field not impacted by spray or spill





S3 and S4 Additional soil samples to illustrate impact on receiving environment surface soils.

S5 Water column composite background sample.

S6 Water column composite contaminated sample.

S7 and S8 Use "Thief Sampler" to collect composite sample, or drain directly from containers S7 and S8 for possible source comparison for analytical fingerprinting. If possible, collect last to avoid cross contamination of other samples.

S9 and S10 Collect and/or photograph dead wildlife.

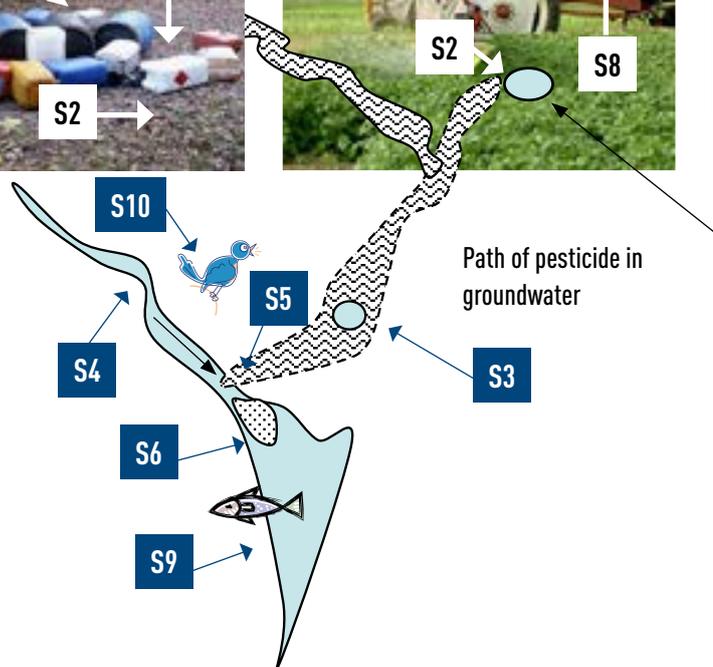
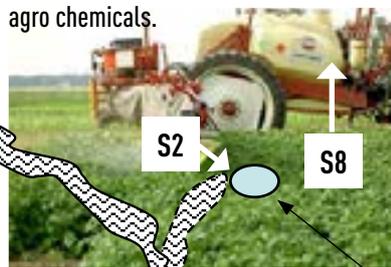
See **SECTIONS 2.7.4 AND 9.4**

Case 2 Pesticide contaminates deeper soil and/or groundwater.

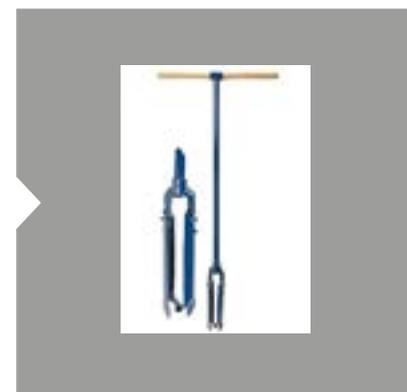
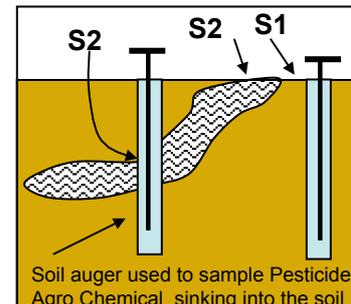
Abandoned pesticide, agro chemicals.



Excessive/illegal spraying of pesticide/ agro chemicals.



S1 Background sample from a street or a field not impacted by spray or spill



Use a clean stainless steel scoop and soil auger at each site to collect:

S1 - Use a scoop and soil auger to determine background contamination at the surface and at depth similar to the depth the pesticide/ agrochemical has penetrated.

S2 and S3 - Use a soil auger to determine at least one subsurface sample along the path of the pesticide/ agrochemical.

See **SECTION 4.6**

S4 - At least one background water sample.

S5 - At least one upwelling water sample. See **WATER 7 AND SECTION 6.7**

S6 - At least one composite water sample from the stream to illustrate impact on receiving environment surface water.

S7 and S8 - At least one sample from the source for analytical chemical fingerprint comparison between the possible source



and receiving environment samples. If possible, sample last to avoid cross contamination of other samples.

S9 and S10 Collect and/or photograph dead wildlife.

2. Photograph crime scene and contaminated area, in relation with source if possible. Photograph all sample sites from at least four directions and an elevated view if possible.
3. Interview responsible people and all witnesses.
4. Write a report and submit it to the prosecutor or judge.

See **WATER 1**



SOIL 3: CONTAMINATED WITH BLOOD AND SLAUGHTER WASTE FROM AN ABATTOIR

73

The discharge of blood and animal tissue into surface water and soils presents a high risk of spreading bacteria and viruses that can contaminate drinking water sources, soils for agricultural purposes and spread illness in people and animals.

The decomposition of blood and tissue by bacteria in water will result in a depletion of available dissolved oxygen which can kill aquatic organisms and fish. This is called high biochemical oxygen demand. The degree of oxygen demand caused by the waste can be measured in a water sample using the 5 day Biochemical Oxygen demand test also referred to as the BOD₅ test.

INVESTIGATIVE STRATEGY

- Determine the type of slaughter waste contamination.
- Determine the source of contamination.
- Determination scale of contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and collect at least one background sample, one source sample and one receiving environment sample.

1. Select a representative sampling procedure

CASE 1: Slaughter waste only contaminates surface soil

CASE 2: Slaughter waste contaminates deeper soil, shallow groundwater and/or surface water

CASE 3: Slaughter waste discharges to storm sewer, shallow groundwater and/or surface water

Safety: The risk of bacterial and viral infection is high. The sampler should wear protective safety gear. See **SECTION 2.6.5**

BASIC EQUIPMENT NEEDED

- Safety glasses
- Protective gloves, clothes and boots
- Disinfectant
- Notebook
- Sampling dark brown glass bottles/cans

See **SECTION 2.9.2**

- Soil auger, scoop, shovel, bucket, stopwatch

See **SECTION 4.6**

- Transportable cool box
- Camera

FOR WATER CONTAMINATION

- pH strips or meter, thermometer or temperature meter
- Dissolved oxygen kit or meter

See **SECTION 2.6** for Safety and **SECTION 10** for Hazardous Waste sampling

Case 1 Slaughter waste only contaminates surface soil

a. If material is highly visible, photographic evidence is the minimum evidence which should be collected. See **SECTION 2.7.4** on photography

b. Use a clean stainless steel scoop at each site to collect samples at:

S1 - Background sample surface runoff and surface soil and analyse for biochemical oxygen demand (BOD_5) to determine surface runoff and soil background contamination. If possible, collect first to avoid cross contamination from other samples.

S2 - Surface runoff of slaughter waste and analyse for BOD_5 to determine surface soil contamination at the spill site.

S3 and S4 - Additional surface runoff of slaughter waste samples to illustrate impact on receiving environment surface soils.



(Courtesy of South Africa - DOE)

c. Analyse soil for BOD_5 . If dump site is remote from suspected source there may be a need to collect samples for DNA to connect the source with the dump site. DNA sampling techniques are not included in this version of the manual.

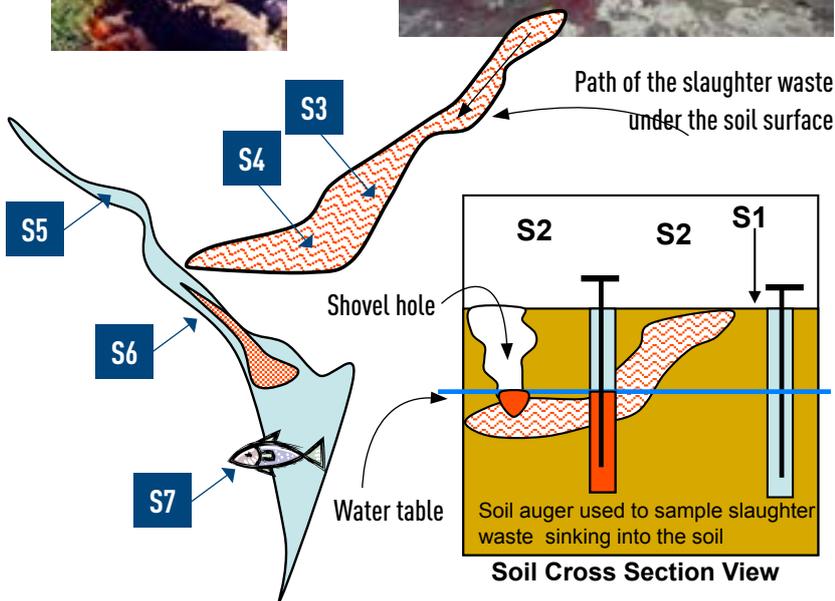


Case 2 Slaughter waste contaminates deeper soil and/or shallow groundwater which discharges to surface water

- a. If material is highly visible, photographic evidence is the minimum evidence which should be collected. See SECTION 2.7.4 on photography.
- b. Use a clean stainless steel scoop at each site to collect samples at:
 - S1** - Background sample surface runoff and surface soil. Analyse for BOD₅ demand to determine surface soil background contamination - If possible, collect first to avoid cross contamination from other samples. For deeper soil and shallow groundwater samples use a clean stainless steel scoop, core sampler or shovel at each site to collect samples at;
 - S2** - Source site, sub-surface shallow groundwater sample and analyse for BOD₅ to determine soil contamination at the level of the water table at the spill site.
 - S3 and S4** - Distant sites, collect sub-surface water and analyse for BOD₅ and runoff and additional soil samples to illustrate impact on receiving environment surface soils.
 - S5** - Depth composite surface water background sample for temperature, pH, dissolved oxygen and BOD₅.
 - S6** - Depth composite surface water contaminated sample for temperature, pH, dissolved oxygen and BOD₅.
 - S7** - Photograph and/or collect samples of dead organisms (fish) likely killed by low dissolved oxygen (caused by high BOD₅).



S1 Background sample from a street or a field not impacted by slaughter waste

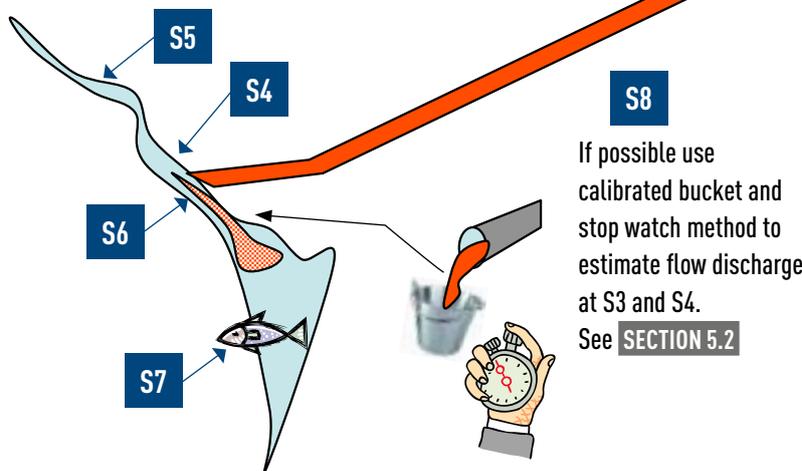


Case 3 Slaughter waste discharges to storm sewer

- a. If material is highly visible, photographic evidence is the minimum evidence which should be collected. See **SECTION 2.7.4** on photography.

Use a clean stainless steel scoop at each site to collect samples at:

- S1** - Background sample surface runoff and soils and analyse for Biochemical oxygen demand (BOD_5) to determine surface soil background contamination. If possible, collect first to avoid cross contamination from other samples.
- S2** - Source site, surface runoff sample and analyse for BOD_5 to determine surface contamination at the spill site.
- S3** - Surface runoff sample and analyse for BOD_5 to determine surface contamination just prior to entry into the storm drain.
- S4** - Discharge from storm drain to surface water, and analyse for BOD_5 .
- S5** - Depth composite surface water background sample and analyse for BOD_5 .
- S6** - Depth composite surface water contaminated sample for temperature, pH, dissolved oxygen and BOD_5 .
- S7** - Photograph and/or collect samples of dead organisms (fish) likely killed by low dissolved oxygen (caused by high BOD_5).
- S8** - If possible, use calibrated bucket and stop watch method to estimate flow discharge at S3 and S4. See **SECTION 5.2**



(Courtesy of South Africa - DOE)

S1 Background sample from a street or a field not impacted by slaughter waste

2. Interview responsible people and all witnesses.
3. Write a report and submit it to the prosecutor or judge. See **WATER 1**



AIR 1: OPEN BURNING OF NON-HAZARDOUS WASTE

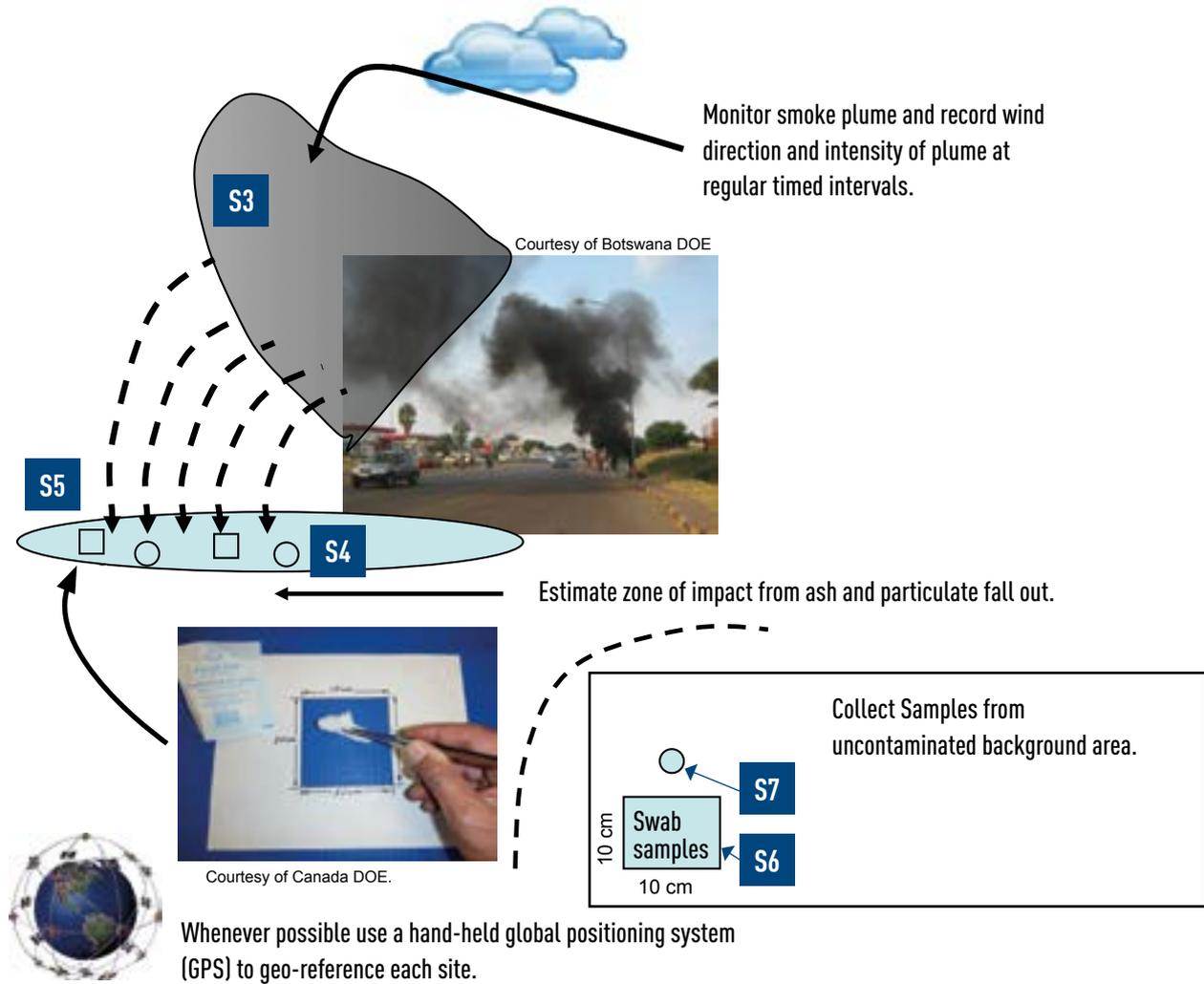
INVESTIGATIVE STRATEGY

Open burning of non-hazardous waste can have serious effects on air quality which impacts human and animal health. Combustion products such as fine suspended particulates can worsen condition for people with heart and lung conditions. Inspection determines that the type of waste burnt does not contain hazardous materials.

Safety: Wear protective gear – disposable coveralls, dust mask, gloves, boots suitable for protection against non-hazardous dust. See **SECTION 2.6**

1. Define a sampling plan that assesses human and environmental risk and objectives.
2. Photograph burning at regular intervals (every 10 to 15 minutes) to document smoke plume intensity and direction.
3. Monitor and record wind direction, make notes and diagram of potential zone of impact from ash and particulate fall out. Photos and notes may be sufficient evidence when non-hazardous waste is burnt depending on local legislation.
4. Photograph crime scene and contaminated area, in relation with source if possible. Photograph all sample sites from at least four directions and an elevated view if possible.

- Take samples in relation to objectives. Collect background samples prior to collecting any other samples to avoid cross contamination.



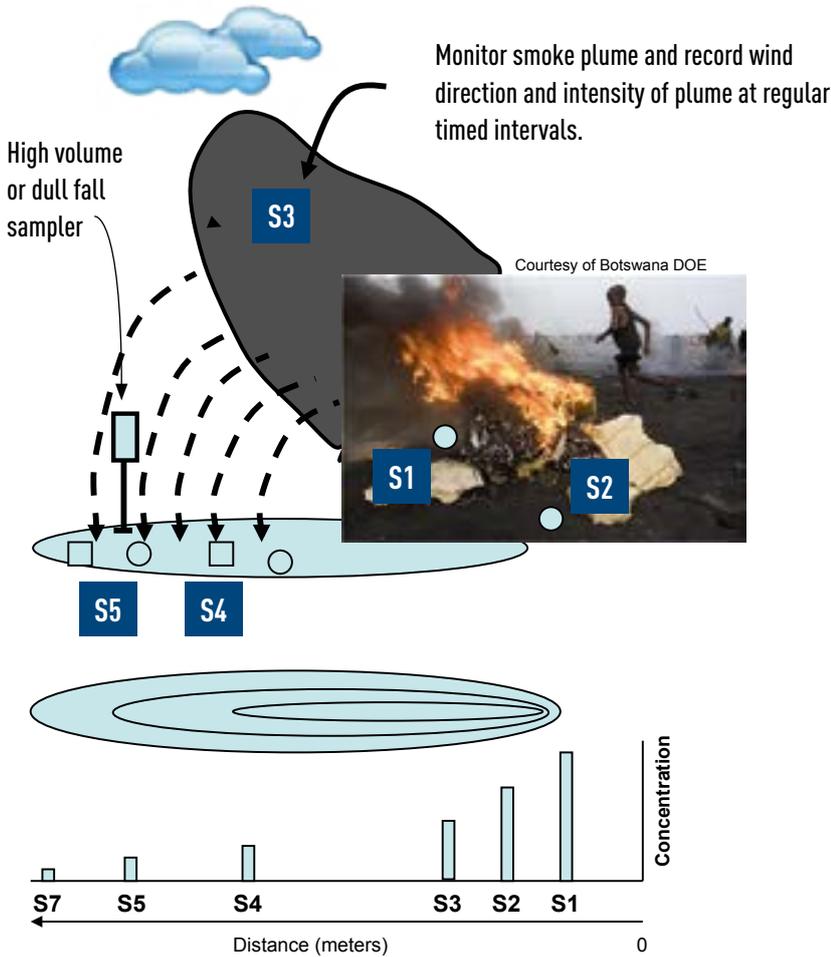
S6 and S7 - Collect surface soil samples and surface swab samples at an uncontaminated background site. (Collect first to avoid cross contamination.)

S4 and S5 - Collect surface soil samples and surface swab samples at increasing distances from the source of the fire. (Collect from furthest away to closest to avoid cross contamination)

S3 - Monitor smoke plume and record direction and intensity of the plume at regular timed intervals.



6. Collect impact zone samples starting from furthest distance away towards center of the fire to avoid cross contamination:



- S2** – Ash sample from the source of the fire. (Collect last if possible to avoid cross contamination.)
 - S1** – Swab sample from a surface near the source of the fire. (Collect last if possible to avoid cross contamination.)
 - S3** - If time and capacity exists or this is a chronic problem, collect dust in a dust fall canister or other volume or gas sampler.
- See **SECTION 8**

7. Interview responsible people and all witnesses.
 8. Compile sample data, plot out concentration grids or graphs relative to distance from the source.
 9. Draft clean up orders relative to local legislative authorities if applicable.
 10. Work with local health authorities if human health impacts occur.
 11. Write a report and submit it to the prosecutor or judge.
- See **WATER 1**

AIR 2: HAZARDOUS WASTE ILLEGALLY DISPOSED OF AND INCINERATED

Hazardous wastes may be illegally disposed or incinerated in very large quantities such as a warehouse fire or in small quantities by dumping into drains, burning in 200 litre metal drums or fed into domestic type waste incinerators. The wastes may contain organic (carbon based chemicals) contaminated with chlorine (polychlorinated biphenyls (PCBs), dioxins and furans), or toxic heavy metals such as arsenic, cadmium, chromium, copper, lead, mercury and zinc. Low temperature burning can cause the organic chemicals to form toxic and environmentally persistent compounds such as dioxins and furans or spread toxic heavy metals into the smoke which distributes randomly with the wind. Fire-fighting foams and spray water runoff also represent a serious hazard to human life or health and to the environment. This can contaminate homes, land, water and food crops and poison humans, plants, animals and aquatic life.

INVESTIGATIVE STRATEGY



BASIC EQUIPMENT NEEDED

- Safety glasses
- Protective gloves, clothes and boots
- Notebook
- Scoop
- Sampling tubes
- Drager tubes (air samples)
- Swab sampling equipment
- Transportable cool box
- Camera
- Handheld GPS receiver
- Appropriate bottles, preservatives for sampling metals and/or organics

See **SECTION 2.9.2**

See **SECTION 2.6** for Safety

Illegal metal recycling operation, smoke laden with partially burnt organics including PCBs, dioxins and furans and heavy metals from plastic and metal components. (Courtesy of the Netherlands - ILT)

If possible, keep people and animals away from areas impacted by hazardous waste. Ensure the site is secured and if there has been a fire that it is extinguished before any site entry and sampling occurs.

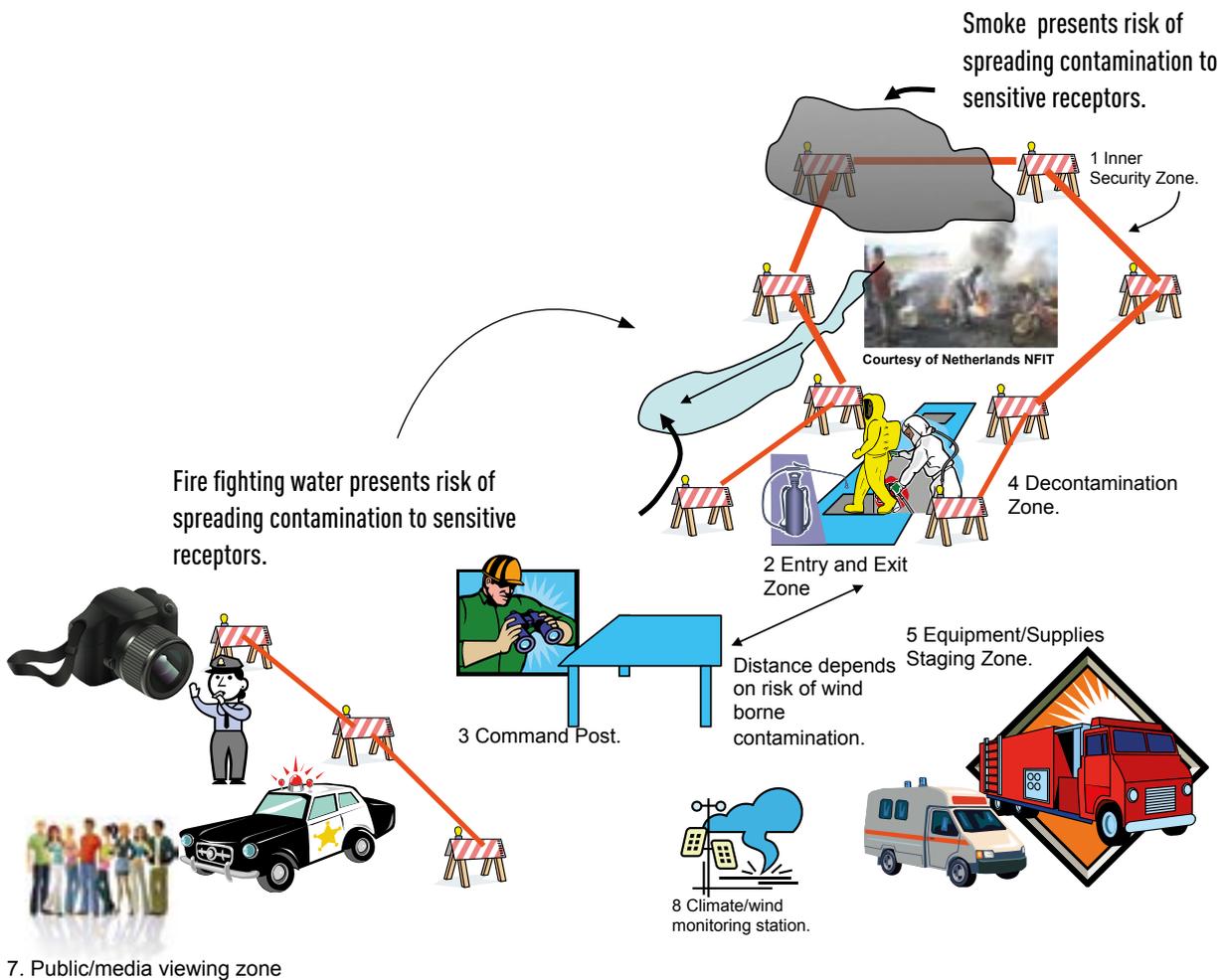
- Determine the source of the waste if possible and identify the hazards it presents.
- Determine the scale of the contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and reduce the risk of tracking of contamination from the source zone to the surrounding area.
- Define a sampling plan which collects at least one background sample, one source sample and one receiving environment sample and collect all available evidence which can define the type of waste and ownership responsibility.



SAFETY

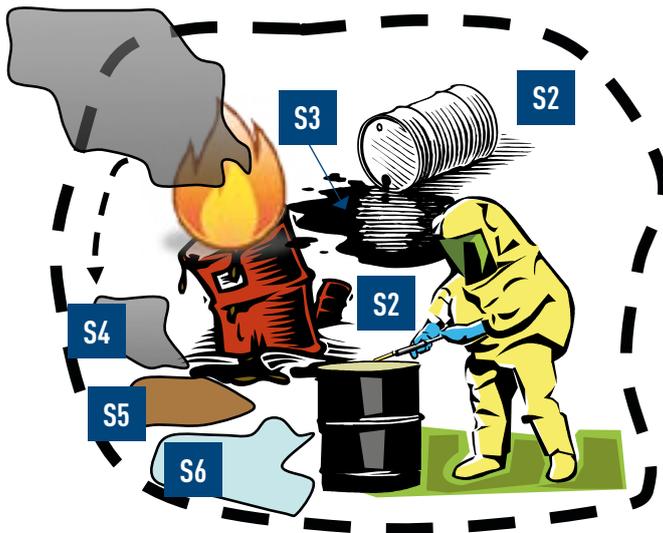
Depending on the scale/size/type of hazardous waste fire, the safety precautions will need to be adjusted accordingly. The following minimum criteria need to be established by the environmental enforcement officer in consultation with the Hazardous Materials Response (HAZMAT) team responding to the situation.

1. Secure the area with barriers and/or warning tape.
2. Establish a safe entry and exit zone based on known or suspected soil contamination, risk of smoke and firefighting water discharges. If this is a major situation putting public safety at risk, then the following may be required:
3. Establish a command post (depending on scale of site, this can be a single vehicle to a full scale response unit).
4. Establish a decontamination zone.
5. Establish an equipment/supplies zone.
6. Establish a first aid post.
7. Establish a public/media viewing zone.
8. Establish a climate/wind monitoring station.



1. Inside the highly contaminated zone: liquid and solids sampling.
 - a. Assess wind direction and evaluate the spread of contamination while smoke is being generated. Determine the best route for a safe approach to the site. **Only approach the site after the fires have been extinguished.**
 - b. Establish Safety Zones and mark off with flagging tape. Keep public and animals out of the zone. Do not enter the contaminated zone unless trained and equipped to do so. See **SECTION 2.6** for Health and Safety information
 - c. If not trained in hazardous site entry, then contact the hazardous materials response (HAZMAT) team, fire department, or the government agency with staff trained in hazardous site entry.
 - d. Using binoculars or other means try to establish the type of waste by examining labels or markings on the containers.
 - e. Develop a sampling plan. See **SECTIONS 2 AND 10**. In a fire situation great care must be taken not to track contaminated soot from the fire scene out to un-contaminated areas.
 - f. Inside the highly contaminated zone there are not likely to be background samples and most waste materials are likely to be highly toxic. Provide sampling instructions to the hazardous site entry person based on the safety requirements. See **SECTION 2.6**, and type of samples and containers required. See **SECTION 2.9** and sampling methods.

- S2** - Collect samples from barrels, containers, tanks
- S3** - Collect samples of spilled chemicals.
- S4** - Collect samples of ash and fallout to determine if metals or chlorinated organics are present.
- S5** - Collect samples of soil.
- S6** - Collect samples of spilled/pooled fire-fighting water.



Contaminated zone

- g. Take photographs of all relevant objects and labels and collect any available documents. See **SECTION 2.7.4**
- h. Ensure decontamination of all persons exiting the zone.

(Courtesy of United States - EPA/
Canada - DOE)



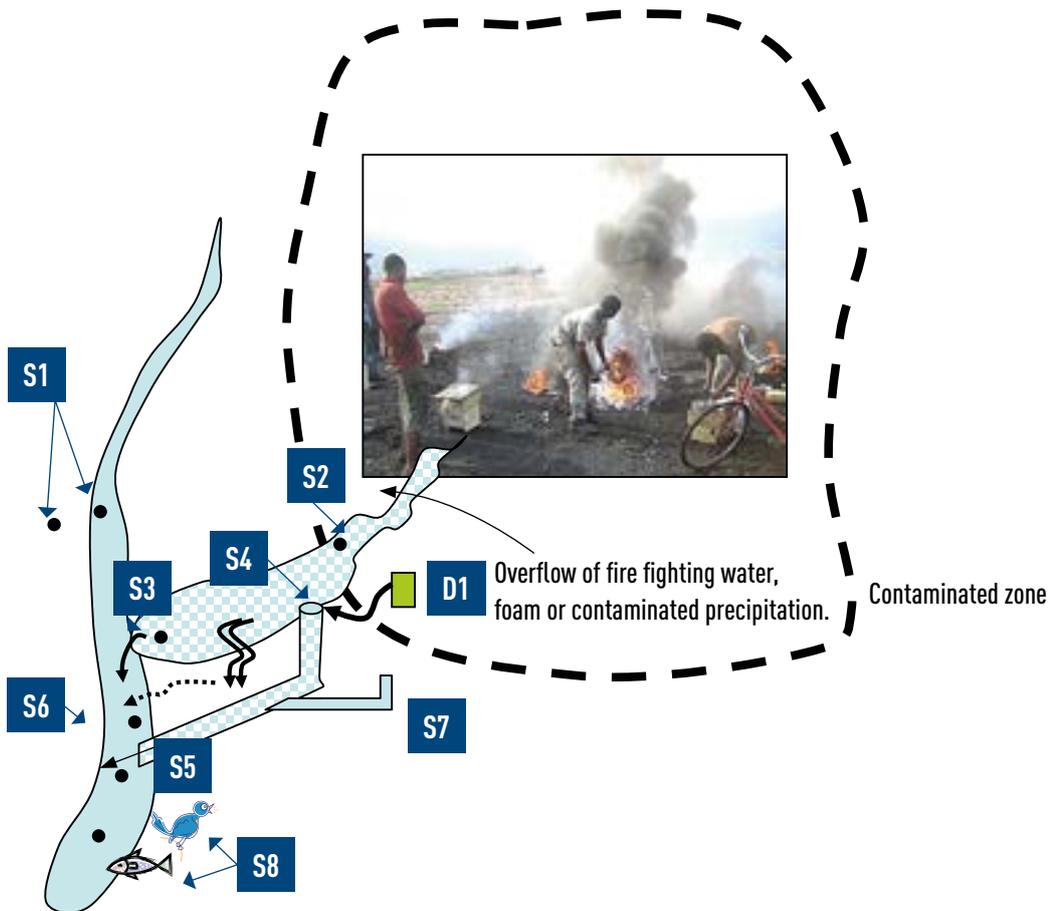
Drum liquid sample is dispensed into a glass sample jar for organics analysis. A duplicate can be placed in a clear glass jar to illustrate multiple layers of chemicals. Hazardous liquid waste of higher density (usually chlorinated organics) may be hidden under a benign layer (commonly called cocktailing).



2. Adjacent to the highly contaminated zone: Surface (fire-fighting water/foam) runoff sampling.

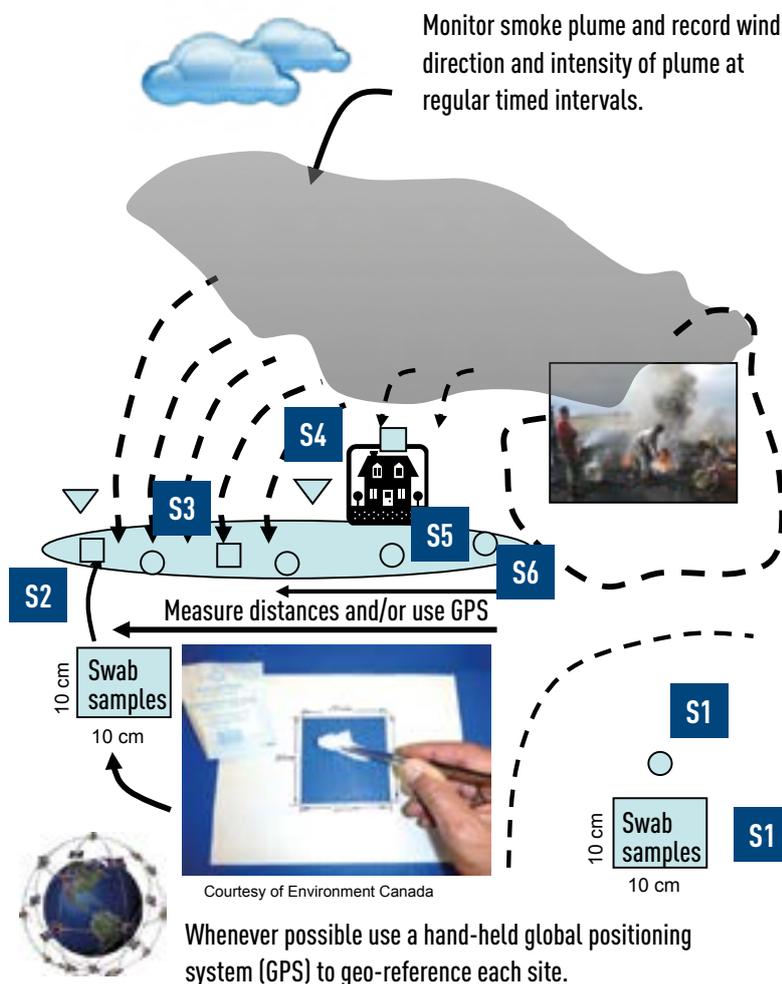
- a. Establish Safety Zones and mark off with flagging tape. Keep public and animals out of the zone. **Do not enter the contaminated zone unless trained and equipped to do so.**
- b. Determine if contaminated fire-fighting water and foams have entered storm sewers and if the sewers discharge to local streams.
- c. Determine if contaminated fire-fighting water and foams have run overland and saturated the ground and entered groundwater.
- d. Collect samples:

- S1** - Background stream sample and soil sample.
- S2** - Overland flow sample.
- S3** - Overland flow sample just prior to stream entry.
- S4** - Entry into storm sewer sample.
- S5** - Exit from storm sewer sample.
- S6** - Upwelling groundwater sample.
- S7** - Sample of fluids entering any other sewers which may connect to the main discharge sewer.
- S8** - Impacted fish, bird and biota sample.
- D1** - Conduct a dye test to confirm storm sewer discharge.



- e. Dye tests should be conducted whenever there is uncertainty over the potential sources of contamination which may complicate the assessment of a sewer system. See **WATER 3 AND SECTION 3.9**

- f. Take photographs of all relevant objects and labels and collect any available documents, and of the sample sites and any impacted biota. See **SECTION 2.7.4**
 - g. Ensure decontamination of all persons exiting the zone.
3. Outside the highly contaminated zone in the area impacted by smoke and fallout. **Safety:** Wear protective gear - disposable coveralls, dust mask, gloves, boots suitable for protection against hazardous dust. See **SECTION 2.6**
- b. Photograph burning at regular intervals (every 10 to 15 minutes) to document smoke plume intensity and direction.
 - c. Monitor and record wind direction, make notes and diagram of potential zone of impact from ash and particulate fall out. Do not enter fall out zone until the fire has been extinguished.
 - d. Take samples in relation with the objectives. Collect background sample prior to collecting any other samples to avoid cross contamination.
 - e. Collect samples from least contaminated to most contaminated, i.e. S1, S2, S3, S4, S5, S6.
 - f. Ensure decontamination of all persons exiting the zone.



- Swab samples using 10 cm x 10 cm cotton swab with hexane if organic chemicals are involved, dilute nitric acid if metals are involved.
- Soil composite samples using stainless steel spoons.
- ▽ Dust fall out samplers may need to be set up to measure immediately falling particles and/or particles which are re-suspended by wind and vehicle traffic. See **SECTION 8** on dust fall sampling

Estimate zone of impact from ash and particulate fall out.

Collect samples from uncontaminated background area.



4. Interview responsible people and all witnesses.
5. Submit all samples for analysis. Analytical requirements depend on the type of waste and the contaminants which may have been created by the fire. For heavy metals, see **SECTION 2.9.2.5**. For chlorinated organics, such as Polychlorinated Biphenyls and pesticides (which can form dioxins and furans), see **SECTION 2.9.3.10**
6. Compile sample data, plot out concentration grids relative to distance from the source.
7. Draft clean up orders relative to local legislative authorities if applicable.
8. Work with local health authorities if human health impacts occur.
9. Interview transporter, factory engineer or foreman and ask questions about how the plant process works, waste handling, shipping, etc.
10. Obtain copies of transporter or plant operating records if possible.
11. Write a report and submit it to the prosecutor or judge.

See **WATER 1**

AIR 3: HAZARDOUS WASTE ILLEGALLY DISPOSED OR INCINERATED (MEDICAL)

Medical wastes may be illegally stored, disposed or incinerated in very large quantities such as a ware house or in small quantities by dumping into landfills, disposed or buried in farming or rural areas. This can contaminate homes, land, water and food crops and poison humans, plants, animals and aquatic life.

The wastes may contain:

- infectious human or animal tissue, blood-contaminated bandages, pathogenic (infectious) bacterial and virus cultures
- sharps, such as needles and scalpels
- heavy metals, such as arsenic, chromium, cadmium, lead or mercury
- toxic organic liquids, such as formaldehyde, solvents, acids (Note: picric acid is particularly hazardous) or bases, photographic X-ray film or silver fixer solutions
- chemo-therapy drugs and X-ray equipment which may or may not contain radioactive materials, waste or expired drugs, pesticides or fungicides
- equipment which contains high pressure sodium and mercury vapor lamps or batteries
- paints and cleaning products and miscellaneous laboratory chemicals

INVESTIGATIVE STRATEGY

If possible, keep people and animals away from areas impacted by medical waste. Ensure the site is secured and if there has been a fire that it is extinguished before any site entry and sampling occurs.

- Determine the source of the waste if possible and identify the hazards it presents.
- Determine the scale of the contamination and health risks.
- Define a sampling plan with objectives to minimize health risks and reduce the risk of tracking of contamination from the source zone to the surrounding area.
- Define a sampling plan which collects at least one background sample, one source sample and one receiving environment sample and collect all available evidence which can define the type of waste and ownership responsibility.

Safety: Depending on the scale/size/type of medical waste, the safety precautions will need to be adjusted accordingly. The following minimum criteria need to be established by the environmental enforcement officer in consultation with the Hazardous Materials Response (HAZMAT) team responding to the situation.

1. Secure the area with barriers and/or warning tape.
 2. Establish a safe entry and exit zone based on risk. If there has been a fire, consider the impact of smoke and fire-fighting water discharges. See **AIR 2** for fire related issues
- If this is a major situation putting public safety at risk, then the following may be required:

BASIC EQUIPMENT NEEDED

- Safety glasses
- Protective gloves, clothes and boots
- Notebook
- Scoop
- Sampling tubes
- Large wide mouth, sealable hard plastic containers, such as a new plastic paint bucket
- Drager tubes (air samples)
- Swab sampling equipment
- Transportable cool box
- Camera
- Handheld GPS receiver
- Appropriate bottles, preservatives for sampling metals and/or organics

See **SECTION 2.9**

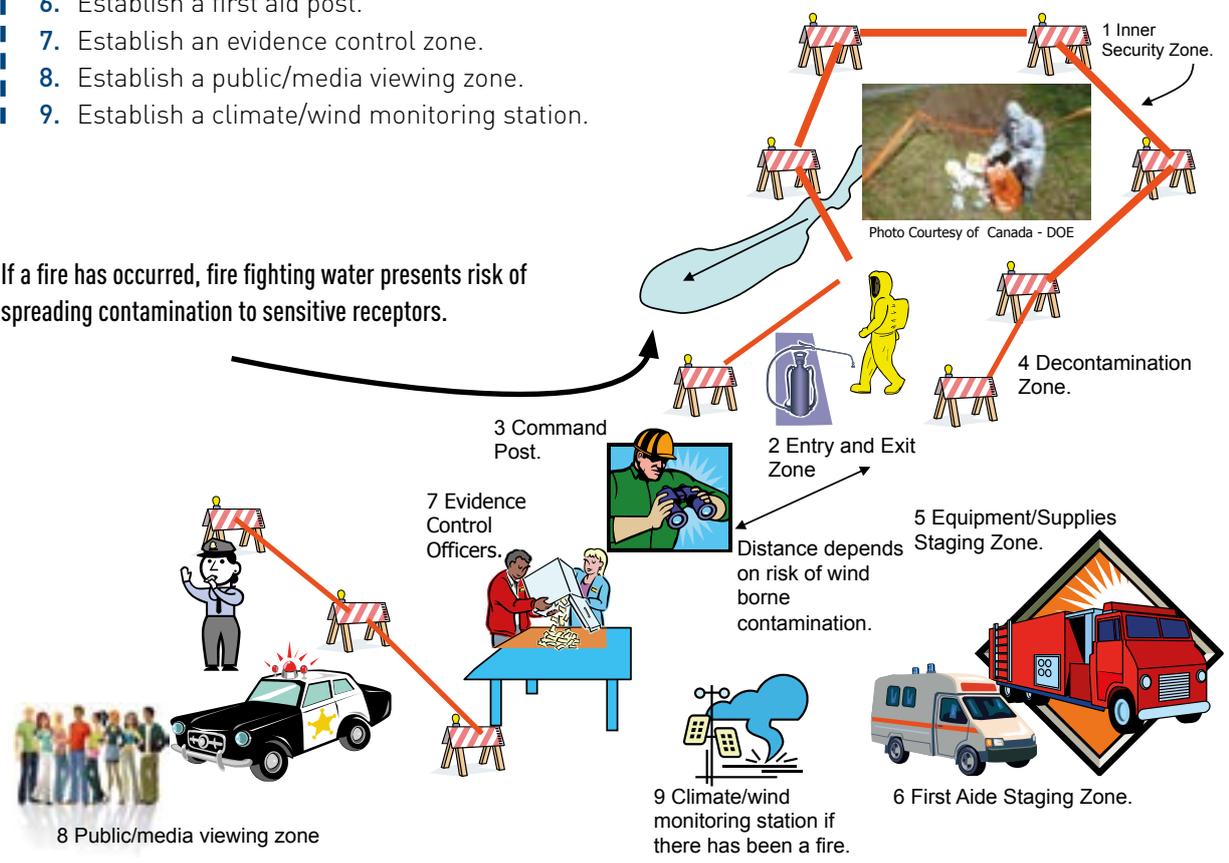


Note possible exposures to the public or animals. In this case a public walkway near the dump site.

(Courtesy of Canada - DOE)

1. Secure the area with barriers warning signs and/or warning tape.
2. Establish a safe entry and exit zone. If this is a major situation putting public safety at risk then the following may be required.
3. Establish a command post. (Depending on scale of site, this can be a single vehicle to a full scale response unit.)
4. Establish a decontamination zone.
5. Establish an equipment/supplies zone.
6. Establish a first aid post.
7. Establish an evidence control zone.
8. Establish a public/media viewing zone.
9. Establish a climate/wind monitoring station.

If a fire has occurred, fire fighting water presents risk of spreading contamination to sensitive receptors.



1. Inside the highly contaminated zone: Liquid and solids sampling
 - a. **Do not enter the contaminated zone unless trained and equipped to do so. Be particularly aware of needles and sharps which can puncture safety boots, gloves and protective suits.**
 - b. If not trained in hazardous site entry, then contact the fire department hazardous materials response team, or the government agency with staff trained in hazardous site entry.
 - c. Using binoculars or other means try to establish the type of waste by examining labels or markings on the containers.
 - d. Develop a sampling plan. See **HAZARDOUS WASTE 1**
 - e. Provide sampling instructions to the hazardous site entry person based on the type of samples and the containers. Inside the highly contaminated zone, there are not likely to be background samples.

S1 Collect labels from stationary, prescription bottles, delivery addresses on envelopes or medical cards to determine the source of the waste.

S2 Use large stainless steel forceps to collect samples of biological waste, needles or sharps. Store in puncture proof clear plastic containers or wide mouth plastic sealable buckets or take photographs to verify presence.

S3 Collect samples of mercury-containing equipment such as broken thermometers, esophageal dilators, cantor tubes, miller abbot tubes, feeding tubes and dental amalgam. Or take photographs to verify presence.

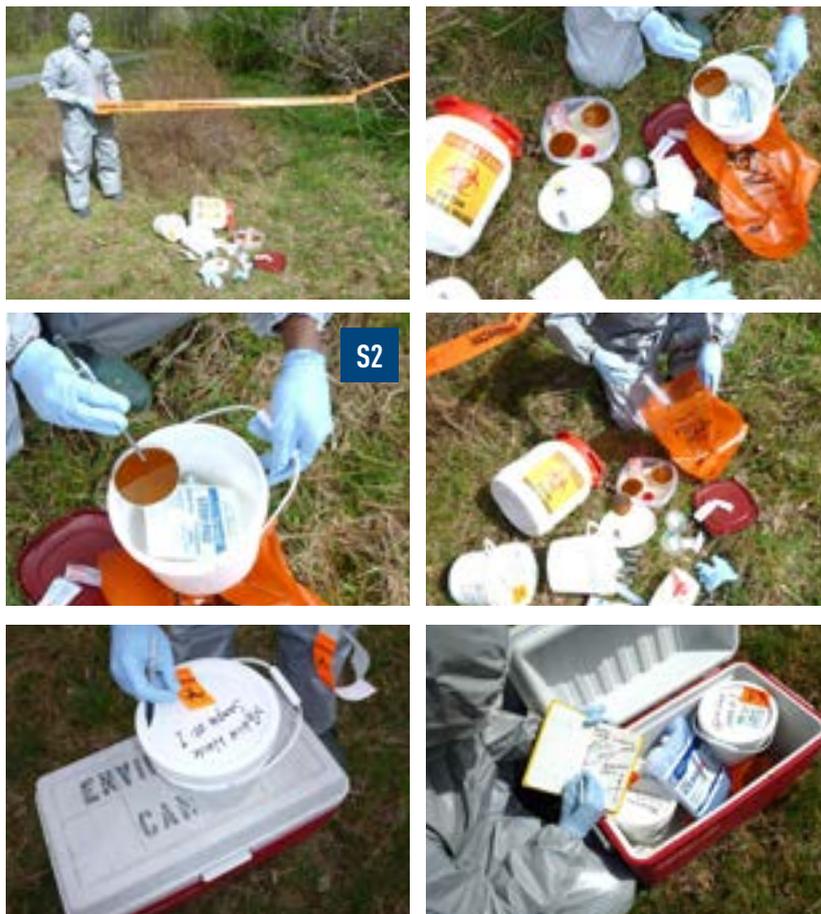
S4 Collect samples of spilled chemicals (heavy metals, organic liquids, acids, bases) - see **SECTION 2.9** for bottle types or take photographs of labels on containers to verify presence.

S5 Collect samples of bandages, tissue, bacterial cultures using sterile protocol and store according to the criteria in **SECTION 2.9** for bottle types and preservation or freezing. Or, take photographs of labels on containers to verify presence.

S6 Collect samples of soil inside the heavily contaminated zone to analyse for metals or solvents.

S7 Collect samples of spilled/pooled fire-fighting water. Analyse for metals or solvents or pathogenic (infectious) bacteria/viruses. See **SECTION 2.9** for containers and protocol.

S8 (If a fire has been present), collect samples of ash and fallout to determine if metals or chlorinated organics are present. For fire, see **AIR 2**. See **SECTION 7.1** for swab sampling and **SECTION 2.9** for bottles and preservation.



Use large stainless steel forceps to collect samples of biological waste, needles or sharps. Store in puncture proof clear plastic containers or wide mouth plastic sealable buckets or take photographs to verify presence. (Courtesy of Canada - DOE)

2. Outside the highly contaminated zone: Liquid and solids sampling
Provide sampling instructions to the hazardous site entry person based on the type of samples and the containers.



S9 - Collect surface water samples from uncontaminated background areas for analysis based on the types of materials found or suspected inside the highly contaminated zone. Place on a white background to photograph clear glass jars to show the difference between background and impacted sites. For organic chemicals use amber glass jars for the actual samples and clear glass ones to show the visual difference. See **SECTION 2.9**

S10 - Collect soil samples from uncontaminated background areas for analysis based on the types of materials found or suspected inside the highly contaminated zone, metals, chlorinated organics. Remove large stones with stainless steel forceps to leave uniform fine sediment/soil for analysis. See **SECTION 2.9**

S11 - Where groundwater contamination is suspected, collect samples from uncontaminated background areas and contaminated zone for analysis based on the types of materials found or suspected inside the highly contaminated zone such as metals or chlorinated organics. See **WATER 7** and **SECTION 6.7**

Note: If radioactive materials/equipment/chemotherapy drugs are known or suspected, contact the national agency responsible for the control of radioactive materials. Keep a safe distance and do not handle the material or equipment. Follow all instructions provided by the radioactive materials handling expert.

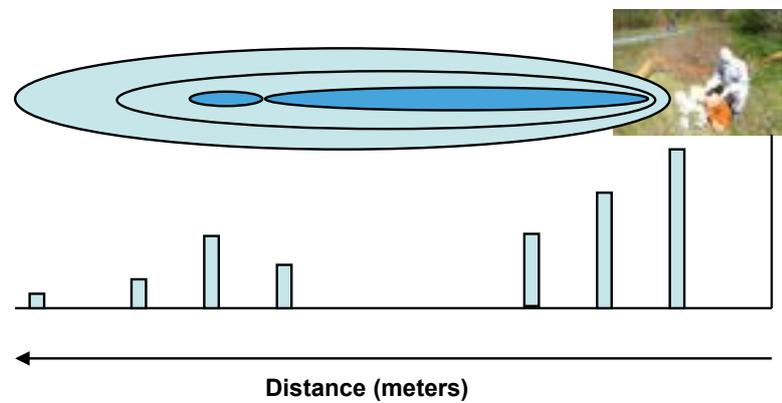


Remove excessively large rocks from soil or sediment samples. (Courtesy of Canada - DOE)

3. Identification of the source of the medical waste
 - a. If identifying documents were found in the waste, contact the source facility to determine who their waste removal contractor was, obtain copies of the contract, invoices or bills of lading.
 - b. If no identifying documents were found in the waste, contact local source facilities (hospitals, clinics, medical offices, dental clinics) to determine who their waste removal contractor was, obtain copies of the contract, invoices or bills of lading.
 - c. If no identifying documents were found, check with local medical equipment, medical chemical and biological laboratory equipment suppliers.
 - d. Interview witnesses, determine if there are vehicle descriptions or license numbers.
 - e. Review files, determine if there are reports of similar crimes and compare details.
 - f. Take photographs of all relevant objects and labels and collect any available documents and photograph the scene from four directions and elevated position.
4. Interview responsible people and all witnesses.
5. Submit all samples for analysis depending on the type of waste and the contaminants which may have been created by a fire. See **AIR 2 AND SECTION 7.1** for information on surface swab samples.



6. If there has been a fire, compile sample data, plot out concentration grids relative to distance from the source.



(Courtesy of Canada -DOE)

- 7. Draft clean up orders relative to local legislative authorities if applicable.
- 8. Work with local health authorities if human health impacts occur.
- 9. Interview medical waste transporter and ask questions about how the waste handling, shipping etc. works and obtain any documentation that relates to financial issues and profits.
- 10. Obtain copies of transporter or plant operating records if possible.
- 11. Write a report and submit it to the prosecutor or judge.

See **WATER 1**



2

SAMPLE PLANNING AND DOCUMENTATION



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Sample Planning And Documentation

Thorough planning is important to ensure success in your sampling and collection of data/information for a successful enforcement action. The goal of any sampling program is to produce a set of samples representative of the source under investigation and suitable for analysis to identify the compound(s) in question.

There may be more than one objective when planning your sampling; the primary objective may be an emergency response to a spill, while a secondary objective may be a subsequent legal investigation.

You will be able to meet both objectives through preparation of a detailed sampling plan. It is important to research existing information sources before the start of a sampling trip to ensure that you understand the sampling protocols required for the compliance assessment or legal investigation. You should also plan that you have enough sampling containers and the correct tools, and that you have taken the required safety precautions.

Creating a well-documented sampling plan will support the actions taken before, during and after the sampling. A systematic approach will demonstrate to the court the quality of the work and reliability of the evidence and assist you in recalling details for factual or expert reports or court testimony.

The written “Sample Plan” may have many different formats and **TABLE 2.1** presents a basic logical format.

Table 2.1 | Content of a typical environmental forensics sampling plan

CATEGORY	DETAILS	NOTES AND REFERENCE
TITLE	Title which describes the project.	
INFORMATION SOURCES	A summary of the background information of the site.	This may require that a preliminary site inspection be conducted.
INTRODUCTION AND OBJECTIVES	Describe the issue and the purpose of the investigation/sampling. Typical goals include identification of the type and concentration of substances of concern.	
LEGAL ISSUE(S)	A description of the legislative issues and potential violations. Will this be routine sampling or legal sampling for the purpose of an enforcement action?	This section will have to address under what legal authority the inspection or investigation is being conducted and what legal tools such as inspection and investigation search warrants are required.

SCOPE	The extent of the investigation and description of the actual or alleged zone of impact. Description of any preliminary inspection information.	
CONSULTATIONS	This may include consultations with technical staff, sampling experts, and especially the analytical laboratories.	
SAMPLE MATRIX	Describe the types of samples which have to be collected.	
METHOD OF SAMPLING	Describe the types of equipment required.	
DETAILED SAMPLING PLAN AND SCHEDULE	Provide details of the number and location of sample sites and the types of analysis required at each site. This is often done best by developing a spreadsheet which details the sites in a logical order, usually from upstream to downstream.	This will also include control site selection and quality assurance and quality control (QA/QC) requirements.
SAMPLE CONTAINERS, PRESERVATIVES, HOLDING TIMES	Provide details of the number of sample containers per site and preservative and transport requirements. This can be added as additional columns to the sampling plan spread sheet to allow the totalling of equipment, preservative, and analytical requirements.	
COORDINATION WITH LABORATORIES	Identification of certified laboratories must be done. This section must provide details of any logistical issues, contracts, special requirements, and supplies to be obtained from the laboratories.	
HEALTH AND SAFETY PLAN	Once the physical details of the sampling plan have been identified, the risks and hazards and mitigation measures can be developed and the necessary equipment and support procured.	This section will require the development of a Task Hazard Analysis Sheet. This should also include how communications will be handled.
TRAINING	Do any of the issues identified in the plan require that staff receive training or that specifically trained people need to be hired under contract?	
SECURITY	This should identify certain situations which may require site and evidence security support.	Enforcement agencies may have to be contacted to provide site security.
ADMINISTRATIVE ARRANGEMENTS	Once the physical issues, support staff, security, equipment and transportation issues have been identified, the details in terms of equipment, staff, budgets, and contracts can be determined.	

2.1 INFORMATION SOURCES

There are a number of information sources to use in gathering data which should be researched prior to initiating an inspection/investigation, if time permits:

- compliance records
- other existing records
- applicable regulations, guidelines, and codes of practice
- standard reference methods (SRMs) and scientific literature
- newspaper files
- other government agencies
- municipal archives
- hydrographic surveys
- harbour commission records
- past surveys
- topographical maps and charts
- similar circumstances in-house or at other agencies
- health and safety legislation.

Prior to sampling, you should review and understand the applicable local legislation, including regulations, permits, interim orders, guidelines, codes of practice, and other legal or regulatory documents. Some regulations and guidelines include specific sampling procedures or standard reference methods (SRMs) that must be followed.

2.2 CONSULTATION – LEGAL, TECHNICAL AND LABORATORY EXPERTS

One of the most important aspects of the planning process is the joint involvement of the data users: the samplers, laboratory analysts and legal team. Each group should be involved from the outset, because each has a critical role in defining data quality requirements and legal requirements.

The legal team must understand the scope of the technical case and can provide guidance on the type of evidence required and assistance with legal documents/inspection warrants and search warrants. Technical experts must be informed of the site conditions and the legal objectives, and should subsequently provide advice on sampling techniques, industrial processes, or physical environmental constraints and how they can be overcome.

Laboratory analysts must understand the final objectives and ultimate goals of the sampling and analysis.

Understanding the principles of analytical methods is also important in the planning process, since methods can strongly influence the sampling



protocols. For example, the sensitivity to contamination and type of analytical method, the desired detection limits and similar considerations may directly influence the method of sampling, as well as the volume and type of sample to be taken. Analytical methods will also affect the choice of storage containers and preservation techniques.

One essential sampling decision that must be resolved by consultation and documented during the planning stage is if the sampling protocol involves quality control (QC) sampling. How many and what types of QC samples will you need to take? The answer will depend on the sensitivity of the test in question, the conditions of the sampling trip (for example, how widely separated sampling sites are), and the laboratory's requirements.

2.3 PRELIMINARY SITE ASSESSMENT

If you are able to conduct a preliminary site visit, you will be able to more fully understand the sampling requirements. Your site reconnaissance can assist you in explaining the issues and technical details of the case to legal staff, technical experts and laboratory staff. It will aid in identifying what equipment you will need, what safety and hazard considerations to plan for, and what your technical approach to site sampling will consist of.



FIGURE 2.1:
Initial site assessment of a suspected hazardous waste burial site in an agricultural area. Site plans are reviewed and potential exploratory dig or sample sites are logged in with a Global Positioning System (GPS). (Courtesy of Italy - Corpo Forestale dello Stato)

After reading this manual, you should have the ability to answer the questions in each of the three stages:

2.3.1 SAMPLING PREPARATION

- Are you familiar with which regulations apply and what are the requirements?
- Where are you going?
- Do you have background information on the location or facility you are visiting?
- Do you need assistance or a search warrant to conduct your work?
- Do you have all required safety equipment and information?
- Do you have experience in all required techniques available?
- Do you have a sampling plan and is it possible to pre-determine sample sites?
- What are the analytes you will be sampling for?
- Do you know what sample size will be needed?
- Have you talked to the laboratory for consultation?
- What are the quality requirements for data quality objectives, as well as for QA/QC?
- What are the preservation methods for the sample type(s)?
- What are the holding time(s) before the sample must be analysed?
- What sampling containers and equipment will you need?
- How many sites will be sampled and do you have QA blanks for each site (travel, field and equipment blanks)?
- Do you have complete chemical categorization kits and strips?
- If this is a legal sample, do you have chain-of-custody forms, a lockable tool box, numbered seals, plastic bags, and a cooler with a locking device?
- Have you tested your equipment prior to going into the field?
- Do you have the ability to clean equipment in the field?
- Have you checked expiration dates on kits, containers, equipment, etc.?
- Have you included all relevant information in your sample planning documentation?
- Is the sampling procedure dependent on weather or other climatic factors?
- Is the sampling dependant on time, tides?
- Do you have the capacity to geo-reference the sample sites?

2.3.2 SAMPLING

- What method of sampling will you use for physical, chemical, biological, or air samples?
- Is it necessary to change/increase the number of samples? Does the laboratory need to be notified of the change/increase?
- What approach will you use for your sampling (judgmental, systematic or random)?
- Have you documented your sampling approach and which sampling protocols you will use?



- Do you have the correct preservatives with you?
- Do you have the correct containers, lids, and seals (which will not contaminate the sample)?
- Do you have the correct personal protective equipment and other safety equipment?
- Has your equipment been calibrated according to the manufacturer's guidelines?
- Do you have extra batteries?
- Is your camera or video camera working correctly?
- Have you conducted your QC with your required travel, field and equipment blanks?
- Have you labelled and sealed each sample?
- Have you photographed the sampling location?
- Have you recorded all relevant observations and labelling information into the notebook?



FIGURE 2.2:
Transfer of sample custody directly from the field officer to the analyst reduces the chance for error and the number of witnesses which may have to be called to testify.
(Courtesy of Canada – DOE)

2.3.3 SAMPLE DELIVERY

- Have you contacted the lab to let them know what to expect or to check that your samples have arrived?
- Do you know who will be signing for your samples at the lab; is their name listed as the receiver on the shipping information?
- Do you have all your shipping packing material, gel ice packs, and coolers?
- Have you completed all forms?
- Are all containers labelled and sealed correctly?
- For legal samples, have you filled out the chain-of-custody form?
- For legal samples, have you correctly sealed the samples, tool boxes, and coolers?
- If you are sending samples by courier, have you kept a copy of the waybill?
- Will your samples be delivered to the lab in time to be analysed within the correct holding times for the analyte in question?

2.4 LEGAL SAMPLING STRATEGY AND SAMPLE SITE SELECTION

The legal sampling strategy and selection of sampling sites is one of the most critical steps in any environmental monitoring or surveillance planning. The development of a representative sampling strategy will depend on the legal objectives and the analyte of interest. You should be knowledgeable about conditions on-site prior to sampling. When possible, physically inspect the site before taking any samples, or research any available records such as file information or previous reports. Consult with others who may know the site. In some cases, aerial reconnaissance or satellite imagery using tools such as Google Earth may help in targeting sampling sites.

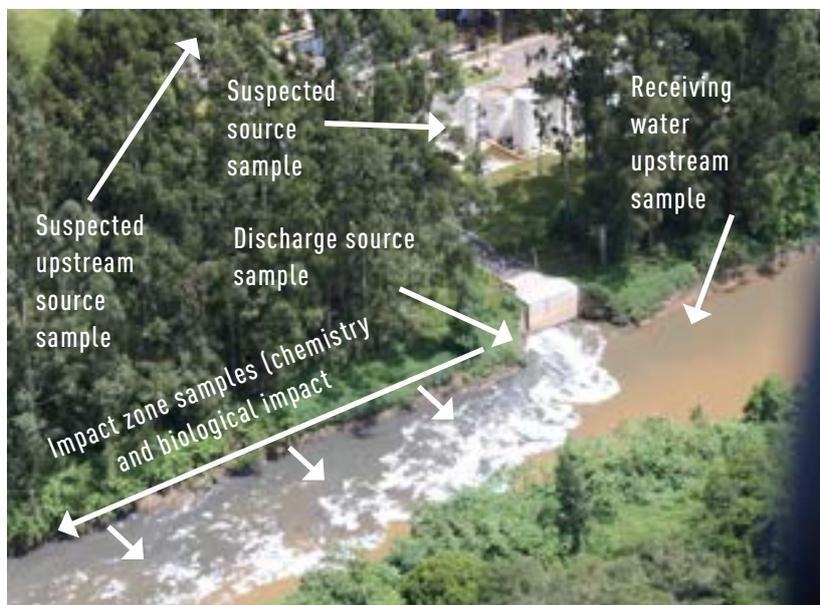


FIGURE 2.3:
Aerial reconnaissance or satellite imagery can be used to determine sample sites and give perspective of the zone of impact.
(Courtesy of Brazil – Federal Police)

- Are regulatory requirements a factor?
- What are the sampling matrices (chemical, soil, water, air, waste, etc.)?
- Does the substance mix with water, float on it, or sink?
- Has the substance dispersed via air or water currents?
- What volume of sample is required?
- Should you collect a grab or composite sample?
- Do you use an automatic sampler or collect samples manually?
- At what depth or elevation will you collect the samples?
- Is access a problem?
- Will it be easy to re-sample if required?
- Can you find the location again?

The selection of a sampling method will depend on the size of the study site and the desired degree of statistical certainty and accuracy. The sampling points are often predetermined for routine compliance monitoring. In situations such as spills or specialized surveys, sampling



locations must be chosen to reflect the objectives of the sampling program. In the case of a spill, the primary objective may be to collect sufficient material for identification in the lab and link the spilled material to the suspected source, while a secondary objective may be to assess the possible impact on aquatic organisms or zone of impact to assess legal and financial penalties.

Ensure your sampling objective matches your strategy for choosing sampling points, for example:

SAMPLING OBJECTIVE:

To find unknown sources of known contamination.

STRATEGY:

Set up a grid of regularly spaced parallel or intersecting lines and take samples at regular intervals by consistently sampling at the axis or centre point in grid segments. If the area is large, consider doing a large-scale grid first, followed by a smaller-scale grid once the target area has been identified.

SAMPLING OBJECTIVE:

To determine the extent of contamination from an industrial outfall in a river.

STRATEGY:

Assume that the concentration of the contaminant will decrease with increasing distance from the source; also consider factors affecting dispersion of materials from the point source (e.g. current). Select sampling stations at fixed distances downstream, following a geometric progression (i.e. distance = x , $2x$, $4x$, $8x$).

SAMPLING OBJECTIVE:

To determine contamination from a sunken ship.

STRATEGY:

Locate sampling stations in concentric rings at fixed distances and specific compass angles (e.g., 45° or 90°).

2.4.1 CONTROL SITE SELECTION

Control sites are used for determining if the analyte of interest is present in the test samples from the impacted site but absent in the control sample. Control samples should be taken upstream or upwind from a point source, a spill or a waste disposal site. Sampling points in control sites must be chosen to avoid possible contamination. There are generally two types of control sites:

LOCAL CONTROL SITES are near the sample site, usually far enough upstream/upwind of the source of contamination so as not to have been affected by the incident. This type is most likely to have similar physical characteristics to the impacted site and is usually preferred.

AREA CONTROL SITES are towns, roads, industrialized, commercial or rural areas or watersheds which are of similar in physical features and climate to the impacted site and which are in the same general area as the affected area. These sites are used when local control sites are not available.

SUGGESTED PROCEDURE

1. Select site(s) with common physical characteristics and climate to the affected area, except for the pollution source.
2. Always take local control site samples first, if available, before sampling effluent or spill site(s) to avoid contamination.
3. Minimize travel between control site and sampling site to avoid contamination.

2.4.2 ZONE OF IMPACT SITE SELECTION

Zone of impact assessment depends on the legislative authority in the jurisdiction. If the only objective is to prove that a criteria or standard was violated at the point of discharge, sample and evidence collection may only be done at or very near the source. Collection of a sample from a pollution source may provide information/evidence of an offence but it is unlikely to provide information on the scope or extent of damage related to the incident.

Some jurisdictions take extent of damage into account when assessing enforcement actions and penalties. The scope of damage will be valuable for the assignment of penalties for an offence and is very useful for the judiciary in understanding “Who was the victim of the offence?”. Not only must you determine “Is it bad?” by sampling directly at the source but you must also determine “How bad is it?” by sampling at greater distances to estimate or determine the extent of damage to the environment and the public interest, especially if the pollution results in economic damages.

For this reason, an actual or estimated “zone of impact” should be considered in the sampling plan. Normally a series of samples starting from the outer limits of the actual or estimated zone of impact are taken progressively closer to the source are required. Estimating the extent of the zone of impact will then support an estimate of the sampling strategy and the number of samples which must be collected. The size and complexity of sampling will provide a basis to estimate costs for sampling, analysis, and the resources in time and personnel necessary to complete the sampling.

See **SCENARIOS** for illustrations of zone of impact assessment.



2.4.3 SAMPLING STRATEGY – JUDGMENTAL, SYSTEMATIC OR RANDOM

There are three primary approaches in sampling: judgemental, systematic (or stratified) and random. It may be useful to use two of these three approaches in combination.

2.4.3.1 Judgmental Sampling

Judgemental sampling is often the method of choice for regulatory and emergency response sampling and is usually implemented on an urgent basis for quick assessment of a site. The number of samples is usually small and thus analytical costs are lower.

Determining locations that will provide the most representative samples require knowledge of the distribution of the parameter(s) in question. This knowledge is gained through personal observations or interviewing witnesses to the event. Validity will depend on the accuracy of this knowledge. Because the validity of judgment sampling can be questioned in court, inspectors should always document reasons for choosing a particular sampling location. Judgemental sampling will depend on knowledge of how a pollutant behaves in a particular setting.

For example: A discharge of cold contaminated water into warm water will result in the pollutant sinking to the bottom. Therefore, the sample would be collected in the bottom of the water column rather than at the surface.

Field measurements such as pH, conductivity or temperature can also be used in selecting the most appropriate sample location.

2.4.3.2 Systematic Sampling

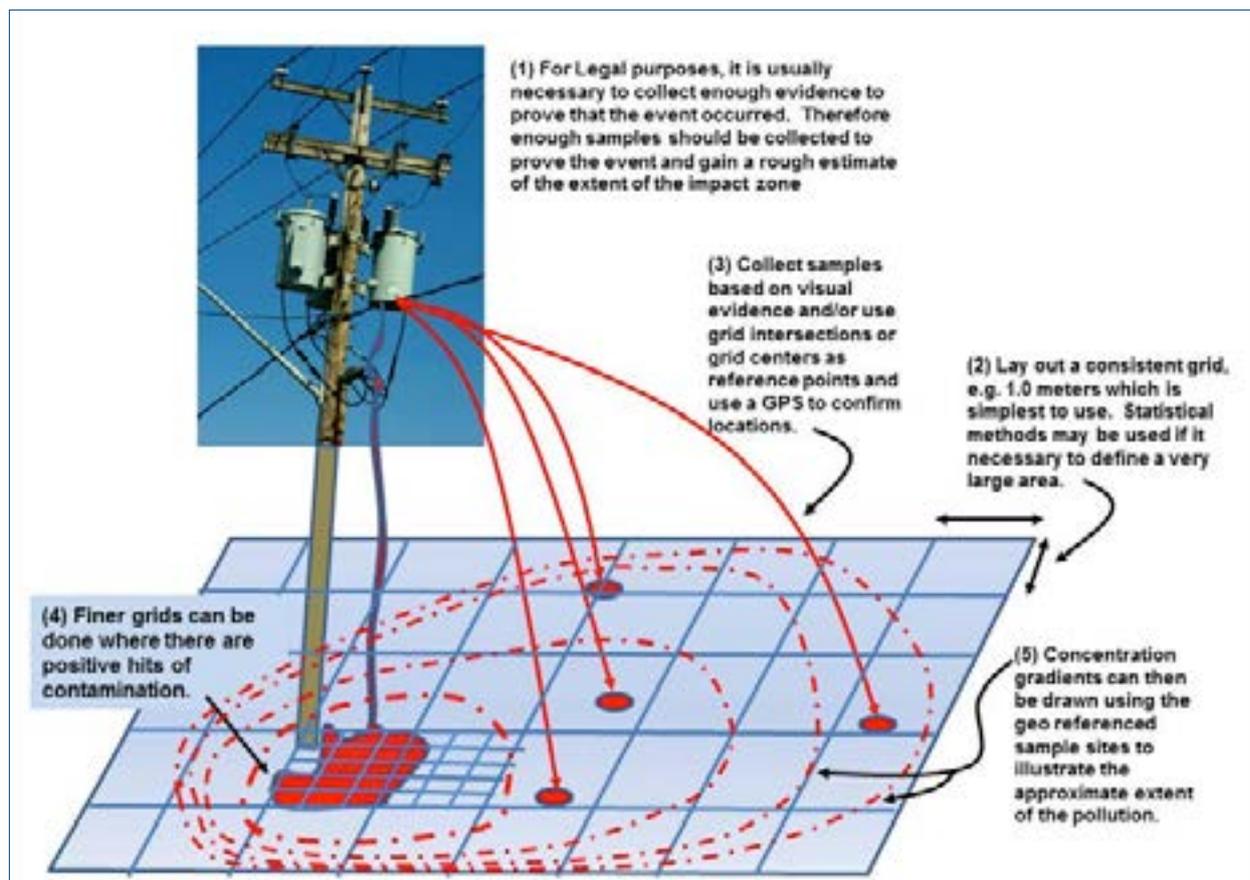
Systematic sampling is relatively easy but may take longer to set up and be more expensive due to the larger number of samples analysed. It involves taking samples over regular distances or intervals in a horizontal and/or vertical grid pattern. The grid size will depend on the event and the degree to which the site must be characterized. For most legal investigations, the grid is larger so as to gain order of magnitude estimates. For clean-up operations, the grid will be smaller so as to provide a statistical assurance that contamination has been cleaned up.

For example: In horizontal sampling, a spill of chemicals from a truck may require a grid size of a 1.0 m x 1.0 m or less whereas a discharge from an outfall may require shellfish samples are taken at 1 km intervals along a shoreline. In vertical sampling, water samples are taken from sequential depths in the water column based on knowledge of current patterns.

Systematic samples taken at regular time intervals can be used for geo-statistical data analysis, or to produce site maps showing analyte locations and zones/lines of similar concentrations.

Sites are chosen inside the impacted zone and outside the impacted zone in the known or suspected path of the contaminant. The same sites are sampled multiple times over a specific time period. The changes in the concentrations at the sites can be used to map the historical, present and predicted future location of the contaminants.

See **WATER 7** for illustrated groundwater plume maps.



2.4.3.3 Random Sampling

Random sampling relies on the theory of random chance to choose representative samples. This process is useful when numerous sampling locations are available, but there are no particular reasons for choosing one over another or if the analytical budget is low. This method is subject to increased uncertainties.

For example: When sampling a dump site involving many drums, separate the drums into groups according to their content, if known. Sample from each group randomly.

Random sampling is also often used for sampling lagoons, ponds, and other surface waters. Here, the area of concern is divided into a two- or three-dimensional grid and the sampling points are chosen randomly. A table of random numbers can be used or some calculators may provide random number generators. Generally for initial site investigation, judgemental and grid sampling are easiest to use.

FIGURE 2.4:
Example of Systematic Grid Sampling.
(Courtesy of Genesis Environmental Sciences Ltd.)



2.4.4 ROUTINE SAMPLES AND DOCUMENTATION

There is usually no distinction between the methods used to collect a routine sample versus a legal sample. Both the routine and the legal sample must use a proper technique which results in the collection of a sample that is representative of the situation. Therefore, the same type of method, sample container, preservative (if required), and transportation conditions (e.g. 4°C in the storage container) are used for a routine sample as are used for a legal sample.

For a routine sample, the requirement to document the history and handling of the sample is usually less rigorous than for a legal sample. However, care should be taken to observe the following best practices:

- Use proper labels, traceable clean containers and lids;
- Follow sampling and handling protocols (preservation, holding time, transport, etc.);
- Use the requisite QA/QC (blanks, replicates, etc.);
- Use proper notes and forms as documentation to prove the samples history.

2.4.5 LEGAL SAMPLES AND CHAIN-OF-CUSTODY DOCUMENTATION

The distinction between legal sampling and routine sampling is the ability to prove in court the chain-of-custody of a sample. This is the practice of ensuring security of the sample so that no one has an opportunity to tamper with or otherwise alter the sample or the results. The prevention of tampering involves the placement of seals on the sample container and locking the sample in storage, shipping containers and/or vehicles in such a manner so that no one other than the documented sample handlers has direct access to the samples.

Legal sampling should be conducted under the following circumstances:

- When you strongly suspect a violation may have or is occurring for which an enforcement action and/or a penalty is likely to apply;
- Spills or environmental accidents;
- When you have no previous knowledge about compliance history;
- There is unlikely to be a subsequent chance to collect a sample or the cost/logistics of collecting a subsequent sample are prohibitively high.

Legal sampling involves approximately 30% more effort to carefully handle and document the samples and evidence. Laboratories require additional security procedures and may charge up to 50% more for handling legal samples and providing special legal reports.

2.4.6 EQUIPMENT FOR LEGAL SAMPLES

Equipment for collection of legal environmental samples is no different than for routine environmental samples. Legal samples require additional steps to maintain the chain-of-custody to protect against claims of tampering with evidence.

2.4.6.1 Sample Containers for Routine and Legal Samples

Sample containers for legal samples must suit the type of sample collected and are generally no different than for routine samples. The basic criteria are that the container is compatible with the type of sample and can protect it until it is analysed.



FIGURE 2.5:
Sample bottles must be selected to match the type of sample.
(Courtesy of Canada DOE)

Commercial suppliers can provide containers to meet United States Environmental Protection Agency (EPA) standards for cleanliness. The bottles are cleaned according to EPA protocols for the parameter or group of parameters to be analysed. A certificate of analysis is available for each batch of sample bottles for an additional cost; the suppliers also retain representative bottles of each batch in case the cleanliness of the containers is questioned. Labels and seals are usually included with the containers. Where sample containers are purchased as “certified clean” they should be stored in such a manner as to keep them clean and only opened just prior to sampling and then immediately closed.

Used household containers or containers (bottles, buckets, jars) purchased at non-laboratory stores should be avoided if possible as they are likely to add contaminants to the sample. Where the circumstances require such a purchase an extra original container should be purchased and sealed so that it can be quality control (QC) tested at the laboratory to determine if it could add contaminants to the sample. Failure to provide such a QC sample may compromise the integrity of the results of the sampling.

Generally the lab conducting the analysis will supply or have requirements for the type of sampling containers needed. This will take into account the following:



- sturdiness
- the sample medium (liquid, solid, gas)
- possible contamination of the sample
- compatibility or chemical reactivity with the sample
- possible sample degradation by light, oxidation, etc.



FIGURE 2.6: Large sample containers should be new and free from extraneous markings, as unnecessary markings will require explanation in court and may introduce an element of doubt as to whether the container had been properly cleaned before use or that all persons handling the sample had been accounted for. (Courtesy of Canada DOE)

When choosing sample containers, keep in mind the following additional considerations:

CONTAINER	USE
Glass	Organic analyses for sampling hazardous materials because glass is inert to most substances.
Amber glass	Prevents photo degradation (if amber glass is not available, shield samples from light by wrapping the clear bottle in aluminium foil and/or packing immediately in an opaque shipping container).
Plastic or Teflon	Strong alkali solutions, hydrofluoric acid and mercury samples.
Teflon or glass	Organic samples and media.
High-density polyethylene (HDPE)	Metals (except mercury) for most inorganic samples and media.
Glass, polyethylene, or polypropylene	Bioassay samples.

Caution: Plastic containers (polyethylene, polypropylene, polycarbonate, polyvinyl chloride or polymethylpentene) must not be used for samples intended for organic analyses, such as petroleum products, PCBs, pesticides and chlorinated organic wood preservatives. Plastics will leach out phthalates, which will interfere with the analyses.

CONTAINER LIDS AND LID LINERS

Inappropriate lids or lid liners such as paper or cardboard can cause serious contamination problems. Lids should be lined with Teflon or Teflon-coated material. In certain cases, polyethylene liners may be acceptable. Lids should be of the screw on variety and form a leak proof seal. Heat-treated aluminium foil is sometimes used to cover the mouth

of a container before the lid is screwed on to avoid contamination from a plastic lid, particularly for sampling petroleum products.
See **SECTION 2.9.2** for sample containers.

2.4.6.2 Labels for Legal Samples

Legal labels may consist of marks scratched into a container using a carbide or diamond scribe, permanent marker written on the sample container, or a prepared adhesive label with serial numbers and spaces to write critical information. The key to a legal label is that it makes the sample identification unique. It should be kept as simple as possible as the information will have to be transcribed to the field notebook → analytical reports → technical reports → and reports to the prosecutor. Therefore, simple clear, and unique labels reduce risk of transcription errors and potential problems with the presentation of evidence in court.

FIGURE 2.7:
Example of the layout of a uniquely numbered adhesive backed label combined with custody seals
(Courtesy of Canada DOE)



FIGURE 2.8:
Prepared Sample Container Labels can be split so that duplicate serial numbered tags can be glued directly into the field notebook.
(Courtesy of Canada DOE)

Ensure that each sample is identified and marked with the following minimum information:



Sampler's Initials	J. D.
Date (Yr-Mo-Day)	2012-10-05
Time (24-hour clock)	18:35
Unique Site Identification	Site #1

The unique site identification may be any type of identifier that is relevant to the site, for example "Site #1", or "Upstream of Outfall" or a kilometre marking "Site 125 km" etc. It should be simple, unique, and transferred to all notes and reports. The shorter and simpler the identification the less chance for transcription errors.

2.4.6.3 Legal Seals

Legal seals may be made of many different materials such as common packing tape or sheathing tape, legal custody tape, Teflon tape (e.g. for leak proofing petroleum product samples), sealable tamper proof plastic bags or numbered metallic or plastic seals. The key feature of the legal seal is usually that once it has been sealed, it must be destroyed to open the container and therefore confirms whether someone has had access to the sample.



FIGURE 2.9:
Example of various legal seals which may be single-use numbered seals or tape where the signature prevents tampering.
(Courtesy of Canada DOE)

2.4.6.4 Permanent Marking Tools

Label the sample using a permanent, waterproof, uniquely numbered label and/or using a diamond-tipped scribe, waterproof marker, or other means of permanent identification with sufficient information to enable you to identify the sample later in court.

To prevent tampering, tape used to seal the lids of containers can be attached so that the glued ends are taped together.



1. Sample containers can be labelled by marking with black felt and etching permanent marks.
2. Lids can be sealed with various tapes and marked with initial
3. Seals can be applied with tape that has glue to glue tabs.

FIGURE 2.10:
Examples of various numbered labels and etching tools.
(Courtesy of Canada DOE)

2.4.6.5 Chain-Of-Custody Form

A chain-of-custody form is a written record for legal samples to document continuity by tracing the possession of the sample from collection through introduction into evidence and ultimately disposal of the evidence after it is no longer required. A sample is in custody if it is in actual physical possession, in view after being in physical possession or in physical possession and locked up so that it cannot be tampered with.

FIGURE 2.11:
Example of a Chain-of-Custody
(Courtesy of United States - EPA)

For full page examples of chain-of-custody forms, see **SECTION 12.2**



2.4.6.6 Legal Notebook

The notebook should be of a type that can be written in even if it is wet, often called Rite in the Rain notebooks. Sketch the site and keep detailed notes of the sample collection methods, point of collection, container markings, sample labels with unique identifiers, packaging and shipping details.



FIGURE 2.12:
Example of a legal notebook.
(Courtesy of Canada – DOE)

2.4.6.7 Camera

Cameras must be suitable for the sampling conditions. Generally they should be waterproof and capable of close or distance photographs. The photographs provide a visual record of the samples and sample shipping container(s) before shipment to document your shipping preparation.

2.4.6.8 Locks for Security

In the field and prior to shipping, keep the sample in your possession or in view at all times or lock the sample in a secure container, inside your vehicle or stored in a secure refrigerator. Limit the number of people handling the sample and ensure that only one person at a time has access to the sample.

2.4.6.9 Lockable Shipping Containers for Security

Lockable shipping containers must be able to protect legal samples from vibration and shock and maintain shipping temperatures. The most common types are insulated plastic coolers that have been modified to accept a lock/padlock. Custom containers may have to be made for specialty shipping. Packages must be secure and rugged and must meet the requirements of applicable legislation related to transportation of dangerous goods and/or IATA Dangerous Goods Regulations. In general, shipping containers should protect samples from a 1.8 m drop and be able to be stacked 3 m high. See **FIGURE 2.9**

2.4.6.10 Global Positioning System (GPS)

A GPS system should be selected to provide a minimum accuracy required to identify the general location of the sample/observation site. Commercially available handheld systems start with an accuracy of ≥ 3.0 m and are used to reasonably locate the site.

2.5 QUALITY ASSURANCE – QUALITY CONTROL OF SAMPLES

The quality of an analytical result can be negatively affected at any stage of the process. Typical examples are provided in **TABLE 2.2**. Quality control measures must be implemented at each stage of the process.

Table 2.2 | Critical Stages of the Sample and Analysis Process

STAGE		POSSIBLE CONTAMINATION
1	Equipment Preparation and Storage	Equipment and apparatus handling.
2	Sample Collection	Contamination by ambient conditions, poor handling techniques, or using contaminated preservatives.
3	Sample transport and storage	Cross-contamination from other samples or contaminated storage containers/lockers/coolers.
4	Analytical Preparation	Contaminated laboratory glassware and equipment, ambient contamination, or poor sample handling practices.
5	Analysis	Contaminated syringes used for sample injection, carry over and memory effects in columns of analytical equipment, contaminated reagents or carrier gases and eluents.

LABORATORY CERTIFICATION AND QUALITY CONTROL SAMPLES

When choosing a laboratory, samplers should check that the laboratory meets a national and preferably an international accreditation program (ISO/IEC 17025). National regulators may also require their laboratories and contract laboratories to have appropriate accreditation. Formal recognition of the competence of the laboratory to carry out specific tests requires ongoing demonstration of performance through proficiency testing and bi-annual laboratory audits to maintain capabilities. Consulting with the laboratory is a necessary first step in ensuring the following quality assurance (QA)/quality control (QC) steps can be achieved.

Quality assurance (QA) is the overall program designed to ensure that the sample data meets data quality objectives (DQOs). This program includes sampling plan design, employee training, equipment maintenance and calibration procedures, quality control, corrective action plans, performance audits, data assessments, validation, storage, management, and reporting.



Quality control (QC) is the system of guidelines, procedures, and practices designed to regulate and control the quality of products and services, ensuring that they meet pre-established performance criteria and standards. This encompasses sample blanks, replicates, splits, equipment calibration standards, sample container size, quality, and the use and amount of preservative. Quality control is part of the overall quality assurance program.

Quality assessment is a system review that determines whether the quality assurance and quality control programs are being properly carried out. It involves evaluating and auditing the policies, guidelines, procedures, practices and results to assess the overall effectiveness of the QA/QC program.

Quality control is essential for the field officer to ensure the samples are representative and free from external contamination or deterioration. The following minimum steps are recommended to ensure quality samples and results:

- Quality control samples should be handled exactly the same as regular samples, using identical sampling devices, sampling protocols, sample containers, shipping procedures, and preservation techniques.
- Up to 5% of the samples (1 in 20) should be quality control samples.

2.5.1 SOURCES OF SAMPLING EQUIPMENT CONTAMINATION

Possible contamination is always a concern when collecting samples. Cleanliness is a high priority, since a contaminated sample is useless. Contamination between containers, tools and equipment could become an issue during legal proceedings.

PROBLEMS WITH ACIDS

When preserving samples with concentrated acids, cross-contamination from acid vapours can significantly alter the pH of an open sample designated for pH analysis. Therefore, ensure that those samples that do not require the addition of preservative are kept tightly capped and do not come in contact with acid vapours from your gloves or other samples.



FIGURE 2.13:
Preservatives, especially fuming ones such as acid, should be stored separately from samples by an additional storage container.
(Courtesy of Canada – DOE)

PROBLEMS WITH SOLVENTS AND FUELS

Sample containers and clean sampling equipment must never be stored near solvents, gasoline or other volatile substances that might cause contamination. If possible, to minimize contamination, do not fill the gas tank of your vehicle on the day of sampling until after all samples are collected. Keep sampling equipment as far from fuel sources as possible, such as gasoline tanks on vehicles or boats.

2.5.2 SOURCES OF SAMPLE CONTAMINATION

PROBLEMS WITH HANDLING SAMPLE CONTAINERS

Disposable gloves should be worn at all times when handling preservatives, sample containers, and sampling equipment. Do not touch the inside of the sample container, the inside of the container lid, the sample or the chemical preservatives with your gloves. **Great care must be exercised in handling these items.**

Samples may also be contaminated by:

- **Inappropriate containers or equipment:** Some chemicals in



samples may attach to sample containers, react with or extract chemicals from the container surface, or deteriorate a container. See **SECTION 2.9.2** for proper sample containers.

- **Containers that have not been properly cleaned** or that have been stored in a dusty environment. See **SECTION 2.5.4**.
- **Dirty container caps:** Do not touch inside of caps or allow foreign materials to contaminate the cap.
- **Loosely or improperly capped containers:** Ensure caps fit and are tightly attached.
- **Contaminated preservatives:** Do not refill preservative containers using contaminated containers or touch the dispensing surfaces of the containers.
- **Cross-contamination introduced by sampling equipment:** Clean equipment between samples and sample sites, and do not touch the sampling portion of the equipment with contaminated gloves.
- **Exposure to open air, which may contain various vapours:** Keep containers closed and away from vapour sources with the proper lids on until just before sample collection. Collect the sample as quickly as possible, and then add preservative and close with the proper lid immediately.
- **Sloppy sampling techniques (liquids):** Collect samples so as not to add contamination. When sampling in streams do not stand or walk upstream of a sample site or allow on-lookers or animals to enter the sampling zone. Collect a sample moving the container in the upstream direction from where you are standing. Then move upstream towards the next sample site, moving closer to the source of contamination.



FIGURE 2.14:
Avoid contamination of the sample containers by holding fingers away from the openings and keeping control of the lids. (Courtesy of of Canada – DOE)



FIGURE 2.15:

Example of improperly and properly holding a sample container using gloved hands, and improper and proper position when sampling in current.

(Courtesy of Canada – DOE)

- **Sloppy sampling techniques (solids):** Collect samples so as to minimize the introduction of fugitive dust.
- **Contamination by the transport vehicle:** When sampling from a boat or airplane sample from the upstream side, far away from the engine/propeller, fuel storage and fuel exhaust area.
- **Contamination from support structures:** When sampling from a dock, pier or bridge, sample from the upstream side to avoid contamination from iron structures or pilings treated with wood preservation chemicals.
- **Using ropes which can be porous** and become contaminated and transfer contaminants between sample sites: Only use rope if you have enough to use a fresh length each time. If long length is necessary, use polypropylene for the main length and if possible, use two to three metres of non-porous material such as stainless steel chain as an attachment to sampling devices. The polypropylene should be washed and rinsed between sites and the stainless steel can be properly decontaminated.
- **Tubing can retain water droplets** and contamination on the inside after a sample is collected: All lengths of polyethylene, surgical tubing and polyvinyl chloride (PVC) tubing should be as short as possible and where feasible replaced with Teflon tubing. Tubing should either be thoroughly cleaned or replaced between sites, or be dedicated to a specific site to avoid cross-contamination. If you are cleaning tubing between sample sites, a tubing blank sample should be collected by running clean water through the tubing and collecting and preserving the sample according to the requirements of **SECTION 2.9.2**.



- **Re-contamination of cleaned equipment:** Sampling equipment should be wrapped in clean aluminium foil and/or plastic and remain in the wrapping material in clean storage containers until it is used in the field. Keep equipment in good repair and keep vehicles as clean as possible during transportation and while on site. Set up a clean zone at the sample site and use decontamination procedures when re-entering the clean zone. Double bagging with clean zip lock polyethylene bags will reduce cross-contamination.
- **Some equipment is difficult to clean:** Some single-use disposable equipment, such as bags, spoons, etc., can be purchased from laboratory companies as certified clean.

SAMPLING TOOLS FOR METAL ANALYSIS

- Low-grade metal tools may cause contamination of metals samples: Do not use metal sampling equipment or hand tools unless they are stainless steel. For certain types of sampling such as soil sampling, a low grade tool such as a shovel may be used to dig the initial hole but a high grade stainless steel tool is used to conduct the final scraping to expose a new surface and collection of the sample.



FIGURE 2.16:
Stainless steel and disposable
plastic scoops for sample
collection
(Courtesy of United States -
EPA/Canada - DOE)

- Aluminium foil used to wrap cleaned tools may cause contamination for metals analyses if aluminium is an issue: Hand tools used for metals samples such as spatulas, pipettes and trowels should be wrapped only in plastic where aluminium is an issue.

SAMPLING TOOLS FOR ORGANIC ANALYSIS

- Organic chemicals and solvents can deteriorate plastic sampling equipment or extract chemicals from plastic sampling equipment: Do not use plastic equipment (use Teflon as much as possible) or use cleaned stainless steel equipment.
- Cleaned tools can become contaminated by organic vapours: Hand tools such as metal spatulas and trowels and glass pipettes should be wrapped in cleaned and heat-treated aluminium foil which should only be opened just prior to sample collection.
- Amber glass containers are normally required for organic samples. See **TABLE 2.9.2.2**.

2.5.3 CLEANING FIELD EQUIPMENT

Always clean equipment parts that come into contact with the sample (water, sediment, sludge, effluent) to avoid cross-contamination.

PREPARATION OF WRAPPING MATERIAL

- Cleaned equipment can be wrapped in aluminium foil for protection. The aluminium foil should be washed with phosphate-free laboratory grade detergent and hot water, rinsed with distilled or de-ionized water and heat treated at 325°C.



FIGURE 2.17:
Prevent contamination by
wrapping cleaned equipment in
aluminium foil.
(Courtesy of Canada - DOE)

GENERAL CLEANING SOLUTIONS

1. General cleaning of equipment/glassware should be done using clean water and phosphate-free laboratory grade detergent.
2. Final rinse solutions should be distilled or de-ionized water.
3. Reagent grade acid rinse is for equipment/glassware used for metals analysis - when making dilute acid rinse always pour a small quantity of reagent grade nitric acid into water.

Warning: Never pour water into concentrated acid as this could result in a steam explosion and serious injury.



Make dilute reagent grade nitric acid rinse by pouring it into distilled or de-ionized water to form a 10% - 20% nitric acid rinse (pH 2.0).

4. Acetone rinse for equipment meant for organics analysis should be reagent grade acetone or better.

CLEANING GROSSLY CONTAMINATED EQUIPMENT

1. For highly contaminated equipment, it may be necessary to use a steam or high-pressure water washer to remove any dirt or residue.
2. Wash equipment with phosphate-free laboratory grade detergent and hot water, using a brush on all accessible surfaces to remove all visible particulate matter and other residue.
3. Rinse equipment three times with distilled or de-ionized water.

EQUIPMENT USED TO SAMPLE ORGANIC (CARBON-BASED) CHEMICALS

1. Wash equipment with phosphate-free laboratory grade detergent and hot water, using a brush on all accessible surfaces to remove all visible particulate matter and other residue.
2. Rinse equipment three times with distilled or de-ionized water.
3. After the equipment has been washed, rinse with reagent grade acetone and air dry or oven dry at 325°C and wrap in cleaned aluminium foil.

EQUIPMENT USED TO SAMPLE METALS

1. Wash equipment with phosphate-free laboratory grade detergent and hot water, using a brush on all accessible surfaces to remove all visible particulate matter and other residue.
2. Rinse equipment three times with distilled or de-ionized water
3. After the equipment has been washed, rinse with reagent grade acid rinse, air dry, and wrap in cleaned aluminium foil. (Only use aluminium foil when aluminium is not an issue in the analysis, otherwise wrap in clean polyethylene.)



FIGURE 2.18:
Field equipment cleaning materials, laboratory grade soap, rinse water, rinse acetone (assists in air drying), hexane (assists in cleaning organics). (Courtesy of Canada – DOE)

EQUIPMENT USED FOR SPECIALTY CHEMICALS

1. Follow approved laboratory cleaning methodology for the analyte in question.
2. Take an equipment blank by running a sample of de-ionized water to the approved volume through or with the equipment and preserving and storing the sample as required by the appropriate laboratory procedure.

GENERAL CLEANING IN THE FIELD

1. Scrub equipment with a dilute solution of phosphate-free detergent and remove all visible particulate matter and other residues. Rinse several times with tap water, then three times with de-ionised water to remove the detergent. Use reagent grade acetone rinse for organic samples; dilute reagent grade acid rinse for metals samples.
2. Contain all contaminated rinsate in approved storage containers for later proper disposal at the laboratory.

CLEANING PUMPS (AT THE LABORATORY OR IN THE FIELD)

Pumps used to collect samples present a special cleaning challenge. Peristaltic pumps are the most commonly used in the field. Ideally, the flexible silicon rubber used in the peristaltic pump chamber should be replaced between each legal sample site as should the main hose used to collect the sample. Where this is not possible, the following procedure is recommended:

1. Pump at least 1.0 L of water with phosphate-free laboratory grade detergent in distilled or de-ionized water through the flexible rubber silicon hose.
2. Pump at least 1.0 L of distilled or de-ionized water through the flexible rubber silicon hose.
3. For metals samples, pump at least 500 mL reagent grade acid rinse through the flexible rubber silicon hose followed by reagent grade acetone rinse.
4. For organics samples pump at least 10 volume equivalents (a volume equivalent is the volume of liquid which can be contained within the length of hose being used) with reagent grade acetone followed by a reagent grade hexane rinse through the flexible rubber silicon hose.
5. Take an equipment blank by running a sample of de-ionized water to the approved volume through the pump and preserving and storing the sample as required by the appropriate laboratory procedure.

See also **SECTION 2.9**



FIGURE 2.19:
Disassembled peristaltic pump. For legal samples, the tubing in peristaltic pumps should be replaced between sample sites to prevent transfer of contamination. An alternate is to rinse with the appropriate solvent. An equipment blank sample using final rinsate should be collected to confirm the cleaning. (Courtesy of Canada – DOE)

STORAGE OF CLEANED SAMPLING EQUIPMENT

1. Do not put samples in containers whose history is unknown.
2. Keep storage containers tightly sealed and stored in clean areas.
3. Do not smoke while sampling. Tobacco smoke contains ammonia, oxides of nitrogen and other contaminants. If water samples are left loosely capped in a vehicle filled with tobacco smoke, these samples may be contaminated through diffusion.

2.5.4 SUGGESTED SAMPLE CONTAINER CLEANING METHOD

For sample containers which must be cleaned, the cleaning procedure may be dictated by the specific analysis to be performed on the sample.

General cleaning methods are as follows:

1. Wash sample containers with analyte-free and phosphate-free lab detergent; scrub all surfaces with a brush kept for this purpose.
2. Rinse containers thoroughly, first with tap water and finally with distilled or de-ionized water.
3. Specific container preparation requirements in addition to the normal cleaning procedures are as follows:

Table 2.3 | General Cleaning Methods for Sample Containers

ANALYSES	CLEANING METHOD
METAL	Soak plastic or glass containers in 10% - 20% analytically pure nitric acid and rinse at least three times with de-ionized water and air dry before packing and taking them into the field.
ORGANIC	Clean glass jars and bottles as per lab protocol or use lab-prepared containers. Be aware that cross-contamination with organic solvents or substances can be a serious problem; this is why heat treatment of containers and equipment in ovens at 325° C is frequently recommended.
BACTERIAL AND MICROBIOLOGICAL	Sterile containers are usually available from the laboratory. If not, sterilize bottles and equipment for microbiological sampling, or for any samples requiring sterile conditions, according to Standard Methods for the Examination of Water and Wastewater, Washing and Sterilization 9040 (American Public Health Association).
BIOASSAYS	Plastic containers or plastic liners; Steam clean containers or wash them with soap, and rinse them five times with tap water; rinse containers three times with the sample to be collected.

2.5.5 FIELD QUALITY CONTROL SAMPLES

The number of QC samples depends on the objectives of the sampling program. Often the laboratory or the established analytical protocols dictate the types and number of samples needed. When preparing QC samples always use distilled water (DW) or preferably de-ionized (DI) water, as defined in the latest edition of "Standard Methods for the Examination of Water and Wastewater" for Reagent-Grade Water, Type I. The laboratory supplying the distilled or de-ionized water should maintain a quality control record by periodically analysing it and maintaining a record of the results.

2.5.5.1 Travel Blanks and Temperature Control Blank Samples

A travel blank (also called a trip blank or transport blank) is used to check for background contamination, contamination from transport and handling, or both. A temperature control blank is a sample used to confirm that the samples were kept at 4°C during transport.

SUGGESTED PROCEDURE:

1. Before setting out, choose the appropriate container for the sample type and label the travel blank containers clearly, indicating that these are blanks. **Note:** For blind tests of the laboratory, an alternate identification known only to the sampler may be used.
2. Fill the appropriate containers with DI water. Add appropriate preservative as required by the protocol for the analyte of interest. See **SECTION 2.9**
3. Place samples among the empty sample containers. Keep them at 4°C, or at the same temperature the samples will be kept.
4. Do NOT open the travel blanks in the field. Travel blanks are



transported to the field with the regular sample containers unopened and then return together with the field samples under the same storage conditions to the laboratory unopened.

5. Fill and seal the temperature control blank just prior to shipping. At the receiving laboratory, the temperature control blank can be opened and the temperature measured with a thermometer. An alternative is to use a thermal scanner to measure sample temperatures.

Note: If you do not have access to lab facilities and cannot prepare your own travel blanks, ask the laboratory to provide them.

2.5.5.2 Field Blanks

A field blank is exposed to the same field and travel conditions as the samples of interest and corrects for ambient conditions. It is recommended to prepare at least one field blank per 20 samples collected or at least one per day for each facility being sampled.

SUGGESTED PROCEDURE

1. Transport 2 L - 5 L of DI water in a clean, appropriate container (see SECTION 2.9) to the field. During sample collection, label and prepare a field blank by filling an appropriate container with DI water using identical procedures as used for normal field samples. This process will expose the field blank DI water to the same environmental conditions as the field samples.
2. Treat the field blank(s) exactly as the samples are treated, using the same preservative (if any) and pack the field blank with the samples to expose it to the same conditions during transport and shipping. Send the field blanks to the lab with the field samples.
3. Up to 5% of samples should be field blanks.

Note: If conditions vary significantly between sampling points at a facility, or if the sampling points are more than a kilometre apart, consider collecting extra field blanks at each sampling point.



Transport temperature conditions can be tested by opening the temperature control blank upon receipt by the laboratory without contaminating any of the other samples.

FIGURE 2.20:

Travel blank, field blank and temperature control samples help ensure the quality control of all the samples submitted to the laboratory.

(Courtesy of Canada – DOE)

2.5.5.3 Equipment Blanks

Equipment blanks (rinsate blanks, instrument blanks) are a sample of DI water or solvent used to rinse the equipment. It is essential to take an equipment blank when sampling equipment contains materials that might contaminate the sample (e.g. plastic tubing or metal parts). Rinsate blanks test how well the sampling equipment has been decontaminated between sampling. Check with the laboratory or with experienced personnel to determine if you need to prepare these blanks.

SUGGESTED PROCEDURE

Collect a sample of the final equipment rinse water or solvent as an equipment blank after the equipment has been decontaminated and before the next sampling session.

You may be asked to include additional QC samples. These will be required less frequently, but you may be responsible for providing them.

2.5.5.4 Material Blanks

Material blanks are samples of construction materials such as those used in groundwater wells, pumps and flow testing. These samples can be used to test for experimental artifacts from these materials which could contaminate water samples.

2.5.5.5 Field Spikes

A field spike is a field sample to which a known amount of the analyte of interest is added during field sampling. Spikes are used to identify field, transportation and matrix effects. It is important that field spike samples be prepared by experienced personnel so that interpretation of analytical results is not complicated by human error.

2.5.5.6 Split Samples

SPLIT SAMPLES are two or more samples taken from the same initial sample. Samples may be split in the field or in the lab. It is recommended that laboratory personnel be consulted for advice on splitting samples. For example, splitting samples for organic analysis may result in subsamples that are not identical because organics often adsorb onto container walls. In cases such as this, it is best to split samples immediately at the sampling site.

FIELD REPLICATE SAMPLES are two or more separate samples taken at approximately the same time at the same sampling site. These samples are used to calculate sampling precision. Laboratory in-house replicates are replicates generated by the testing laboratory and are used to calculate test method precision.

After regulatory sampling, an inspector may be requested to provide a split sample to the facility from which samples were collected. **As a general rule, samples collected for compliance monitoring should not be split and given to the regulatee.**



Note: Legal samples should not be split under any circumstances. The preferred alternative is to request facility personnel to collect their own sample.

In some situations, however, inspectors may request the facility owner or operator to provide a split sample from the facility's sampler, where it is not possible to collect a separate sample. In other situations, an inspector may be interested in obtaining comparative analysis for particular parameters, so splitting a sample may be necessary. When splitting samples for analysis comparison, both samples must be treated the same with respect to sample container, preservatives, storage pre-analysis holding time and temperature.

2.6 HEALTH AND SAFETY PLANNING

When the general sampling plan is known, the identified tasks and site conditions should be reviewed to develop the health and safety plan and Task Hazard Analysis Sheet (THAS).

2.6.1 PRINCIPLES OF HEALTH AND SAFETY

You must always be aware of and comply with all applicable health and safety legislation, directives, standards and guidelines. If you are uncertain as to their applicability, consult your supervisor or the appropriate health and safety authorities in your jurisdiction. The general duty of the employer is to ensure that the health and safety at work of every person employed by the employer is protected. The following criteria relate directly to the field operations of environmental inspectors and investigators and should be considered in the health and safety plan.

The employer should strive to ensure the following:

ACCIDENT INVESTIGATION AND REPORTING

Investigate, record and report in the manner and to the authorities as prescribed all accidents, occupational diseases and other hazardous occurrences known to the employer.

FIRST AID

Provide prescribed first-aid facilities and health services.

POTABLE WATER

Provide, in accordance with prescribed standards, potable water.

VEHICLES AND MOBILE EQUIPMENT

Ensure that the vehicles and mobile equipment used by the employees in the course of their employment meet prescribed standards.

PERSONAL PROTECTIVE EQUIPMENT

Provide every person granted access to the workplace by the employer with prescribed safety materials, equipment, devices and clothing.



FIGURE 2.21:
Common health and safety
equipment.
(Courtesy of Canada – DOE)

FIRE AND EMERGENCY MEASURES

Comply with prescribed standards relating to fire safety and emergency measures.

INFORMATION AND TRAINING

Provide, in the prescribed manner, each employee with the information, instruction, training and supervision necessary to ensure their health and safety at work.

HAZARD AWARENESS

Ensure that each employee is made aware of every known or foreseeable health or safety hazard in the area where the employee works.

MACHINERY, EQUIPMENT AND TOOLS

Ensure that the machinery, equipment, and tools used by the employees in the course of their employment meet prescribed health, safety and ergonomic standards and are safe under all conditions of their intended use.

SAFETY CODES AND STANDARDS

Adopt and implement prescribed safety codes and safety standards.

USE OF PERSONAL PROTECTIVE EQUIPMENT

Ensure that every person granted access to the workplace by the employer is familiar with and uses in the prescribed circumstances and manner all prescribed safety materials, equipment, devices and clothing.

ORAL AND WRITTEN INSTRUCTIONS

Comply with every oral or written direction given to the employer by an appeals officer or a health and safety officer concerning the health and safety of employees.

DUTIES OF EMPLOYEES

While at work, every employee should:



- **Use Personal Protective Equipment**

Use any safety materials, equipment, devices and clothing that are intended for the employee's protection and furnished to the employee by the employer or that are prescribed.

- **Follow Prescribed Procedures**

Follow prescribed procedures with respect to the health and safety of employees.

- **Take Precautions**

Take all reasonable and necessary precautions to ensure the health and safety of the employee, the other employees, and any person likely to be affected by the employee's acts or omissions.

- **Comply with Instructions**

Comply with all instructions from the employer concerning the health and safety of employees.

- **Cooperate with Health and Safety Committee**

Cooperate with the policy and work place committees or the health and safety representative.

- **Report Hazards**

Report to the employer any event or circumstance in a work place that is likely to be hazardous to the health or safety of the employee, or other persons granted access to the work place by the employer.

- **Report Accidents and Injuries**

Report in the manner prescribed every accident or other occurrence arising in the course of or in connection with the employee's work that has caused injury to the employee or to any other person.

- **Comply with Oral and Written Directions**

Comply with every oral or written direction of a health and safety officer or an appeals officer concerning the health and safety of employees.

WORK PLACES NOT CONTROLLED

Many of your inspections and investigations will occur at facilities or sites that are regulated by local legislation and private policy. Each site should be examined to determine which safety legislation or policy applies.

FEDERAL FACILITIES

If you are inspecting another federal, provincial, state or territorial facility, you must continue to protect your safety and health. The federal provincial, state or territorial facility must also ensure your safety and health. To them, you are a visitor or person granted access to the workplace.

PROVINCIAL, STATE OR TERRITORIAL FACILITIES

If you are inspecting private corporations or facilities regulated by

provincial, state, or territorial health and safety legislation, both you and your employer continue to be responsible for your health and safety. Some provincial, state or territorial occupational health and safety standards may differ from federal standards. Under your local jurisdiction or United Nations standards for the local Labour Code, there may be provisions for employees to refuse dangerous work. You should familiarize yourself with the procedures and conditional clauses of this legislation so that you fully understand its limitations.

2.6.2 RISK ANALYSIS AND MITIGATION

Risk analysis involves looking at each phase of the sampling plan and evaluating the potential hazards and determining how they can be reduced, eliminated or compensated for. After the risks have been identified, a Task Hazard Analysis Sheet (THAS) should be produced for the project. The THAS should list all the potential hazards that have been identified and the mitigating measures to reduce or eliminate those hazards. The THAS should be reviewed with all the members of the investigative team and any contractors involved with a site investigation. The project manager/team leader and any of the participants should sign off on the THAS after it has been reviewed.



FIGURE 2.22:
each task has to be examined
for physical, biological and
chemical risks.
(Courtesy of United States –
EPA/Canada-DOE)

CONSTRUCTING A TASK HAZARD ANALYSIS SHEET

Development of the Task Hazard Analysis Sheet (THAS) should be in the same logical format as the sample plan. A partial example of collecting water samples from a boat is provided as follows.



Table 2.4 | Typical Risk Analysis and Task Hazard Analysis Sheet

PROJECT	COLLECT WATER SAMPLES FROM A BOAT			
TASK	RISK	MITIGATING STEP	SIGNATURE OF PROJECT LEADER	INITIALS OF PARTICIPATING STAFF
Operate a boat on a river	Drowning	Provide life jackets for participants		
		Provide a floating throw rope for rescue		
Handle Nitric Acid Preservative	Acid burns to body and clothes	Put acid into small single-dose vials		
		Use safety goggles		
		Use acid resistant gloves		
		Have clean water for washing eyes and hands		

Other situations such as entry into sites with hazardous gases or chemicals or medical sharps will require examination of risks and development of mitigating measures. Each site is unique therefore each situation is recommended to have a THAS developed for that operation. Common hazard issues are as follows; others should be examined and mitigating measures developed in a similar manner.

PROJECT	USE OF CORROSIVE MATERIALS			
TASK	RISK	MITIGATING STEP	SIGNATURE OF PROJECT LEADER	INITIALS OF PARTICIPATING STAFF
Corrosive or oxidative reagents	Corrosion of equipment and vehicles and skin burns	Carry minimum amount in non-reactive containers and store in leak proof carrying case		
		Wear protective gloves and eyewear		
Create dilute solutions of strong acids or bases	Thermal reaction if water comes in contact creating steam or corrosive spray hazard	Wear protective gloves and eyewear		
		Always add strong acid or base to water to create a dilute solution Never pour water into strong acid or base		
Load or carry heavy equipment	Muscle and back injury and crush injury	Use proper lifting technique Wear steel toed safety footwear		

2.6.3 COMMON HEALTH AND SAFETY ISSUES

Common health and safety issues include the following:

- Working near traffic or large industrial sites
- Working near water or on boats
- Working in or near confined spaces

2.6.3.1 Working near traffic or large industrial sites

When working near traffic or large industrial sites, the minimum recommended safety equipment includes:

- Hard hat
- Protective safety glasses that wrap to the side of the face
- Hearing protection – ear plugs or ear muffs
- Respiratory protection – dusk masks, filter masks or vapour masks depending on conditions
- Protective body clothing – cloth or paper coveralls
- Protective gloves chemical and/or abrasion resistant depending on the situation
- Protective foot wear – rubber boots/waders with steel toes for liquids, leather boots with steel toes for abrasive dry situations
- Reflective vests

SUGGESTED PROCEDURE:

Wear the equipment recommended in the THAS and which complies with local health and safety regulations.

2.6.3.2 Working near water or on boats

In addition to common protective equipment, the following items are recommended:

- Floatation devices (belts, jackets, full body suits)
- Emergency floating throw rope
- Emergency whistle
- Emergency flares
- Emergency flash lights
- Emergency bailers
- Emergency pumps
- Marine radio
- Maps and/or marine charts
- Binoculars

SUGGESTED PROCEDURE:

Wear the equipment recommended in the THAS and which complies with local health and safety regulations and have emergency equipment which complies with local marine health and safety regulations.



FIGURE 2.23:
Wear proper floatation and protective gear when working on or near water. A non-electrical conducting sampling rod assists with safe sampling to reach difficult locations or as a support when wading in streams. (Courtesy of Canada – DOE)

GENERAL SAFETY PROCEDURES FOR WORKING STREAMSIDE

- If you need to wade into the water to collect a sample, another person should be present and you must wear a flotation device (life jacket). If you have to wade into the water to take a sample from larger streams or rivers, use a wading stick (sampling rod) and have a partner use a throw-line or wear a lifeline as well as the life jacket.
- If you are sampling from shore, be sure to maintain a safe footing and a solidly balanced position.
- If the water is too deep or fast-moving for wading, collect samples from a boat or from shore. Do not take any risks that would endanger your own life or the lives of others.

GENERAL PROCEDURES FOR WORKING FROM BOATS

- Be familiar with basic boating safety rules and follow all applicable boating regulations. Please contact your local government authority to clarify your requirements.
- Always carry the emergency equipment required by local boating regulations.

Examples include:

- Fire extinguisher
 - Marine radio (hand held or fixed)
 - Compass
 - Global Positioning System (GPS, hand held or fixed)
 - Waterproof flashlights (and extra batteries)
 - Floating emergency throw rope
 - Bailing buckets
 - Whistle(s)
 - Life preservers for each passenger
 - Floating survival suits
 - Marine charts
- Always wear your flotation device while on the water.
 - Be aware of the load capacity of the boat that includes passengers, gear and samples, and leave a safe weight margin to accommodate most operating conditions.

- Check and be aware of weather conditions.
- Check and be aware of marine hazards such as shallows, shoals, currents and vessel traffic lanes.

2.6.3.3 General Procedures for Working near or in Confined Spaces

Note: These procedures are general guidelines and do not supersede governing regulations. They must be augmented with specific procedures for each designated confined space.

- Under normal circumstances, samplers should not have to enter confined spaces. Samples can usually be obtained using sampling devices such as sampler poles, buckets and chains.
- No person should enter a confined space or act as an assistant during an entry without proof of current confined space entry training.
- If you have to enter a confined space such as a manhole to collect a sample, another person must be present and all safety issues must be addressed as outlined in local health and safety legislation.
- Confined spaces usually encountered are manholes, sanitary sewage stations, sumps, holes in tanks, culverts, deep ditches, between hulls of ship and barges, or the spaces between stacked shipping containers. See **FIGURE 2.24**
- Be cautious of running water, explosive gases and toxic fumes.
- Ensure confined spaces are tested for suitable breathable atmosphere and the absence of toxic and explosive gases.



Shipping containers may contain materials that produce hazardous dust.

Hazardous liquids leaking into an area of poor air circulation can produce dangerous vapours.

Entry into shipping containers should be done wearing self contained air supply

Before a suspected hazardous waste shipping container is opened it should be tested with a gas sniffer.

Hazardous vapour testers should be used when approaching confined space areas or prior to opening containers.

FIGURE 2.24:

Testing the air of shipping containers and other confined spaces suspected of containing hazardous waste or hazardous vapours.

(Courtesy of Netherlands – ILT, Canada – DOE, United States – EPA)



2.6.4 HEALTH RISK ASSESSMENT OF TOXIC EXPOSURE OF ILLEGALLY DUMPED HAZARDOUS WASTE

Conducting a health risk assessment often requires the assistance of a health risk professional. Detailed health risk assessments are beyond the scope of this manual. However, the reader should be aware of the following basic principles, as illegal disposal of hazardous waste investigations usually involve short-term (hours to weeks) and long-term (months to years) hazardous materials exposure risk and potential health concerns.

2.6.4.1 Short Term Health Risk Assessments

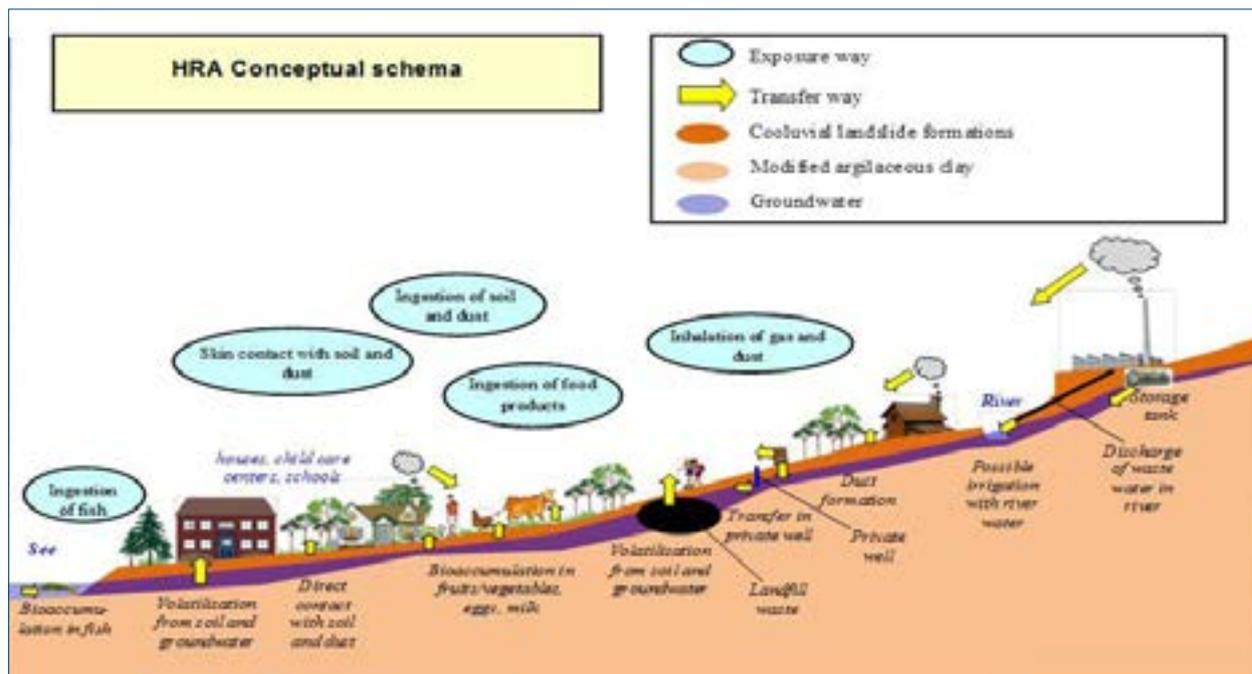
During the initial response and evidence collection of a hazardous waste incident, access to information concerning protective measures is critical. The Task Hazard Analysis procedure may require the identification and implementation of personal protective measures.

The "Emergency Response Guide Book" was developed jointly by transport agencies in Canada, the United States, Mexico and Argentina, for use by firefighters, police and other emergency services personnel who may be the first to arrive at the scene of an incident involving dangerous goods. This document is available online and can be used as a reference.

2.6.4.2 Long Term Health Risk Assessments

Long term health risk assessments are important in forensic environmental investigations as they provide evidence of both short- and long-term damage to human health and the environment. These factors can influence the penalties which may be assessed or in judicial orders as a result of conviction. These are done by professionals and will commonly consider the following issues:

- Detailed research of pollutants in air, surface water and groundwater, soil gas, soil, food stuffs, and drinking water.
- Identification of exposure scenarios by inhalation, ingestion and skin contact.
- Quantification of daily exposure doses and effects.
- Quantification of health risks (cancer risks and others).
- Quantification of uncertainties and interpretation of risks (acceptable or not).
- Definition of rehabilitation threshold levels for acceptable risks.



2.6.5 HEALTH AND SAFETY CLOTHING

Personal protective clothing may be rated by an alphabetical standard (North American Level A, B, C, D) or a numerical standard (Level 1, 2, 3, 4) or alphanumeric standard (British Standard EN1 etc.) depending on the jurisdiction.

This manual provides examples of chemical protective clothing **but not nuclear or biological protective clothing**. The following levels are for information purposes. Further details regarding the types of protection recommended for specific chemicals can be found at the United States Center for Disease Control Web site:

<http://www.cdc.gov/niosh/ncpc/kcpc.html>

SAFETY: The following levels of safety gear may be required depending on the level of risk. If the environmental enforcement agency does not have the capacity to safely assess and contain the risk, contact the national agency responsible for such matters.

2.6.5.1 Very High Risk (non-nuclear/non-high biohazard) - Level 1 or Level A Protective Clothing

Very high risk (Level 1 or Level A) is to be selected when the greatest level of skin, respiratory and eye protection is required against chemical agents. The permeability of the suit material will depend on the type of chemical exposure. This type of suit uses a self-contained breathing apparatus and may only be used by those specially trained. (This type of suit may not be suitable for nuclear or biological risks.)

FIGURE 2.25:
Factors that must be considered for an area-wide Health Risk Assessment (HRA)
(Courtesy of HPC Envirotec)



FIGURE 2.26:
Level 1 or Level A protective
clothing.
(Courtesy of United States EPA/
Canada DOE)

CHARACTERISTICS:

1. Hard hat worn inside the suit.
2. Hearing protection or two way communication device.
3. Positive pressure air supply sealed to the face.
4. Long underwear for cold climate worn under the protective suit.
5. Thermal cooling packs for hot climate worn under the suit.
6. Optional coveralls or dust suit worn under the protective suit.
7. Chemical resistant gloves for inner protective layer.
8. Chemical resistant gloves for outer protective layer, sealed to the sleeves of the suit.
9. Chemical resistant rubber boots with steel toe and shank sealed to the boot with tape.
10. Chemical resistant suit covers all gear.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767 (Ref: US Dept. of Labour)

2.6.5.2 High Risk - Level 2 or Level B Protective Clothing

High risk (Level 2 or Level B) is selected when the highest level of respiratory protection is necessary but a lesser level of skin protection is needed. The permeability of the suit material will depend on the type of chemical exposure. This type of suit uses a self-contained breathing apparatus and may only be used by those with special training. (This type of suit may not be suitable for nuclear or biological risks.)

CHARACTERISTICS:

1. Disposable suit covers entire body including head and neck but not sealed to the face. Chemical resistance depends on the suit material.
2. Hard hat worn outside the suit.
3. Hearing protection or two way communication device.
4. Positive pressure air supply sealed to the face.
5. Long underwear for cold climate worn under the protective suit.
6. Thermal cooling packs for hot climate worn under the suit.
7. Chemical resistant tape seals gloves and boot covers to the suit.
8. Chemical resistant gloves for inner protective layer.
9. Chemical resistant gloves for outer protective layer, sealed to the sleeves of the suit.
10. Leather gloves may be used outside the chemical resistant gloves for abrasion resistance.

11. Chemical resistant rubber boots with steel toe and shank.

12. Chemical resistant outer booties sealed to the pant legs of the suit.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767 (Ref: US Dept. of Labour)



FIGURE 2.27:
High risk - level 2 or level b
protective clothing.
(Courtesy of United States EPA/
Canada DOE)

2.6.5.3 Medium Risk - Level 3 or Level C Protective Clothing

OPTION A: Medium risk (Level 3 or Level C) provides a medium level of respiratory protection with a chemically appropriate filter mask.

CHARACTERISTICS:

1. Disposable suit covers entire body including head and neck, but is not sealed to the face. Chemical resistance depends on the suit material. This plasticized version has better resistance than the next suit which is primarily a strengthened paper version.
 2. Hard hat worn outside the suit.
 3. Hearing protection or two way communication device.
 4. Chemically appropriate filter mask provides seal to the face and eye protection.
 5. Long underwear for cold climate worn under the protective suit.
 6. Thermal cooling packs for hot climate worn under the suit.
 7. Chemical resistant gloves for inner protective layer.
 8. Chemical resistant gloves for outer protective layer, sealed to the sleeves of the suit.
 9. Leather gloves may be used outside the chemical resistant gloves for abrasion resistance.
 10. Chemical resistant rubber boots with steel toe and shank.
 11. Chemical resistant rubber boots with steel toe and shank.
 12. Chemical resistant outer booties sealed to the pant legs of the suit.
- http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767 (Ref: US Dept. of Labour)



FIGURE 2.28:
Medium Risk - Level 3 or Level C
protective clothing
(Courtesy of United States EPA/
Canada DOE)

OPTION B: The medium level of respiratory protection is necessary with dust filter or appropriate chemical vapour filters in the filter mask but a lesser level of skin protection is needed.

CHARACTERISTICS:

1. Disposable suit covers entire body and may include head and neck hood but not sealed to the face. Generally only for dust resistance or low hazard chemical splash situations. Chemical resistance depends on the suit material. **Does not provide protection to exposed head and neck.**
2. Hard hat worn outside the suit.
3. Hearing protection or two way communication device.
4. Dust filter mask or chemically appropriate filter mask provides seal to mouth and nose.
5. Wrap around eye protection provides impact but not chemical protection to the eyes.
6. Long underwear for cold climate may be worn under the protective suit.
7. Thermal cooling packs for hot climate may be worn under the suit.
8. Chemical resistant gloves inner protective layer.
9. Chemical resistant gloves outer protective layer, sealed to the sleeves of the suit.
10. Leather gloves may be used outside the chemical resistant gloves for abrasion resistance.
11. Leather or chemical resistant rubber boots with steel toe and shank.
12. Optional chemical resistant outer booties sealed to the pant legs of the suit.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767 (Ref: US Dept. of Labour)



FIGURE 2.29:
Medium Risk – Level 3 or Level
C protective clothing.
(Courtesy of United States EPA/
Canada DOE)

2.6.5.4 Low Risk - Level 4 or Level D Protective Clothing

The low level safety gear may be appropriate for lowest risk exposure conditions.

CHARACTERISTICS:

1. Disposable cover suit may not be required if there is no risk of hazardous dust, chemical vapours or liquid chemicals.
2. Hard hat worn.
3. Hearing protection or two way communication device.
4. Dust filter mask provides minimum protection against dust but not chemical vapours.
5. Wrap around eye protection provides impact but not chemical protection to the eyes.
6. Long underwear for cold climate.
7. Chemical resistant gloves inner protective layer.
8. Leather gloves may be used outside the chemical resistant gloves for abrasion resistance.
9. Leather or chemical resistant rubber boots with steel toe and shank.
10. Optional chemical resistant outer booties sealed to the pant legs.

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767 (Ref: US Dept. of Labour)



FIGURE 2.30:
Low Risk - Level 4 or Level D
protective clothing.
(Courtesy of United States EPA/
Canada DOE)

2.7 SITE AND SAMPLE DOCUMENTATION

2.7.1 USE OF NOTEBOOKS

Proper site documentation of all activities is an integral part of field inspection and investigation. Samplers must keep individual notes on sampling operations. This is a written record of all field data, observations, field equipment calibration, sample and chain-of-custody forms. These notes should be kept in a notebook, which is bound, water-resistant and has sequential page numbers (printed or hand written). Each person should have their own notebook and the notes should be written in waterproof ink. The notebook should contain the following information which is relevant to the sampling program.

Notebook entries should be a chronological recording of information and activities. Each page should be numbered and contain accurate and inclusive documentation of the sampling activity. Each entry should be marked with date and time. Because the notebook information forms the basis for later reports, it should contain objective factual information, free of personal feelings or other terminology which might be inappropriate. Notebooks should not be shared and only contain notes of the person who the notebook belongs to. Entries should never be scratched out so that they are not legible. If an error is made a single line should be put through the entry and initialled. Pages should not be removed. All notes should be made at the time of the on-site activity or as soon as possible thereafter.



FIGURE 2.31:
Rite in the Rain notebooks with numbered pages are preferred and waterproof ink should be used to record the field notes. (Courtesy of Canada – DOE)

2.7.2 SITE INFORMATION AND POSITION

When inspecting industrial facilities, maps, site diagrams and similar information are generally available from the facility, if you do not already have this information. This should be kept as reference for future inspections. Additional information which is recommended to be recorded in the field notebook includes:

- Date of site entry preferably written as year, month day, i.e. 2012-09-10



- Hour and minute of site entry preferably written as a 24-hour clock, i.e. 23:18
- Field conditions (e.g. physical, meteorological, hydrological)
- Name of sample collector
- Name of company
- Site name (use a brief acronym)
- Latitude and longitude of significant landmarks or sample sites and/or paths used to find the site are recorded via global positioning systems (GPS)

GPS systems are now accurate to within 3 m to 5 m. Many systems offer multiple station locations, data recording, way marking and navigation capabilities. GPS units receive signals transmitted from three or more orbiting satellites and then calculate their position relative to the satellites.

The type of GPS unit selected depends on the desired accuracy of the project. Units are rated as mapping grade and commercial grade (accuracy $\geq 3.0\text{m}$), differential grade (accuracy $\leq 1.0\text{m}$), and survey grade (accuracy $\geq 5.0\text{ mm}$). When using commercial grade, select a unit that receives wide area augmentation system (WAAS) signal for accuracy $\geq 3.0\text{ m}$; otherwise it will be approximately $\geq 10\text{ m}$.

SUGGESTED PROCEDURE

1. Select locations with an unrestricted view of the sky which result in as many satellites as possible, and position the unit vertically and/or use an antennae to improve signal reception.
2. GPS coordinates depicting the specific location of the sampling station in terms of latitude and longitude or plane coordinate systems such as Universal Transverse Mercator (UTM) units should be recorded, so that the user can return to the same position or depict graphic information, including:
 - Mark the location of sampling sites on or near streams, rivers, outfall areas, estuaries and shorelines in the diagram in the field notebook or on prepared maps or store to the memory on the GPS unit.
 - Mark affected shorelines during oil or chemical spills or mark zones of impact on land in the diagram in the field notebook or on prepared maps or store to the memory on the GPS unit.
3. Estimate distances, elevation, gradients and areas in the field. UTM coordinates are better as they allow calculation of distances using metric units.
4. Include a general description of the area, including land-use practices upstream and downstream of sampling locations.
5. Record information on processes or products observed, waste generations, etc.
6. Note the reason for the visit.
7. Record names and affiliations of persons present (e.g. business cards).
8. Record field instrument calibration information.



FIGURE 2.32:
Global Positioning Systems accuracy depends on the number of satellites the unit can detect and the resolution of the system algorithms. They range from small hand-held units to portable backpack units capable of data logging.
(Courtesy of United States EPA/ Canada DOE)

9. Record all pertinent observations (e.g. flow rates).

2.7.3 INFORMATION REGARDING THE SAMPLING

Sampling protocols are pre-established written descriptions of the procedures to be followed in collecting, packaging, labelling, preserving, transporting and storing samples. Proper documentation of sampling protocols is an essential component of the field quality assurance program. Sample protocol documentation should be saved for future reference; you may need to consult these in court or they may be useful for planning future sampling trips.

The overall sampling protocol documentation should identify sampling locations and include all of the equipment and other information needed for sampling such as:

- Nature of spilled materials or contaminating substances, composition and concentration, if known.
- Types of sampling devices used to collect samples and any factors that may affect sample quality.
- Field measurements such as pH, dissolved oxygen, temperature, etc.
- Sample type (e.g. water, sediment, biota, air).
- Any field preparations (e.g. filtering).
- Specific preservation instructions for each sample type and parameter in question.
- Sample container labelling.

It is recommended to complete the label and attach it to the sample container prior to sampling as moisture and dirt will normally interfere with writing on the label after sampling. Use pre-numbered, waterproof, permanent adhesive polyester labels (or equivalent). They can be ordered pre-printed and in two parts with corresponding unique numbers: one part for the container, the other for your documentation. Another way is to etch the container with a glass etcher. The etchings are marked



directly into the glass and form a permanent record.

The label should contain:

- Site name – usually a brief acronym or number that represents the site
- Date (year – month – day)
- Time (24-hour format)
- Initials of sampler
- Type of analysis requested

Transfer an exact copy of the information from the label to the notebook. Keeping the label information brief and clear will reduce the transcription errors as this information will be transferred to laboratory submission sheets, laboratory reports, scientific, engineering and legal reports. Every transcription represents an opportunity for error and confusion.

1. Seal the sample and where legal numbered seals are involved, record them in the field notebook.
2. Record the number of samples.
3. Record the volume of samples.
4. Record numbers and types of QA/QC samples, including blanks, splits, etc.
5. Record information on any background or control sites.

Where electronic data logging by the test equipment is not possible or preferred, then the collection of field data such as pH, conductivity, temperature, static water levels and ambient air characteristics should be recorded. Link your site notes to the physical position of the site. If possible use GPS coordinates.



FIGURE 2.33: Physical marking of evidence, electronic logging during scanning and recording of data in notebooks are essential techniques for recording information. (Courtesy of United States EPA/ Canada DOE)

Details of sample storage (presentation and temperature), packing (on ice or refrigerated) and transportation method from the field to the lab and chain-of-custody information should be summarized in the field notebook.

2.7.4 USE OF STILL CAMERAS

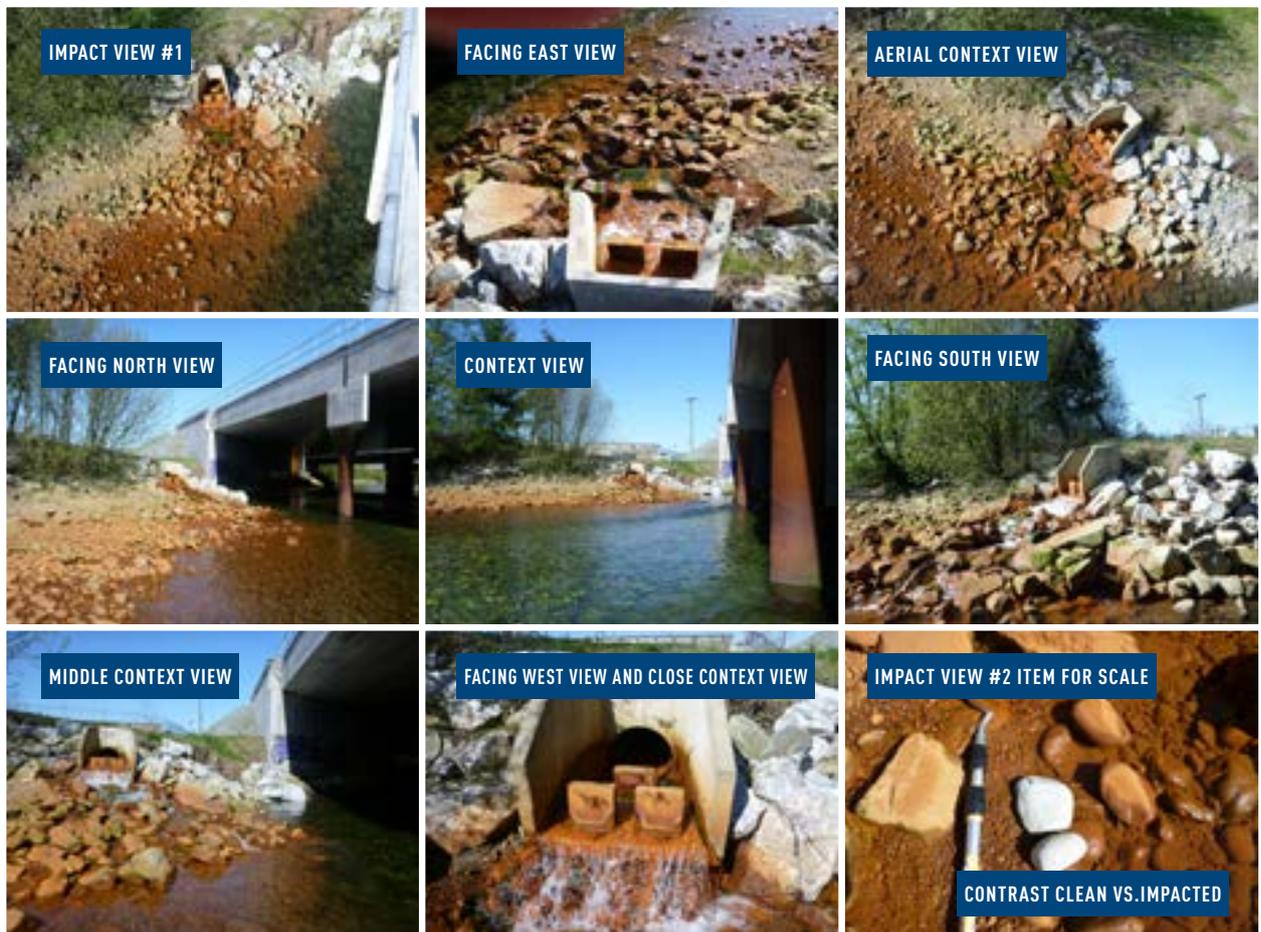
In many cases you will want to document sampling activities using photographs (conventional or digital). Photographs are often the easiest, most accurate and convenient way to demonstrate your observations and provide positive identification of the sampling point. Photographs documenting sampling points should include two or more reference points to make it easier to find the point at a later date. The scene should

be photographed from as wide an angle as possible to provide context to the scene. Then the photographs should move progressively closer to the point of interest so that details can be viewed. If safely possible, obtain an elevated view of the scene.



FIGURE 2.34:
Cameras are essential tools to collect evidence. The photographs should be taken to provide the context and setting of the crime scene from a broad perspective and then narrow down in greater detail with consecutive close up photographs. (Courtesy of Brazil – Federal Police)

FIGURE 2.35:
Context views from all four directions and aerial views. (Courtesy of Canada - DOE)





Photographs of samples in their containers should be taken after they have been labelled and sealed, close enough to show their labels with the sample number clearly visible and linking the samples to its source.

It may be beneficial to collect a duplicate of a sample in a clear glass container and one in an amber glass if the proper type of glass is amber (i.e. an organic sample to prevent photo degradation). The photo can show the condition of the sample at the impacted site via the clear glass container however the analytical results will be taken from the proper amber glass sample. A second clear glass sample may be taken of a control site if there is sufficient visual difference between the control site and the impacted site.

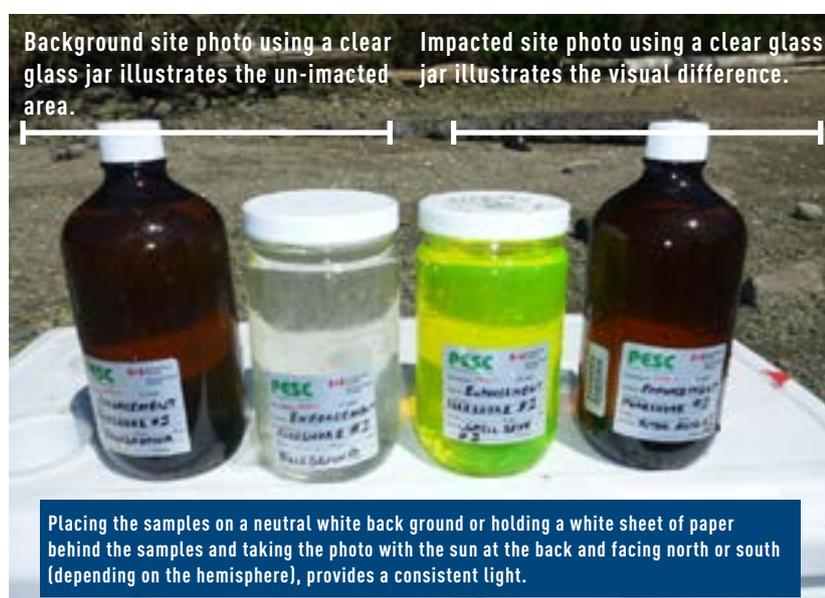


FIGURE 2.36:
Where color and/or clarity are important evidence, samples should be collected in clear bottles and photographed against a neutral background. (Courtesy of Canada – DOE)

For each photograph, record in the notebook:

- Date and time of the photograph
- Photographer's name
- Name of site
- GPS location or compass direction and description of the subject taken
- Digital photograph number and/or film roll number
- What is significant about the view depicted in the photograph

When taking a panning shot of the scene, care should be taken to hold the camera steady or preferably on a tri-pod and have a slow panning speed. Be sure to label the digital storage device or videotape with the place, date, incident number and your name. If you decide to include a verbal documentary of the scene on the video camera's sound track, ensure that your descriptions of the scene are accurate. It is normally better to film the scene only to record the sounds of the activities and no voice of the videographer. The videographer can then write notes of what the scene depicted which can be used for subsequent testimony.

2.7.6 USE OF VOICE RECORDING DEVICES

Voice recording devices may be used to record field notes and, in some jurisdictions, the interviews with witnesses. Care should be taken to clearly record notes which should later be transcribed into written text. Local jurisdictions may have specific legal requirements under which a voice recording device may be used especially in relation to recording conversations where there is an expectation of privacy or confidentiality. Check with your jurisdiction's department of justice for the applicable policy.



2.8 FIELD AND EXPERT REPORTS

Factual and expert reports will depend on the quality and reliability of the sample and physical evidence collected in the field. Adherence to proper preparation and sampling and analytical protocol will assist in tracing sources of potential or actual errors in the data or defending evidence in legal proceedings.

2.8.1 DATA QUALITY AND FACTUAL AND EXPERT REPORTS

Data quality objectives (DQOs) define the degree of uncertainty or error that can be tolerated in the data. DQOs may be qualitative or quantitative. Qualitative DQOs are specific descriptions of actions to be taken if a response does not meet the DQO. Data quality problems are often from two sources, transcription errors or contamination during the sampling, transport or analytical process.

2.8.2 DETECTING TRANSCRIPTION ERRORS

Transcription errors can be minimized by using the minimum numbers of identifiers on sample labels, electronic entry of analytical results and accurate copying of the electronic data files.

What action will be taken if transcription errors are suspected?

Possible solutions include:

- Transcription errors are normally detected and corrected by methodically comparing the field notes (especially in relation to sample identifiers) to analytical results and reports.

2.8.3 DETECTING ANALYTICAL QUALITY CONTROL ERRORS

Quality control errors can be detected by using quality control samples, such as sample blanks, transportation blanks equipment blanks, or spiked samples. When quality control errors are suspected or detected what action will be taken to assist in correcting the situation:

- Discarding the data.
- Testing the analytical equipment with blanks or spiked samples.
- Re-sampling.
- Subtracting the contaminated amount from the data.

Quantitative DQOs, on the other hand, involve specific quantitative terms such as standard deviations, relative standard deviations, percent recovery, relative percent difference and concentration.

For example, if the desired lowest limit of detection cannot be met, possible actions should be taken:

- Re-analysing the sample. It is critical that the sample is large enough to allow verification analysis.
- Accepting a higher detection level.
- Compositing several samples to obtain one large sample. (This may reduce the accuracy of the data set in defining the problem.)
- Trying a different analytical method.
- Re-sampling the same site or a different site and taking larger samples.

2.8.4 FIELD AND EXPERT REPORTS FORMAT

Reporting format and content will depend on the purpose of the report and requirements of the legal jurisdiction. Generally, environmental reports must be in clear language, with a minimum of technical acronyms. Any technical terms should be identified and interpreted into plain language that allows a legal and lay audience to understand the terms.

WATER 1 provides an example of how to present technical and scientific information in an illustrated format that legal and judicial audiences can understand.



2.9 TABLES OF INFORMATION

2.9.1 TEST SELECTION BY INDUSTRY TYPE

Depending on the situation, toxicology testing could be requested for any of these industry types.

Table 2.9.1.1 | Toxicology tests by industry type

Industry type	toxicology testing
AGRICULTURAL RUNOFFS	Herbicides, NO ₂₊₃ , Pesticides, Phosphorus, pH
CHEMICALS & PLASTIC	Metals
COAL MINES	NFR, PAHs
CONTAMINATED SITES	BTEX, EPH, VH/VPH, Metals, PAHs
DUST SUPPRESSION OILS	PCBs
FISH FARMS	Available Phosphorous, H ₂ S (field), Redox (field), Sediment Grain Size, Temperature (field), Total Metals, TVR
FISH HATCHERIES	Ammonia, NFR, Total Phosphorus
FOOD PROCESSING	Ammonia
GROUNDWATER	Bromide, Chloride, Fluoride, Metals, NO ₂₊₃ , Pesticides, pH, Turbidity
HAZARDOUS WASTE	Metals, PCBs, Pesticides
INDUSTRIAL EFFLUENT	Acidity, Alkalinity, Ammonia, Bacteria (Total/Fecal Coliforms), Bioassays, (Trout/Daphnia LC50 & LT50), BOD, Bromide, COD, Chloride, Fluoride, Metals, NFR, NO ₂₊₃ , TOC, Turbidity
LANDFILL LEACHATES	Mercury, NO ₂₊₃ , pH
LAUNDROMATS	Ammonia, Phosphorous, pH, PERC
MEAT & POULTRY	Oils & Grease, pH
MINING & METAL FINISHING EFFLUENTS	Ammonia, Cyanide, Mercury, Metals, NFR, PAHs, pH, Sulphides
MUNICIPAL EFFLUENTS	Ammonia, Bacteria (TC, FC, Strep.), BOD, Bioassay (Daphnia and Trout), COD, Conductance, Metals NO ₂₊₃ , Ortho-P, pH, TOC, Total-P, Turbidity
PETROLEUM PRODUCTS (REFINERY)	VH/VPH for gasoline, mineral spirits, paint thinners EPH for diesel fuels, lubricating oils & grease, hydraulic oils BTEX, Oil & Grease, TOC, Metals, Sulphides, Turbidity, NFR, pH, Phenols NOTE: Test for EPH in conjunction with VH to capture the quantitative values of most petroleum products. Let lab know if there is a need to distinguish between naturally occurring vs. petroleum hydrocarbons
PULP AND PAPER	Ammonia, BOD, Dioxin/Furans, LC50/LT50 Fish & Daphnia, Metals, NFR, pH, Resin Acids
SMELTERS	Mercury, Metals, NO ₂₊₃
SURFACE WATER	Acidity, Alkalinity, Bacteria (enterococcus, E. coli, total/fecal coliforms), Chloride, Fluoride, NFR, Ortho-P, pH, TIC, Total-P, Turbidity
TRANSFORMERS, CAPACITOR	PCBs
WASTE OILS	EPH, Oil & Grease, PCBs, SWOG
WOOD CHIPS	Chlorinated Phenols
WOOD PRESERVING FACILITIES	Antisapstains (DDAC, IPBC, Cu-8, TCMTB), Chlorinated Phenols (penta, tetra, tri, di-chlorophenols, guaiacols, catechols), PAHs

2.9.2 SAMPLING CONTAINERS, PRESERVATION, HOLDING TIME

To get the best quality analytical results, the correct handling of the samples and their prompt delivery to the laboratory are crucial. The tables in this section and the protocols in the following section outline container and preservation usage. Samples should be delivered to the laboratory as soon as possible to ensure the analytical results are representative of the collection site. Two definitions you should be aware of:

HOLDING TIME - is the length of time between when the sample is collected and when the sample is analysed or fixed (i.e. extracted out of the matrix into solvent).

TURNAROUND TIME - is the length of time between when the laboratory receives the sample and when it issues a result of analysis to the submitter.

In most cases, it will be critical to get the sample to the lab as soon as possible. You should always keep holding time as short as possible and submit samples promptly. Samples will be flagged in the laboratory analytical report if holding times are exceeded and the submitter should be informed.

SAMPLE PRESERVATION

Since it is difficult to know what physical, biological and chemical changes may occur during holding time, samples should be refrigerated at approximately 4°C to reduce biological activity and the rate of chemical decomposition. Chemical preservatives should be added to the sample where required to fix the analyte in question from loss or breakdown.

Table 2.9.2.1 | Inorganic chemistry sampling containers, preservation, holding time



Parameter	Substance	Sample Container	Preservation	Holding Time (days)+
ACIDITY, ALKALINITY	water	HDPE, 1 L++	4°C	14
AMMONIA	water	HDPE, 1 L++	4°C	5
BIOCHEMICAL OXYGEN DEMAND	water	HDPE, 1 L	4°C	3
BROMIDE, CHLORIDE, FLUORIDE, NITRATE, NITRITE, PHOSPHATE, SULPHATE, TOTAL NITROGEN	s/s/b	tissue cup, 125 mL	4°C	30
CHEMICAL OXYGEN DEMAND	water	HDPE, 250 mL	H ₂ SO ₄ < pH 2*** (at lab)	30
CHLORIDE, FLUORIDE, SULPHATE	water	HDPE, 1 L++	4°C	30
CHLORINE, RESIDUAL	water	on site test	4°C	immediately
COLOUR	water	HDPE, 1 L++	4°C	3
CONDUCTIVITY	water	HDPE, 1 L++	4°C	30
CONDUCTIVITY	s/s/b	tissue cup, 125 mL	4°C	30
CYANIDE	water	HDPE, 250 mL	field NaOH > pH 12***	14
CYANIDE	s/s/b	tissue cup, 125 mL	4°C	30
DISSOLVED OXYGEN	water	HDPE, 1 L	none; fill to exclude air; 4°C	ASAP
HEXAVALENT CHROMIUM	water	HDPE, 250 mL	4°C	24 h
LEACHATE	water	amber glass, 1 L		7
LEACHATE	s/s/b	amber glass, 1 L		7
MERCURY dissolved	water	acid washed amber glass, 100 mL	field filtered thru 0.45µ cellulose acetate filter, K ₂ Cr ₂ O ₇ & HNO ₃ < pH 2*** (at lab)	30
MERCURY total	water	amber glass, 100 mL	K ₂ Cr ₂ O ₇ & HNO ₃ < pH 2*** (at lab)	30
MERCURY total	s/s/b	amber glass, 180 mL or tissue cup, 125 mL	4°C	30
METALS dissolved	water	new certified clean or acid washed HDPE, 250 mL	field filtered thru 0.45µ cellulose acetate filter, HNO ₃ < pH 2 or filter & preserve at lab (source dependent)	180
METALS total	water	new certified clean or acid washed HDPE, 250 mL	field HNO ₃ < pH 2 or at lab (source dependent)	180
METALS total	s/s/b	tissue cup, 125 mL	4°C	180
MOISTURE	s/s/b	tissue cup, 125 mL	4°C	30
NITRATE, NITRITE, PHOSPHATE - total, dissolved, ortho	water	HDPE, 1 L++	4°C	3
NITROGEN total, dissolved	water	HDPE, 1 L++	4°C	5
NITROGEN total, kjeldahl	water	HDPE, 1 L++	4°C	28
NON-FILTERABLE RESIDUE - total, total dissolved, suspended also known as total suspended solids	water	HDPE, 1 L++	4°C	24 h pulp & paper effluent; 7 days other
pH	water	HDPE, 1 L++	4°C	3
pH	s/s/b	tissue cup, 125 mL	4°C	30
RADIONUCLIDE, RADIUM - 226	water	HDPE, 1 L		30
SULPHIDE	water	HDPE, 500 mL	field ZnAc	7
SULPHIDE	s/s/b	tissue cup, 125 mL	field ZnAc	30
TURBIDITY	water	HDPE, 1 L++	4°C	3
VOLATILE RESIDUE IN SEDIMENT	s/s/b	tissue cup, 125 mL	4°C	7

Table 2.9.2.2 | Organic chemistry sampling containers, preservation, holding time

Parameter	Substance	Sample Container	Preservation	Holding Time (days)+
ADSORBABLE ORGANIC HALIDES	water	amber glass, 500 mL**	field HNO ₃ < pH 2***	30
ANTI-SAPSTAINS	water	amber glass, 1 L	4°C (refer to sampling protocol)	30
ANTI-SAPSTAINS	s/s/b	amber glass, 180 mL	4°C (refer to sampling protocol)	30
BEAR BILE	water	amber glass, 180 mL**	4°C	30
BEAR BILE	s/s/b	amber glass, 180 mL**	4°C	30
CARBON - total inorganic, total organic, dissolved inorganic, dissolved organic	water	HDPE, 250 mL	HCl < pH 2, 4°C	28
CARBON, total	solid	tissue cup, 125 mL	HCl < pH 2, 4°C	28
CHLORINATED PHENOLS	water	amber glass, 1 L**	4°C	30
CHLORINATED PHENOLS	s/s/b	amber glass, 180 mL**	4°C	30
DIOXIN & FURAN	s/s/b	amber glass, 180 mL**	4°C	30
DIOXIN & FURAN	water	amber glass, 1 L**	4°C	30
FATTY ACIDS	s/s/b	amber glass, 180 mL**	4°C	30
FATTY ACIDS	water	amber glass, 1 L**	4°C	30
GLYCOLS	water	amber glass, 1 L**	4°C	7
GLYCOLS	s/s/b	amber glass, 180 mL**	4°C	7
HERBICIDES (AEH)	water	amber glass, 1 L**	4°C	7
HERBICIDES (AEH)	s/s/b	amber glass, 180 mL**	4°C	30
HYDROCARBONS	water	amber glass, 1 L**	4°C	7
HYDROCARBONS	s/s/b	amber glass, 180 mL**	4°C	14
HYDROCARBON IDENTIFICATION	water	amber glass, 1 L**	4°C	7
HYDROCARBON IDENTIFICATION	s/s/b	amber glass, 1 L**	4°C	7
HYDROCARBON, OIL & GREASE	water	amber glass, 1 L**	HCl < pH 2*** (at lab)	30
HYDROCARBON, OIL & GREASE	s/s/b	amber glass, 180 mL**	4°C	30
OZONE-DEPLETING SUBSTANCES	container	2 cans of product	4°C	7
PCBS	water	amber glass, 1 L**	4°C	30
PCBS	s/s/b	amber glass, 180 mL**	4°C	30
PESTICIDES	water	amber glass, 1 L**	4°C	7
PESTICIDES	s/s/b	amber glass, 180 mL**	4°C	30
POLYCYCLIC AROMATIC HYDROCARBONS	water	amber glass, 1 L**	4°C	7
POLYCYCLIC AROMATIC HYDROCARBONS	s/s/b	amber glass, 180 mL**	4°C	30
RESIN ACIDS	water	amber glass, 1 L**	NaOH > pH 12*** (at lab)	30
RESIN ACIDS	s/s/b	amber glass, 180 mL**	4°C	30
SUBSTITUTED PHENOLS	water	amber glass, 1 L**	4°C	14
SURFACTANTS	water	amber glass, 1 L**	4°C	30
TRIHALOMETHANE	water	2 x amber glass, 40mL septum vials*	4°C	14
TRIHALOMETHANE	s/s/b	amber glass, 180 mL**	4°C	30
VOLATILES	water	2 x amber glass, 40mL septum vials*	4°C	7
VOLATILES	s/s/b	amber glass, 180 mL**	4°C	14

**Table 2.9.2.3 | Toxicology samples**

Parameter	Sample Container	Preservation	Holding Time (days)+
DAPHNIA (chronic 21d, chronic EC ₂₅)	20 L bioassay container	4°C	5
DAPHNIA (LC ₅₀ , LT ₅₀)	2 x 1 L HDPE	4°C	5
TROUT (LC ₅₀)	4 x 20 L bioassay containers	4°C	5
TROUT (LT ₅₀)	2 x 20 L bioassay containers	4°C	5

Table 2.9.2.4 | Bacterial sampling, sampling containers, preservation, holding time

Parameter	Sample Container	Preservation	Holding Time (days)+
FECAL COLIFORMS	aseptic 250 mL container	4°C; for chlorinated samples add sodium thiosulphate	6 hours max
BOTTLE DEFINITIONS			
HDPE	high density polyethylene bottle		
AMBER GLASS	heat treated amber glass bottle		
S/S/B	soil/sediment/biota		

*No headspace/air bubbles in container

**Containers must have Teflon lined cap

***Corrosive – wear protective gloves

+Holding time is from sampling to start of analysis (or fixed)

++Only one HDPE, 1 L bottle is required for all analysis

Table 2.9.2.5 | Heavy metals and organic samples

Parameter	Sample Container	Preservation	Holding Time (days)+	Analysis
VEGETATION	250 ml wide mouth polyethylene*	4°C or freeze**	***	heavy metals
	250 ml wide mouth amber glass	4°C or freeze**	2	organic chemicals****
ANIMAL TISSUE	250 ml wide mouth polyethylene*	4°C or freeze**	***	heavy metals
	250 ml wide mouth amber glass	4°C or freeze**	2	organic chemicals****
VEGETATION	250 ml wide mouth clear glass	do not freeze Store at 4°C	1	cell and tissue structure
ANIMAL TISSUE	250 ml wide mouth clear glass	do not freeze store at 4°C	1	cell and tissue structure

* Borosilicate glass contains metals therefore bottle should be acid washed high density polyethylene (HDPE)

** After biological material is frozen, the cells rupture. Upon thawing the cell content may leak as “exudate” and can contain materials which can be lost if not included in the sample.

*** Metals holding times depends on the metals. E.g. Mercury can sublime therefore should be done as soon as possible.

**** For organic chemicals it is recommended that the sample be analysed within 2 days where the chemical has a short half-life. Certain chemicals such as chlorinated organics/pesticides (DDT, PCBs, Dioxins and Furans) may have a much longer sample life. Check with the analytical laboratory prior to collecting the sample

2.9.3 SAMPLING PROTOCOLS BY TEST TYPE 

Table 2.9.3.1 | Adsorbable organic halides (aox)

LIQUID SAMPLING POINT	Paper mill effluent, including bleach water and stages of pulp bleaching process
SAMPLING TECHNIQUE	Grab or composite over 1 h
CONTAINER TYPE AND SIZE	Amber glass, 500 mL; Teflon lid liner, Teflon septum
PRESERVATION	Exclude air headspace in container; add 0.5% sodium sulphite (Na_2SO_3) if needed and 1 mL concentrated nitric acid (HNO_3); store at $< 4^\circ\text{C}$; DO NOT FREEZE
HOLDING TIME	
FINAL EFFLUENT	30 days
C AND E STAGES	2 days
SOIL, SEDIMENT, BIOTA SAMPLING	Sludges
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 180 ml
PRESERVATION	4°C
HOLDING TIME	30 days

PROTOCOL

1. Collect sample in an amber glass bottle.
2. Fill bottle completely to exclude headspace.
3. Prepare a traveling blank of reagent water, acidified to pH 2 with 1 mL concentrated HNO_3 .
4. If composite samples are required, collect over a 1 h period.
5. Test sample for the presence of residual chlorine as follows:
 - transfer approximately 10 mL of sample to a test tube
 - add a few crystals of potassium iodide
 - add 5 drops of a 1% soluble starch solution
 - a blue colour indicates presence of residual chlorine
6. Any residual chlorine must immediately be removed with sodium sulphite, add 1 mL of a 0.5% $\text{Na}_2\text{SO}_3/\text{L}$ sample; add more if necessary until the blue colour disappears. Use the minimum possible, since excess sodium sulphite will give erroneously low AOX results.
7. Upon collection, but after adding any sodium sulphite, adjust samples to pH 1.5 - 2 with concentrated HNO_3 (1 mL/L is sufficient).
8. Tightly cap sample; transport with freezer packs and store at $< 4^\circ\text{C}$ (do not freeze). Protect from light.

**Table 2.9.3.2 | Alkalinity/acidity**

LIQUID SAMPLING POINT	Water; effluent
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	14 days

PROTOCOL

1. Rinse bottle three times with water to be sampled.
2. Immerse container in water to a depth approximately 1/3 from the bottom. Avoid skimming the surface.
3. Fill container 95% full.
4. Remove from water and tightly cap sample.
5. Store at 4°C.

NOTE: Choosing the sampling depth requires careful judgment. For deep water, taking the sample 1/3 from the bottom may be impractical; sample at least 1 m from the surface. In shallower water, you may take samples 1 m from the surface and 1 m from the bottom. In pipes or open channels, take samples 1/3 of the way up from the bottom.

Table 2.9.3.3 | Anti-Sapstains (Fungicides Used in the Sawmilling Industry)

Wood preservatives: didecyltrimethylammonium chloride (DDAC); 3-iodo-2-propynylbutyl carbamate (IPBC); copper-8 (Cu-8); and 2-(Thiocyanomethylthio) benzothiazole (TCMTB).

SAMPLING POINT	Wood preserving/treatment plant effluent; soil; sediment
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L; Teflon lid liner
SEDIMENTS	Wide-mouth glass jar, 180 g
PRESERVATION	4°C
DDAC AND IPBC LIQUIDS	5 mL Rexonic N25-7* + 10 mL 37% formaldehyde/L sample
DDAC AND IPBC SEDIMENT	2.5 mL Rexonic N25-7 + 5 mL 37% formaldehyde/100 g sample
CU-8	1 mL 3 N NaOH
TCMTB	No preservative
HOLDING TIME	30 days

NOTE: Rexonic N25-7 is a trade name for alkoxypropyleneoxyethanol.

PROTOCOL

1. No rinsing should occur, solids should be placed in a 180 mL wide-mouth glass jar.
2. Add preservative as specified in list above. Tightly cap sample.
3. Store at 4°C.

Table 2.9.3.4 | Bacteria: fecal coliforms and streptococci

SAMPLING POINT	Sanitary effluent; surface water; wastewater sediment; biota
SAMPLING TECHNIQUE	Grab only
CONTAINER TYPE AND SIZE	Sterile HDPE or sterile amber glass, 250 ml
PRESERVATION	For Chlorinated samples: add sodium thiosulphate; 4°C
HOLDING TIME	6 h

NOTE: Bacterial sampling is almost always the responsibility of health authorities. Taking samples without bacterial contamination requires special handling techniques (called aseptic technique). If you must take bacterial samples, get a health inspector or another person with training in aseptic technique to take the sample for you.

PROTOCOL

1. Obtain sterile bottles from lab. Specially treated bottles are required for samples having a chlorine residual up to 15 mg/L (e.g. sewage treatment plant effluent). These bottles should contain 0.1 mL of 10% sodium thiosulphate to de-chlorinate the sample.
2. Collect sample as aseptically as possible; the sample bottle must be kept unopened until ready to be filled. Do not rinse bottle with sample. Keep open bottle neck at an angle to prevent bacteria from drifting in from above; hold bottle cap with the open side facing down. Do not pass your hand, clothing, or any object over open bottle neck. Recap as quickly as possible.
3. If sampling drinking water from a tap, run the water for 2-3 minutes before collection to clear the line; then uncap the bottle quickly, fill and recap immediately.
4. For surface water, uncap the bottle and quickly plunge it about 30 cm under the water. If a current is present, direct the mouth of the bottle against the current.
5. Be sure to leave ample air space in the bottle to permit mixing during analysis.
6. Keep sample at 4°C; do not freeze. Samples not kept at 4°C will not be analysed.

Table 2.9.3.5 | Bioassay or acute lethality testing (LC_{50} / LT_{50})

LIQUID SAMPLING POINT	Runoff and wastewater
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Pail, jerry can, or carboy; HDPE, 1 L, 20 L, 50 L, 100 L drums or 20 L collapsible plastic container
PRESERVATION	4°C; do not freeze; samples should be kept dark and at a temperature of 4°C during transport
HOLDING TIME	5 days

NOTE: Always call the environmental toxicology section to confirm sample requirements prior to sampling for legal analysis. Sample volume requirements depend on numbers of daphnids or fish size exposed to each test solution, loading-density requirements, test concentrations and the use of replicates. For single-concentration tests using rainbow trout, sample volumes of 25 L - 50 L are normally required. For tests to determine an LC_{50} , sample volumes of 120 L or more are normally required. For Daphnia bioassay, approximately 2 L is required. Check with laboratory.

PROTOCOL

1. Rinse containers three times if quantity of sample permits.
2. Collect the required volume of effluent in a new or thoroughly cleaned container.
3. Label with the sample type, source, date and time of collection and name of sampler.
4. Store at 4°C

**Table 2.9.3.6 | Carbon (Inorganic/Organic/Total/Dissolved)**

LIQUID SAMPLING POINT	Sewage treatment wastewater; surface wastewater; petroleum refinery effluent
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 250 ml
PRESERVATION	HCl < pH 2, 4°C
HOLDING TIME	28 days

PROTOCOL

1. Immerse container in source to a depth of 5 cm - 10 cm.
2. Fill container 95% full.
3. Add preservative; tightly cap sample.
4. Store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Soil; sediment; biota
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Tissue cup, 125 mL
PRESERVATION	HCl < pH 2, 4°C
HOLDING TIME	28 days

PROTOCOL

1. For fluid samples, immerse container into source to a depth of 5 cm - 10 cm.
2. Fill container to exclude air; tightly cap sample.
3. Store at 4°C.

Table 2.9.3.7 | Chlorinated Phenols

Parameter, wood preservatives; pentachlorophenol; tetrachlorophenol (2,3,4,6- and 2,3,5,6-); trichlorophenol (2,3,4-, 2,3,5-, 2,3,6-, 2,4,5- and 2,4,6-); dichlorophenol (2,4- and 2,6-); tetrachloroguaiacol; trichloroguaiacol (3,4,5-, 3,4,6- and 4,5,6-); dichloroguaiacol (4,5- and 4,6-); monochloroguaiacol (5- and 6-); tetrachlorocatechol; 3,4,5-trichlorocatechol; dichlorocatechol (3,4-, 3,5- and 4,5-); 4-monochlorocatechol.

LIQUID SAMPLING POINT	Wood preservative plant effluent; wood chips
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L, quantity may vary with lab requirements; Teflon lid liner
PRESERVATION	4°C, protect from light
HOLDING TIME	30 days

PROTOCOL

1. Fill container 95% full.
2. Tightly cap sample.
3. Protect from light. Store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Wood preservative plant effluent; wood chips
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 180 mL
PRESERVATION	4°C
HOLDING TIME	30 days

Table 2.9.3.8 | Chloride, Fluoride and Sulphate

LIQUID SAMPLING POINT	Surface water; groundwater; effluent; sediment
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 1 L /Sediments: tissue cup, 125 mL
PRESERVATION	4°C
HOLDING TIME	30 days

PROTOCOL

1. Rinse bottle and lid three times with sample water before filling.
2. Tightly cap sample. Store at 4°C

Table 2.9.3.9 | Cyanide

LIQUID SAMPLING POINT	Mining effluent; metal-finishing effluent, illegal fishing area
SAMPLING TECHNIQUE	Grab; or 7 day, 24 h composite
CONTAINER TYPE AND SIZE	HDPE, 250 mL
PRESERVATION	Ascorbic acid, if needed; 1.5 mL 40% NaOH/100 mL or add 2 NaOH pellets/250 mL; 4°C
HOLDING TIME	14 days

NOTE: Oxidizing agents can destroy cyanide. Therefore check for oxidants by putting a drop of sample on 5% potassium iodide-starch paper; a blue colour indicates that ascorbic acid must be added. Add ascorbic acid a few crystals at a time until sample produces no colour change on indicator paper then add 0.5 g excess. NaOH raises the pH of the sample to above 12 in order to stabilize the cyanide compound by preventing dissociation. NaOH at the concentration used and in pellet form is extremely corrosive and can cause severe burns to skin and eyes; routine safety procedures should be followed. This preservative is normally supplied in small vials by the laboratory doing the analysis. If taking composite samples, put preservative in the container before collecting samples.

PROTOCOL

1. Put on protective disposable gloves.
2. Rinse container with sample water three times.
3. Check for presence of oxidizing agents and add ascorbic acid if necessary.
4. Add NaOH preservative; tightly cap sample.
5. Store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Mining, metal-finishing effluent area, illegal fishing area
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE	Tissue cup, 125 mL
PRESERVATION	4°C
HOLDING TIME	30 days


Table 2.9.3.10 | Dibenzo-Dioxins, Dibenzo-P-Dioxins, Dibenzofurans (PCDD/PCDF)

SAMPLING POINT	Pulp mill effluent; sediment; biota
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L
PRESERVATION	Sediments: wide-mouth glass jar, 180 g 4°C; (Na ₂ SO ₃ for bleach plant effluent)
HOLDING TIME	30 days

See **EPS L/RM/19 FEBRUARY 1992** <http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=89496F4E-1> for sampling effluents from pulp and paper mills. For other cases, collect sample directly into containers. For aqueous samples, do not rinse the containers before filling them; take 1 L samples in amber glass bottles

PROTOCOL

1. Solids should be placed in a 180 mL wide-mouth glass jar.
2. Store at 4°C

SAMPLING POINT	Defoamers; contaminated surfaces
SAMPLING TECHNIQUE	
DEFOAMERS	Grab
SURFACES	Wipe with hexane
CONTAINER TYPE AND SIZE	
DEFOAMERS	Amber glass; foil or Teflon lid liner
SURFACES	Amber glass for wipe sample
PRESERVATION	4°C
HOLDING TIME	30 days

PROTOCOL - DEFOAMERS

1. Collect 180 mL defoamer in a glass container.
2. Seal with cap lined with Teflon or aluminium foil.
3. Store at 4°C.

SAMPLING POINT	Defoamers; contaminated surfaces
SAMPLING TECHNIQUE	
DEFOAMERS	Grab
SURFACES	Wipe with hexane
CONTAINER TYPE AND SIZE	
DEFOAMERS	Amber glass; foil or Teflon lid liner
SURFACES	Amber glass for wipe sample
PRESERVATION	4°C
HOLDING TIME	30 days

PROTOCOL - DEFOAMERS

1. Collect 180 mL defoamer in a glass container.
2. Seal with cap lined with Teflon or aluminium foil.
3. Store at 4°C.

PROTOCOL - FUGITIVE EMISSIONS

1. Soak a sorbent pad with a known volume of pesticide-grade hexane. Wipe (stroking both ways) a 25 cm x 25 cm area. Insert wipe in amber glass bottle; use Teflon or foil-lined cap.
2. Protect from light. Store at 4°C.

Table 2.9.3.11 | Glycol

SAMPLING POINT	Airport effluent, storm water and drainage streams; glycol guidelines
SAMPLING TECHNIQUE	Grab; 2 samples, one taken at least 30 minutes and not more than 24 hours after the first sample
CONTAINER TYPE AND SIZE	Amber glass, 180 mL or 1 L
PRESERVATION	4°C
HOLDING TIME	7 days

PROTOCOL

1. At airport, take the first sample, then wait at least 30 minutes and not more than 24 hours before taking the second sample.
2. Store at 4°C.

Table 2.9.3.12 | Leachate (Toxicity Characteristic Leaching Procedure (TCLP))

SAMPLING POINT	Various; waste or hazardous waste material
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L or 1 kg
PRESERVATION	4°C
HOLDING TIME	Analyte dependent

PROTOCOL

1. For volatile components, do not leave any headspace. If the material is solid minimize the amount of air space in the container.
2. Due to the variability in the types of samples related to the test, no specific sampling protocol can be provided. The protocol will be based on the type of material to be tested and the analytes of interest.
3. Refer to the sections on the types of matrices and the analyte-specific requirements for sampling procedures and containers.
4. For granular solid samples, take composite samples from various locations of the waste material.
5. Do not preserve samples by any means other than storing at 4°C.
6. Ship to lab as soon as possible.

Table 2.9.3.13 | Metals (total, extractable, dissolved or suspended)

Including: aluminium (Al), antimony (Sb), arsenic (As), boron (B), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), phosphorus (P), potassium (K), selenium (Se), silicon (Si), silver (Ag), sodium (Na), strontium (Sr), sulfur (S), thorium (Th), tin (Sn), titanium (Ti), uranium (U), vanadium (V), zinc (Zn).

NOTE: Lab protocols will depend on the analyte of interest. Check with the laboratory to determine the volume of sample needed and metals available to be analysed.

SAMPLING POINT	Municipal wastewater treatment effluent; industrial effluent (forest products, pulp and paper, chemicals, plastics, petroleum processing, metal finishing); mining and refining
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	HDPE, 250 mL
PRESERVATION	HNO ₃ (see protocol)
HOLDING TIME	180 days

WARNING! Nitric acid is extremely corrosive; use gloves. It fumes freely. NEVER ADD NITRIC ACID TO SAMPLES THAT MIGHT CONTAIN CYANIDE, AS NITRIC ACID WILL CAUSE THE RELEASE OF DEADLY CYANIDE GAS.



Samples containing nitric acid must be shipped via a carrier certified to handle dangerous goods; they cannot be shipped by air (IATA), unless the nitric acid as a preservative is less than 20% limit.

PROTOCOL - TOTAL OR EXTRACTABLE

1. Put on protective gloves.
2. Rinse container with sample water three times.
3. Add preservative; 1 mL, 35% nitric acid per 100 mL sample or 2 mL 1:1 HNO₃/250 mL sample. Tightly cap sample; shake to mix.
4. Sample can be stored at room temperature.

PROTOCOL - DISSOLVED

1. Put on protective gloves.
2. Using a disposable 60 mL latex free syringe inject sample through a 29 mm, 0.45 pore size, single use, hydrophilic Durapore membrane filter (Milipore).
3. Repeat to accumulate the 250 mL volume of sample required.
4. Rinse the container once with a small amount of filtrate. Fill container with remainder of filtrate; add preservative (1 mL 35% nitric acid per 100 mL sample). Tightly cap sample; shake to mix.
5. Sample can be stored at room temperature.
6. Be sure to clean up any disposable filters or syringes.

NOTE: Suspended metals are those retained on the filter.

TOTAL METALS

SOIL, SEDIMENT, BIOTA SAMPLING	Municipal wastewater treatment sites; industrial sites (forest products, pulp and paper, chemicals, plastics, petroleum processing, metal finishing); mining and refining
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Tissue cup, 125 mL
PRESERVATION	4°C
HOLDING TIME	180 days

Table 2.9.3.14 | Metals - Hexavalent Chromium (CrVI)

SOIL, SEDIMENT, BIOTA SAMPLING	Municipal wastewater treatment sites; industrial sites (forest products, pulp and paper, chemicals, plastics, petroleum processing, metal finishing); mining and refining
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 250 mL
PRESERVATION	4°C
HOLDING TIME	24 h

Table 2.9.3.15 | Nitrogen Compounds - Nitrate And Nitrite

Including: nitrate, nitrite, ammonia, total Kjeldahl nitrogen, total dissolved nitrogen, total nitrogen.

LIQUID SAMPLING POINT	Sewage/effluent; landfill leachate; smelters; agricultural runoff; groundwater
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	3 days

PROTOCOL

1. Rinse container with sample water three times.
2. Submerge container into water to a depth of approximately 5 cm - 10 cm.
3. Store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Agricultural sites; soil; vegetation; sediment; sludge
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Amber glass, 180 mL
PRESERVATION	4°C; protect from sunlight
HOLDING TIME	3 days

Table 2.9.3.16 | Nitrogen - Ammonia

LIQUID SAMPLING POINT	Municipal wastewater treatment plant effluent; industrial effluent (food processing, metal finishing, mining and refining); laundries and Laundromats; private domestic sewage discharge; industrial sanitary effluent; pulp and paper effluent
SAMPLING TECHNIQUE	Grab or 24 h composite
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	5 days

PROTOCOL

1. Rinse container with sample water three times.
2. Fill container to the rim; tightly cap sample.
3. Store at 4°C.

Table 2.9.3.17 | Nitrogen - total Kjeldahl

LIQUID SAMPLING POINT	Municipal wastewater treatment plant effluent; food processing; metal finishing; mining and refining; laundries and Laundromats; sewage discharge; pulp and paper industries
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	28 days

PROTOCOL

1. Rinse container with sample water three times.
2. Fill container to the rim; tightly cap sample.
3. Store at 4°C.

**Table 2.9.3.18 | Non-Filterable Residue (NFR)**

Including: filterable residues/non-filterable residues, also known as total suspended solids (TSS).

LIQUID SAMPLING POINT	Surface water effluent; pulp and paper mill effluent; metal mining effluent
SAMPLING TECHNIQUE	
GENERAL	Grab or composite
PULP AND PAPER	Composite
METAL MINING	Grab
CONTAINER TYPE AND SIZE	
GENERAL	HDPE, 200 mL for turbid sample; 1 L for clear sample
PULP AND PAPER / MINING	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	24 h for pulp and paper effluent; 7 days for other samples

PROTOCOL

1. Rinse container with sample water three times.
2. If compositing, keep sample at 4°C.
3. Keep sample at or below 4°C.

Table 2.9.3.19 | Oil and Grease

SAMPLING POINT	Refinery effluent; soil from contaminated sites; meat and poultry operations; transformer fluid
SAMPLING TECHNIQUE	Grab; petroleum refinery 24 h composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L; Teflon or aluminium-foil lid liner
PRESERVATION	HCL < pH 2*** (done at lab); 4°C
HOLDING TIME	30 days after preserved

NOTE: Oil and grease will adhere to the sides of the bottle. For this reason, DO NOT RINSE BOTTLE with sample water; simply fill the container, add preservative and cap the bottle. For petroleum refineries, a 24 h composite is required.

PROTOCOL

1. Collect approximately 1 L sample in glass bottles with Teflon or foil-lined caps.
2. Add 2 mL of conc.H₂SO₄, or HCl/per Litre and store sample at 4°C.
3. For auto samplers or composite samples, add preservative to sample container before sampling begins. Keep sample at 4°C during sampling period (for petroleum refineries).

Table 2.9.3.20 | Oxygen - Dissolved

Tests for dissolved oxygen are normally done in the field using dissolved oxygen (DO) meters or multi-mode meters equipped with a DO sensor for dissolved oxygen are normally done in the field using dissolved oxygen (DO) meters or multi-mode meters equipped with a DO sensor as part of their multiple readout capability. These meters require calibration before use. Colorimetric DO kits are also available. They are user friendly and do not require calibration.

The time frame for lab analysis of DO demand varies depending on the type of sample collected. Samples from effluent treatment facilities have a very short analytical time frame due to the possibility of high Chemical Oxygen Demand (COD) and/or biochemical oxygen demand (BOD). Consult with the lab before sampling for DO. Lab analytical methods may require the addition of preservatives to the sample depending on the analytical time requirements.

LIQUID SAMPLING POINT	Water; effluent
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	None; fill to exclude air; 4°C
HOLDING TIME	ASAP

PROTOCOL

1. Submerge sample container into source. Do not skim surface.
2. Fill sample container to the top.
3. Store at 4°C.

Table 2.9.3.21 | Oxygen - Chemical Oxygen Demand (COD)

LIQUID SAMPLING POINT	Water; effluent
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	HDPE, 250 mL
PRESERVATION	H ₂ SO ₄ /L < pH 2 (at lab); 4°C
HOLDING TIME	30 days

PROTOCOL

1. Rinse container with sample water three times.
2. Submerge container into source to a depth of 5 cm - 10 cm (do not skim the surface).
3. Fill container 95% full.
4. Add preservative; tightly cap sample.
5. Store at 4°C.

Table 2.9.3.22 | Oxygen Demand (Biochemical, BOD)

LIQUID SAMPLING POINT	Water; effluent
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	No preservative; fill to exclude air; 4°C
HOLDING TIME	3 days

NOTE: BOD tests are highly time sensitive. Coordinate your sampling times with the lab beforehand to ensure that samples will be analysed as quickly as possible.

**PROTOCOL**

1. Before preparing BOD sub-samples, ensure that the containers and lid are rinsed at least three times with the composite sample water and then fill bottles to the rim to exclude air before capping with glass lids.
2. If analysis is begun within 2 h of collection, cold storage is unnecessary. If analysis is not started within 2 h, keep sample at or below 4°C.
3. For composite samples, keep samples at or below 4°C during compositing period and limit compositing period to 24 h. Holding time in this case begins at the end of compositing. Mix vigorously and pour off samples into appropriate bottles, excluding air.

Table 2.9.3.23 | Ozone-Depleting Substances (ODS)

Including: CFCs, carbon tetrachloride, methyl chloroform, halons.

SAMPLING POINT	Commercial products
SAMPLING TECHNIQUE	n/a
CONTAINER TYPE AND SIZE	2 cans of product
PRESERVATION	none
HOLDING TIME	7 days

PROTOCOL

Most environmental protection labs do not have the capability to analyse for CFCs. Commercial samples may be contracted out for analysis.

Table 2.9.3.24 | Pesticides

Including: herbicides, organophosphates and carbamates.

LIQUID SAMPLING POINT	Surface water; groundwater; agricultural runoff
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L - 4 L; Teflon lined lids
PRESERVATION	4°C; protect from sunlight
HOLDING TIME	7 days

PROTOCOL

1. Normally 1 L - 4 L of water is collected in amber glass containers.
2. Since there is no universal preservative possible, consult the lab for advice before sampling.
3. Samples must be stored at < 4°C and protected from sunlight.
4. In the case of sediment, collect 180 mL samples; in the case of biota, collect one or more whole organisms. Shellfish are good indicators.

SOIL, SEDIMENT, BIOTA SAMPLING	Agricultural sites; soil; vegetation; sediment; sludge
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Amber glass, 180 mL
PRESERVATION	4°C; protect from sunlight
HOLDING TIME	30 days

Table 2.9.3.25 | Phosphorus - Inorganic (P205 OR P)

SAMPLING POINT	Laundry detergent (commercially packaged and bulk); unleaded gasoline
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	
DETERGENTS	Unopened commercial product or 125 mL glass jars for bulk samples, liquid or solid; 1 L for bulk products
PRESERVATION	4°C
HOLDING TIME	3 days

NOTE: For sampling gasoline products, check with the lab and with the regulations to determine container, preservation, holding time and sampling protocol.

PROTOCOL

1. Purchase product.
2. Send product to laboratory unopened.
3. For bulk samples: choose small quantities from different locations of the bulk product.
4. Store at 4°C.

Table 2.9.3.26 | Phosphates (Ortho-, Total Dissolved And Total)

LIQUID SAMPLING POINT	Effluent; surface water
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	3 days

NOTE: Phosphates adhere to glass; hence the samples should be taken into individual HDPE bottles that the lab then uses for its analysis. Check with the lab beforehand to obtain the containers it requires.

PROTOCOL

1. Rinse container with sample water three times.
2. Collect effluent in a HDPE, 1 L bottle.
3. Do not freeze samples; store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Effluent
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Tissue cup, 125 mL
PRESERVATION	4°C
HOLDING TIME	30 days

**Table 2.9.3.27 | Polychlorinated Biphenyls (PCBs)**See **SECTIONS 6.6.1 TO 6.6.4****Table 2.9.3.28 | Polycyclic Aromatic Hydrocarbons (PAHs)**

LIQUID SAMPLING POINT	Wood preservative plant effluent; aluminium smelters; coal mine effluent, roofing materials
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L; Teflon or heat-treated aluminium foil lid liner
PRESERVATION	4°C
HOLDING TIME	7 days

PROTOCOL

1. Rinse container with sample water three times.
2. Insulate container mouth and lid with a piece of heat-treated aluminium foil, or use Teflon-lined lid. Tightly cap sample
3. Store at 4°C.

SOIL, SEDIMENT, BIOTA	Wood preservative plant effluent;
SOLIDS SAMPLING	aluminium smelters; coal mine effluent; contaminated roofing.
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 180 mL wide mouth; Teflon or heat-treated aluminium foil lid liner.
PRESERVATION	4°C
HOLDING TIME	30 days

PROTOCOL

1. Collect a sample with appropriate tool such as stainless steel spoon/spatula or cut with knife..
2. Insulate container mouth and lid with a piece of heat-treated aluminium foil, or use Teflon-lined lid. Tightly cap sample.
3. Store at 4°C.

Table 2.9.3.29 | Radionuclide – Radium -226 (226Ra)

SAMPLING POINT	Metal mining effluent
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	HN03
HOLDING TIME	30 days

PROTOCOL

1. Put on protective gloves.
2. Rinse container and lid three times with sample.
3. Add preservative. 1 mL 35% nitric acid per 100 mL sample, to a pH <2 sample or 2 mL 1:1 HN03/250 mL sample. Preservatives can be added up to 5 days after sampling.
4. Tightly cap sample and shake.
5. Samples may be stored at room temperature.

Table 2.9.3.30 | Resin Acids

Including: abietic, chlorodehydroabietic, dehydroabietic, isopimaric, levopimaric, neoabietic, sandaracopimaric and dichlorodehydroabietic acids.

LIQUID SAMPLING POINT	Municipal wastewater treatment effluent; wood products/industries (pulp and paper, forest products)
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 1 L; Teflon or heat-treated aluminium foil lid liner
PRESERVATION	NaOH > pH 12*** (done at lab)
HOLDING TIME	30 days

PROTOCOL

1. Insulate container mouth and lid with a piece of heat-treated aluminium foil, or use Teflon lined lid. Tightly cap sample.
2. Protect from sunlight.

SOIL, SEDIMENT, BIOTA SAMPLING	Municipal wastewater treatment effluent; wood products/industries (pulp and paper, forest products)
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Amber glass, 180 g; Teflon or heat-treated aluminium foil lid liner
PRESERVATION	4°C
HOLDING TIME	30 days

Table 2.9.3.31 | Sulphur Compounds - Sulphate

LIQUID SAMPLING POINT	Effluent; wastewater
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	30 days

PROTOCOL

1. Rinse container with sample water three times.
2. Collect sample in HDPE bottle.
3. Store at 4°C.

Table 2.9.3.32 | Sulphur Compounds Sulphides

LIQUID SAMPLING POINT	Effluent and wastewater from mills, mines, refineries, petroleum industry
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 500 mL
PRESERVATION	field ZnAc (2M)
HOLDING TIME	7 days

NOTE: Sulphides oxidize readily. Check with the lab for the preservatives to use; zinc acetate and sodium bicarbonate are frequently used. Add preservative to the collecting bottle before starting composite sampling.

**PROTOCOL - GRAB**

1. Rinse sample bottle three times with sample water.
2. Collect sample.
3. Add preservative (0.2 mL of 2M zinc acetate per 100 mL of sample).
4. Tightly cap sample; store at 4°C.

PROTOCOL - COMPOSITE

1. Rinse sample bottle three times with sample water.
2. Add preservative.
3. Collect sample.
4. Store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Petroleum industry, fish farms
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Tissue cup, 125 mL
PRESERVATION	field ZnAc
HOLDING TIME	30 days

Table 2.9.3.33 | Surfactants (anionic)

LIQUID SAMPLING POINT	Refinery effluent; sewage wastewater;	detergent plants; mines
SAMPLING TECHNIQUE	Grab	
CONTAINER TYPE AND SIZE	Amber glass, 1 L; Teflon or heat-treated aluminium foil lid liner	
PRESERVATION	4°C	
HOLDING TIME	30 days	

PROTOCOL

1. Rinse container with sample water three times.
2. Collect sample in an amber glass container with Teflon or foil-lined screw cap.
3. Store at 4°C.

Table 2.9.3.34 | Turbidity

LIQUID SAMPLING POINT	Surface water; effluent
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	HDPE, 1 L
PRESERVATION	4°C
HOLDING TIME	3 days

PROTOCOL

1. Collect water from below the surface; do not skim, fill container to approximately 95% full.
2. Tightly cap sample; store at 4°C.

In the field tests, see **SECTION 3.7**

Table 2.9.3.35 | Volatile Organic Carbon (VOC)

Also known as head-space or purgeable organic analysis; including benzene, toluene, ethylbenzene and xylene (BTEX).

LIQUID SAMPLING POINT	Effluent; surface water; groundwater; petroleum industry
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Amber glass, 40 mL x 2; Teflon septum cap
PRESERVATION	4°C
HOLDING TIME	7 days

PROTOCOL

1. Fill vial to rim. Add one drop concentrated hydrochloric acid.
2. Tightly cap sample, making sure that there is no head space in the sample; top up as necessary.
3. Store at 4°C.

SOIL, SEDIMENT, BIOTA SAMPLING	Storage tanks; contaminated sites; petroleum industry
SAMPLING TECHNIQUE	Grab
CONTAINER TYPE AND SIZE	Amber glass, 180 mL; Teflon septum cap
PRESERVATION	4°C
HOLDING TIME	14 days

Table 2.9.3.36 | Volatile Residues In Sediment

SOIL, SEDIMENT, BIOTA SAMPLING	Domestic wastewater; agricultural fumigants; refinery and mill outfall; metals and metal processing; soil; sediment
SAMPLING TECHNIQUE	Grab or composite
CONTAINER TYPE AND SIZE	Tissue cup, 125 mL
PRESERVATION	4°C
HOLDING TIME	7 days

PROTOCOL

1. Collect sediment in tissue cup.
2. Store at 4°C.



2.10 ACRONYMS

AEH	Acid extractible herbicide
AOX	Adsorbable organic halides
BOD	Biochemical (Biological) oxygen demand
BTEX	Benzene, toluene, ethylbenzene, and xylene (see VOC)
CGI	Combustible gas indicator
COD	Chemical oxygen demand
COLIWASA	Composite liquid waste sampler
CP	Chlorinated phenols
CR ⁶	Hexavalent chromium
CRM	Certified reference material
CU-8	Copper 8 - quinolinolate
DDAC	Didecyldimethylammonium chloride
DI	De-ionized water
DIC	Dissolved inorganic carbon
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DQO	Data quality objective
DW	Distilled water
EPH	Extractible petroleum hydrocarbon
FC	Fecal coliforms
GPS	Global positioning system
HDPE	High-density polyethylene
HEPH	High extractable petroleum hydrocarbons
HNO ₃	Nitric acid
H ₂ S	Hydrogen sulphide
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IEC	International Electrotechnical Commission
IPBC	3-iodo-2-propynylbutyl carbamate
ISO	International Organization for Standardization
LC ₅₀	Lethal concentration
LEL	Lower explosive limit
LEPH	Low extractable petroleum hydrocarbons
LT ⁵⁰	Lethal time
LOD	Limits of detection
MMER	Metal mining effluent regulation
NFR	Non-filterable residue (also know as TSS)
NO ₂ + ₃	Nitrite + Nitrate
NP	Nitrogen phosphorus
OC	Organochlorine
OD	Outer diameter
ODS	Ozone-depleting substances
OP	Organophosphate
Ortho-P	Ortho Phosphorus
P	Elemental phosphorus
P ₂ O ₅	Phosphorus pentoxide
PAH	Polycyclic aromatic hydrocarbons

PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
PERC	Tetrachloroethylene
PID	Photo Ionization Detector
ppb	parts per billion
ppm	parts per million
PPE	Personal Protective Equipment
QA/QC	Quality assurance/Quality control
²²⁶ Ra	Radium
Redox	Oxygen reduction potential
SAD	Strong acid dissociable
SRM	Standard reference method
S/S/B	Soil/Sediment/Biota
Strep	Streptococci
SWOG	Special waste oil and grease
TC	Total coliform
TCDD	tetrachlorodibenzo-para-dioxin
TCDF	tetrachlorodibenzo furan
TCLP	Toxicity Characteristic Leaching Procedure
TCMTB	2-(thiocyanomethylthio) benzothiazole
THAS	Task Hazard Analysis Sheet
THM	Trihalomethane
TIC	Total inorganic carbon
TOC	Total organic carbon
Total-P	Total Phosphorus
TSS	Total suspended solids, also known as NFR non-filterable residue
TVR	Total volatile residues
UEL	Upper explosive limit
UHF	Ultra High Frequency
VACSAM	Vacuum sampler
VH/VPH	Volatile Hydrocarbon/Volatile Petroleum Hydrocarbon
VHF	Very High Frequency
VOC	Volatile organic carbon
WAD	Weak acid dissociable



2.11 CONVERSION FACTORS

WHEN YOU KNOW	MULTIPLY BY	TO FIND
inches	25	millimetres (mm)
inches	2.54	centimetres (cm)
feet	0.305	metres (m)
yards	0.914	metres (m)
miles	1.61	kilometres (km)
square inches	6.45	square centimetres (cm ²)
square feet	0.093	square metres (m ²)
square yards	0.834	square metres (m ²)
acres	0.405	hectares (ha)
square miles	2.59	square kilometres (km ²)
cubic inches	16.39	cubic centimetres (cm ³)
cubic feet	0.028	cubic metres (m ³)
cubic yards	0.765	cubic metres (m ³)
ounces	28.35	grams (g)
pounds	0.454	kilograms (kg)
tablespoons	14.71	millilitres (mL)
fluid ounces	28.41	millilitres (mL)
cups	227	millilitres (mL)
quarts (U.S.)	0.95	litres (L)
quarts (Imperial)	1.14	litres (L)
gallons (U.S.)	3.79	litres (L)
gallons (Imperial)	4.55	litres (L)

TO CONVERT DEGREES FAHRENHEIT TO DEGREES CELSIUS

Subtract 32, then multiply the result by 5/9.

2.12 UNITS OF MEASURE ABBREVIATIONS

alk	alkali
aq	aqua; aqueous; water
at, atmos	atmosphere
av, avg	average
bar	barometer
bp	boiling point
Bq	Becquerel
C	Coulomb
C	concentration
ci	curie
ca	circa; approximately; about
cm	centimetre
conc	concentration; concentrated
cu	cubic
cyl	cylinder
dB	decibel
dil	dilute
f	frequency
ft	foot
g	gram
h	hour; hecto (prefix)
<i>h</i>	Planck constant; height
<i>H</i>	hydraulic charge
ha	hectare
in	inch
insol	insoluble
J	joule
k	kilo (prefix)
K	Kelvin; absolute temperature
kg	kilogram
km	kilometre
L	litre
<i>L</i>	length
LD ₅₀	median lethal dose
liq	liquid
m	metre; milli (prefix)
M	mega (prefix); molar
m ²	square metre
m ³	cubic metre
max	maximum
mg	milligram
min	minute
mL	millilitre
mol	mole; molecule
mole	gram- molecular weight
mp	melting point



n	nano (prefix)
N	normal
ng	nanograms (10 ⁻⁹)
no	number
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
p	pico (prefix)
P	pressure
pH	measure of acidity/alkalinity
ppb	parts per billion
ppm	parts per million
precip	precipitated
P _s	standard pressure
psi	pounds per square inch
rpm	revolutions per minute
s	second
sq	square
sol	soluble
stp	standard temperature and pressure
t	general temperature; time; tonne
T	absolute temperature;
μ	micro (prefix); micron μm
μg	microgram
V	volume
W	watt;
wt	weight
giga (G) 1 000 000 000	a thousand millions = a billion
mega (M) 1 000 000	a million
kilo (k) 1 000	a thousand
hecto (h) 100	a hundred
deca (da) 10	ten
deci (d) 0.1	a tenth
centi (c) 0.01	a hundredth
milli (m) 0.001	a thousandth
micro (B5) 0.000 001	a millionth
nano (n) 0.000 000 001	a thousand millionth

2.13 CHECKLIST OF EQUIPMENT FOR FIELD SAMPLING

This list is by no means exhaustive, but will serve as a guide. Not all equipment is required for each field sampling trip, but the list may be helpful in reminding you of items you might otherwise overlook.

STATIONERY

Analysis request forms
Calculator
Inspector card
Chain-of-custody forms
Conversion tables
Notebook, waterproof
Occurrence report forms
Paper, waterproof
Pens, pencils, permanent markers
Space pen
Statement forms
Warning card

ELECTRONIC EQUIPMENT

Audio recorder
Batteries and battery charger
Binoculars
Camera
Cellular phone
Computer
Gas monitors
Global positioning system
Pager
Photographic film
Spare video or audio tape
Video camera
VHF radio

REFERENCE MATERIALS

Aerial photos (if possible)
Charts (hydrographic)
Compass
Compliance files
Emergency Response Guide (Local Country Guideline)
Inspector's Safety Guide (Local Country Guideline)
The INTERPOL Pollution Crimes Forensic Investigations Manual
Instrument operation manuals: pH meter, conductivity meter, etc.
Maps (topographical, road)
Other protocols or manuals for sampling



Regional emergency contact list

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SAFETY AND FIRST AID

Air pack (self contained breathing apparatus-SCBA)
Apron, splash
Aspirin
Blanket
Boot covers, disposable
Ear protection gear
Emergency rations/survival kit
Eye wash kit
Fire extinguisher
Fire resistant clothing
First aid kit
Flares
Flotation vest/suit
Goggles, 2 pair
Hardhat
Respirator
Respirator filters
Rubber boots
Safety harness (fall protection)
Suits, disposable yellow, x 3
Whistle
Work boots

PERSONAL SUPPLIES

Backpack
Hand lotion
Hand soap
Insect repellent
Matches in waterproof container
Rain gear
Reflective blanket
Reflective vest
Sample vest
Sunglasses
Sunscreen
Toilet paper
Water

SAMPLE PACKING MATERIALS

Cooler
Electrical tape
Gel ice packs
Labels, sticky

Masking tape
Sample box, lockable (tool kit box with lock)
Seals, legal
Shipping labels
Shipping waybills
Stickers (“THIS END UP,” “FRAGILE,” “KEEP COOL,” “DO NOT FREEZE,” “KEEP FROZEN,” etc.)
Tags, cardboard, with wire attachments
Worker Health Management Information System (WHMIS) labels

TOOLS

Axe
Batteries (dispose of as hazardous waste)
Flashlight
Knife, exacto/utility
Knife, regular
Ladder
Manhole opener
Measuring tape
Pick
Scissors
Shovel
Stopwatch
Toolbox and tools: hammer, screwdrivers, nails, wrenches, measuring tape, etc.

SAMPLING TOOLS

Acid-washed membrane filters, 0.45 μm (disposable, luer lock = syringe adapter); for field filtering of metal samples
Aluminium foil
Bioassay container
Bottles, HDPE, with caps (500 mL, 1 L, 2 L)
Bottles, amber glass, with Teflon-lined caps (1 L)
Buckets, graduated
Drip trays
Filters, disposable (for field filtering of metal samples)
Funnel
Gloves, latex
Gloves, polyethylene
Kim wipes
Paper towels
Pipettes, disposable (5 mL)
Pipettes, disposable (50 mL, for transformer sampling)
Scoops, plastic and stainless steel
Spatulas, plastic or metal
Stainless steel chain for bucket
Syringes, disposable (for field filtering of metal samples)



Test tubes
Trowel
Tweezers, Teflon-coated

SAMPLERS

COLIWASA
Extended bottle sampler (Wheaton Dip)
Flow meter and tables
Grain sampler
Kemmerer depth sampler
Open tube (thief) sampler
Ponar dredge
Pond (dip) sampler
Pump heads
Pump, peristaltic
Pump, submersible
Pump tubing connectors
Pump tubing, silicon
Sampling iron
Sampling pole
Sampling trier
Sequential autosampler
Soil-sampling rod
Split-spoon corer
Thin-wall corer
VACSAM
Weighted bottle sampler

LEGAL SAMPLING EQUIPMENT

Bioassay container
Cooler
Cooler seals
Chain-of-custody form
Disposable gloves
Duct tape
Gel ice packs
Labels, two-part uniquely numbered, permanent adhesive
Notebook
Sample box, lockable (tool kit box with lock)
Sample bottles
Seals, legal
Sealable plastic bags
Scribes
Permanent marker
Preservatives

FIELD TEST EQUIPMENT

Conductivity meter and calibration standards
pH meter
pH buffers
pH paper
Thermometer
Dissolved oxygen meter and standards

CHEMICALS/PRESERVATIVES

Acetone
De-ionized (DI) water
Dye, colour marker
Hexane
Hydrochloric acid, concentrated (for chlorinated phenols)
Mercury preservative (1 mL, 5% potassium dichromate + 1 mL, 70% nitric acid; obtain from lab)
Metal preservative (1 mL, 35% nitric acid; obtain from lab)
Nitric acid (70%)
Potassium iodide (5%)
Rexonic N25-7 solution
Sodium carbonate (0.5N for sulphide sample)
Sodium hydroxide (3N)
Sodium hydroxide (40% for cyanide samples)
Sodium hydroxide pellet
Sodium sulphite, granular (for chlorinated dioxins/furans)
Sodium thiosulphate solution (10% for fecal coliforms samples)
Starch solution (BDH or Fisher Scientific)
Sulphuric acid, concentrated (for COD)
Zinc acetate (0.1M, for sulphide sample)

CLEANUP SUPPLIES

Garbage bags, kitchen
Garbage bags, large
Paper towels
Spill kit, commercial or baking soda
Vinegar
Cat litter or vermiculite
Absorbent pads (for hydrocarbons)
Disposable gloves

POLICIES, GUIDELINES AND PROCEDURES

All inspectors and investigators should familiarize themselves with local policies, guidelines and procedures.



OTHER LEGISLATION

You must always be aware of and comply with:

- provincial/territorial/state health and safety legislation
- municipal health and safety laws
- bylaws and other regulations that govern local jurisdictions

If you are uncertain as to the applicability of any laws, statutes or regulations, consult:

- your supervisor
- your local health and safety committee
- a regional health and safety advisor or the appropriate governing authority

2.14 CALCULATIONS AND FORMULAS

2.14.1 AREA OF CIRCLES

The area of a circle (such as a discharge pipe) may be calculated using the formula:

$$\text{Area} = A = \frac{\pi \times D^2}{4} \text{ where } \pi = 3.1417, D = \text{diameter of the pipe.}$$

Example: For a pipe which measures 0.22 metres in diameter the area is:

$$A = \frac{\pi \times D^2}{4} = \frac{3.1417 \times (0.22\text{m})^2}{4} = 0.04 \text{ m}^2$$

2.14.2 AREA OF SQUARES AND RECTANGLES

The area of a square or rectangle (such as a discharge channel or average stream depth) may be calculated using the formula:

$$\text{Area} = A = \text{base} \times \text{height} = B \times H.$$

Example: For a channel which measures 2.22 metres deep x 4 metres wide the area is:

$$A = B \times H = 2.22 \text{ m} \times 4 \text{ m} = 8.88 \text{ m}^2$$

2.14.3 AREA OF TRIANGLES

The area of a triangle (such as a discharge channel in a wier) may be calculated using the formula:

$$\text{Area} = A = \frac{1}{2} \text{ BASE} \times \text{HEIGHT} = \frac{1}{2} B \times H.$$

Example: For a weir which measures 1.2 metres deep x 4 metres wide the area is:

$$A = \frac{1}{2} B \times H = \frac{1}{2} \times 1.2 \text{ m} \times 4 \text{ m} = 2.4 \text{ M}^2$$

2.14.4 FLOW ESTIMATION

The flow of liquid that completely fills an area such as a pipe or channel may be calculated using the following formula. (note that velocity changes near the edge of a channel or pipe, being slower close to the edge and faster near the center. therefore you must use an average velocity for a simple flow estimation.)

$$\text{Flow} = F = \text{Velocity}_{\text{average}} \times \text{Area} = V_{\text{avg}} \times A$$

Example: The flow of water through the pipe with 0.04 m² with an average velocity of 1.1 m/s is:

$$\text{Flow} = F = V_{\text{avg}} \times A = 1.1 \text{ m/s} \times 0.04 \text{ m}^2 = 0.044 \text{ m}^3/\text{s}$$

In the field measurements, see **SECTION 5.2**





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