4.4.1 Grab Sample of Drill Cuttings

Soil cuttings brought to the surface during drilling operations can be collected for future reference and, if required for laboratory analysis. However, undertaking of chemical analysis on grab samples of soil cuttings is not normally recommended as there are a number of potential problems that could affect the results of the testing and/or assessment of results. These include:

- The sampling interval is not accurately known: due to there being a time lag between the cutting of the soils a t the drill bit and the discharge of these soils at the surface. In fact, it is not uncommon where for cuttings from depth not to reach the surface for significant time intervals, of course this is dependent on the rate of drilling.
- Possibility of cross-contamination of uncontaminated soils: relatively uncontaminated soils from depth when being brought to the surface may come into contact with contaminated soils closer to the surface. This casts doubt over the reliability of such data, and results may not be representative of the in-ground concentrations.
- Loss of volatile compounds: drilling can generate quite high temperatures at the drill bit, which can result in the volatilisation of volatile contaminants. Thus, analytical results may not be representative of the in-ground volatile concentrations.
- Cross-contamination of soils by drilling fluids: drilling fluids that come into contact with a narrow zone of contamination can distribute this contamination to areas of soil relatively uncontaminated. Again, results of chemical analysis of samples of drill cuttings may not be representative of actual in-ground concentration.

Therefore, while soil cuttings are useful for logging of holes and can be monitored during drilling with OVA, they should not normally be sampled for subsequent laboratory analysis. Samples for analysis should be collected by one of the methods discussed above.

4.4.2 Surface Grab Samples

Grab samples can be collected from the ground surface or an exposed excavation face using a towel, shovel or similar. Provided the sampling equipment is properly decontaminated there should be no major concerns with the collection of grab samples using this method.

Sample containers can be filled directly from the sampling equipment or compositing of a sample either from a number of different locations or from a shallow depth interval at the one location may be undertaken.

When selecting the location of the surface grab samples the objectives of the sampling should be borne in mind. For example, is the objective to collect a sample of stained soil or is it to collect a sample of soil representative of a larger area? Obviously, this will effect the type of location selected.

The condition of the surface soils in the area sampled and the surrounding area should be recorded. It may be prudent to complete a sketch plan of the area and/or take some photographs for records.

4.4.3 Grab Sample from Test Pit

Grab samples can be collected from the walls or base of a test pit or from the bucket of the backhoe. If collecting a sample from the bucket, it is preferable to collect the sample from the centre of the bucket, where the soil has not come into contact with the bucket. This will minimise the risk of cross-contamination, which can arise by the bucket, including some contaminated soil from higher up in the pit. If collecting from the walls of the our is preferable to excavate a sample from the walls of the pit,

and discarding the soil in the original wall if the pit, which may have been cross-contaminated by the action of the backhoe bucket.

Sample containers can be filled directly or a composite sample from a number of different locations within the test pit may be collected.

When selecting the location of the grab samples, the objectives of the sampling should be borne in mind. For example, is the objective to collect sample of stained soil or is it to collect sample of soils representative of the main soils in the pit. Obviously, this will effect the type of location selected.

The condition of the soils in the area sampled and the surrounding area should be recorded. It may be prudent to complete a sketch plan of the area and/or take some photographs for records.

4.4.4 Grab Sample from Soil Stockpile

Grab samples can be collected from a soil stockpile. Provided the sampling equipment is properly decontaminated, there should be no major concerns with the collection of grab samples using this method.

Similar comments apply to grab surface soil samples.

5. Field Monitoring and Testing

As discussed above, field monitoring for volatile compounds, typically volatile organic compounds and gases can be carried out during the field investigations. The monitoring enables the in-field screening of samples and cuttings generated during the investigations. Results of the screening can be used to select samples for laboratory analysis.

In the field, screening of soils is conducted to preliminarily evaluate the distribution of soil contamination, and to select soil samples for subsequent laboratory analysis. OVA, CGI, or other detector is used to obtain organic vapour measurements from soils contained in various types of samplers and of cuttings and soil excavated during investigations.

As samples, cuttings, bulk samples, etc. are recovered the field monitors are passed over the materials with results of monitoring recorded on the log. The soil materials should be separated enough to allow for insertion of the monitors' probe into the space created in the soil. After inserting the probe, the void should be sealed with the covered, as well as the free hand. Peak instrument readings should be noted from a number of locations in each sample. The range of readings should be recorded on the boring log.

Alternatively, ambient temperature headspace (AHT) testing may be carried out. A portion of the sample may be placed in a half-filled container, which is sealed, and allowed to sit for at least 1 hour (where possible) prior to measuring the concentration of vapour accumulating in the headspace above the soil sample, using a field monitor. Details of the ATH testing procedure are given in the Work Instruction titled ***"Field Measurements"***.

6. Sample Management

The Work Instruction ***"Selection of Sample Containers, Sample Preservation, Sample Handling, Labelling and Documentation"*** in this manual provides details of sample containers, handling, labelling and documentation for soil samples.

7. Quality Assurance / Quality Control

The Work Instruction titled ***"Quality Assurance/Quality Control"*** in this manual, provides details of the QA/QC requirements for soil sampling programs. However, in general, QA/AC samples for soil investigations typically include:

- Duplicate samples: used to check the analytical laboratory QA/QC. Two or more samples are collected from the same material at the same time and sent anonymously to the same laboratory (blind duplicates) or to a check laboratory (field split duplicate).
- Equipment and trip blankets: used as control or external QA/QC samples to detect contamination that may be introduced in the field or during transportation.

8. Decontamination

All sampling equipment should be decontaminated between sampling events. The Work Instruction titled ***"Decontamination"*** in this manual provides details on the decontamination procedures to be followed.

9. Logging of Soils & Rock

All soils and rock are to be logged in accordance with AS1726-1993 Geotechnical site investigations and SKM geotechnical standards for the logging of soil samples.

10. General Soil Sampling Procedures

Included below are general soil sampling procedures for the collection of soil samples from:

- Hand auger boreholes
- Drilling rig borehole
- Trenches and test pits
- Surface soil sampling
- Sediment sampling
- Field compositing procedures

10.1 Hand Auguring

The soils sampling procedure when using the hand auger shall be as follows:

1) Prepare borehole log or sampling record form.
2) Lay out equipment on plastic sheeting, adjacent to sampling location to prevent direct contact with the ground surface.
3) Ensure the hand auger and all sample equipment has been decontaminated before use at a new location.
4) Remove surface vegetation, leaves, debris and other surface material not designated for sampling from the vicinity of the sample location.
5) Auger to the desired sampling depth is reached or the auger is full of soil. Record the depth. Carefully remove the auger from the hole with the soil sample. If the desired depth has not been reached, continue auguring, emptying the auger as needed.
6) Collect sample for ambient temperature headspace.

7) Collect soil sample using appropriate sampling method discussed above. If collecting a composite sample, transfer the collected material to a quartering or compositing tray, mix thoroughly and quarter.
8) Collect required number of representative sub-samples, and place in appropriate sample containers. To prevent loss of volatile, the soil will be mixed and transferred to the jars as quickly as possible. Care should be taken to fully fill the sample jars, leaving no headspace.
9) Immediately cover the top of the jars with aluminium foil and tightly screw on the lid.
10) Lithologically log all samples and borings.
11) Label the jars and store in a cooled esky.
12) Complete a Chain of Custody Form.
13) Either discard or decontaminate all items, which contact the sample before proceeding to the next sampling location.

10.2 Boreholes

The soil sampling procedure to be followed in boreholes, when using the drill rig shall be as follows:

1) Prepare a borehole log or Sampling Record Form.
2) Lay out equipment on plastic sheeting adjacent to sampling location to prevent direct contact with the ground surface.
3) Ensure all drilling and sampling equipment has been decontaminated before use at a new location.
4) Remove surface vegetation, leaves, debris and other surface material not designated for sampling from the vicinity of the sample location.
5) Drill until the desired depth is reached, record the depth.
6) Insert drive, push or continuous sample to the base of the borehole and drive (450mm), push or drill sampler into the soil as discussed above. Record the depth of the sampler before and after completion of sampling event.
7) Remove the sampler from the borehole, and open the split spoon.
8) Collect sample for ambient temperature headspace.
9) Collect representative soil sample(s) directly from the splits, or if collecting composite sample transfer the soil from the splits to a quartering or compositing tray, mix thoroughly and quarter.
10) Collect required number of representative sub-samples, and place in appropriate sample containers. To prevent loss of volatile, the soil should be transferred to the jars as quickly as possible. Take care to fully fill the sample containers, leaving no headspace, except for volatile vials, which some laboratories require to be only half-filled.
11) Immediately cover the top of the jars with aluminium foil and tightly screw or crimp on the lid.
12) Lithologically log all samples and borings.
13) Label the jars and store in a cooled esky.
14) Complete a Chain of Custody Form.
15) Either discard or decontaminate all items, which contact the sample before proceeding to the next sampling location.

10.3 Trenches and Test Pits

The soil sampling procedure when using the backhoe or excavator shall be as follows:

1) Prepare a test pit or Sampling Record Form.
2) Lay out equipment on plastic sheeting adjacent to sampling location to prevent direct contact with the ground surface.
3) Ensure the backhoe or excavator bucket and all sampling equipment has been decontaminated before use at each new location, where possible.

4) Remove surface vegetation, leaves, debris and other surface material not designated for sampling from the vicinity of the sample location.
5) Excavate trench or pit to the required sampling length.
6) Recover sample over required sampling interval with excavator or backhoe bucket. Note to minimise cross-contamination, sample should be selected from soil in the middle of the excavator bucket, which is less likely to have come into contact with the excavator bucket.
7) Collect sample for ambient temperature headspace.
8) Collect sample of representative sample form bucket, and transfer directly to sample containers, or if collecting composite samples to quartering, or compositing tray where the sample is mixed thoroughly and quartered.
9) Collect required number of sub-samples, and place in appropriate sample containers. To prevent loss of volatile, the soil should be mixed and transferred to the jars as quickly as possible. Take care to fully fill the sample containers, leaving no headspace, except in volatile vials, which some laboratories require to be only half-filled.
10) Immediately cover the top of the jars with aluminium foil and tightly screw or crimp on the lid.
11) Lithologically log all samples and borings.
12) Label the jars and store in a cooled esky.
13) Complete a Chain of Custody Form.
14) Either discard or decontaminate all items, which contact the sample before proceeding to the next sampling location.

10.4 Surface Soil Sampling

The soil sampling procedure when collecting grab samples shall be as follows:

1) Prepare a Sampling Record Form.
2) Lay out equipment on plastic sheeting adjacent to sampling location to prevent direct contact with the ground surface.
3) Ensure that all equipment to be used for sampling has been decontaminated.
4) Remove surface vegetation, leaves, debris and other surface material not designated for sampling from the vicinity of the sample location.
5) Collect a number of trowel-fulls of the surface or near surface soils.
6) If collecting discrete samples, transfer directly to sample containers, or if collecting composite samples, transfer soil from the trowel to a quartering or compositing tray, where it is mixed thoroughly and quartered.
7) Collect sample for ambient temperature headspace.
8) Collect required number of sub-samples, and place in appropriate sample containers. Take care to fully fill the sample containers, leaving no headspace, except in volatile vials, which some laboratories require to be only half-filled.
9) Immediately cover the top of the jars with aluminium foil and tightly screw or crimp on the lid.
10) Lithologically log all samples and borings.
11) Label the jars and store in a cooled esky.
12) Complete a Chain of Custody Form.
13) Either discard or decontaminate all items, which contact the sample before proceeding to the next sampling location.

10.5 Sediment Sampling

The sediment sampling procedure when collecting sediment samples shall be as follows:

1) Prepare a borehole log or Sampling Record Form.

2) Ensure that all equipment to be used for sampling has been decontaminated.
3) Remove surface vegetation, leaves, debris and other surface material not designated for sampling from the vicinity of the sample location.
4) Push sediment sampler up to 1 meter or refusal into the sediment by hand.
5) Use vacuum to withdraw the tube and sample with minimum disturbance and place end caps on the tube.
6) Measure and describe any layering visible in the tube.
7) Carefully extrude the sample into a stainless steel tray.
8) Collect sample for ambient temperature headspace.
9) Collect required sub-samples of core and place in appropriate sample containers.
10) Immediately cover the sample jars with aluminium foil, and tightly screw or crimp on the lid.
11) Lithologically log all samples and borings.
12) Label the jars and store in a cool esky.
13) Complete a Chain of Custody Form.
14) Either discard or decontaminate all items, which contact the sample before proceeding to the next sampling location.

10.6 Compositing

Sample compositing will normally be conducted in accordance with the mixing bowl compositing procedures described in AS 4482.1-1997 Guide to the sampling and investigation of potentially contaminated soil, Part 1: Non-volatile and semi-volatile compounds. Samples for volatile organics will not be composited in the field. The procedures are as follows:

1) A clean steel mixing bowl or tray and steel scoop are decontaminated. Stainless steel is the preferred type of equipment, however other materials can be used, provided that they do not consist of materials that are of concern. For example painted trowel – paint chips could contain lead or other metals, which may end up in the sample.
2) The sample fractions being composited are placed in equal volumes into the mixing bowel or tray.
3) The resultant composite sample is stirred until homogenous (it may be necessary to break up soil aggregates with the scoop or a decontaminated stainless steel knife or spatula).
4) The mixed sample is then spread evenly in the bottom of the bowl or tray and quartered.
5) Equal amounts of sample are taken from each quarter to fill each of the sample bottles. Duplicate samples will be collected from pone of the other quarters.

1. Introduction

This document provides general procedures and guidelines for sampling groundwater at hazardous and non-hazardous waste sites. The information presented is applicable to both initial investigations of groundwater quality or periodic monitoring of existing wells at a site. Because the suspected or known contaminants, hydrogeologic conditions, purpose and objectives of groundwater sampling programs, and well construction details vary from site to site, a site specific groundwater sampling/monitoring plan should be prepared for each site. Implementation of the procedures and guidelines presented herein will significantly increase the potential of meeting the principle objective of all groundwater sampling: ***collection of groundwater samples that are representative of the physical and chemical properties of groundwater in water bearing strata.***

The state-of-the-art of groundwater sampling is rapidly evolving and various types of new and innovative sampling devices are being developed. The information presented herein reflects standards and protocol generally accepted within the industry in Australia. However, requirements may vary depending on the type of facility, regulatory agency responsible for review of the groundwater data obtained, and the personal biases of individual regulators. The applicable requirements should be established, when possible, prior to development and implementation of a sampling plan. An extensive bibliography is included so that other documents may be used when establishing site specific protocol. In addition, professional journals such as Ground water and Groundwater Monitoring Review, and publications of the National Water Well Association contain numerous articles regarding groundwater sampling for various types of facilities and contaminants.

In preparing this manual, it was assumed that monitoring wells to be sampled are properly constructed (including placement of the well screen at the appropriate interval and use of well materials compatible with the suspected or known contaminants) and located to obtain the desired groundwater quality data (ie, up-gradient, down-gradient, detection monitoring, verification monitoring, etc.). Implementation of the procedures and protocol presented herein require a significant amount of pre-field and pre-sampling preparation and documentation. Much of the necessary documentation can be accomplished by use of checklists. However, the costs associated with this increased level of effort are more than justified, considering the cost of laboratory chemical analysis, re-sampling, additional site assessment, or remedial measures that could be required due to false positive or negative data caused by poor field protocol.

It is important to consider that at some sites, monitoring may continue for several years or more and at some later time, all data may be re-evaluated by regulators, other consultants, or other Sinclair Knight Merz personnel not involved in the project from its inception. Improper documentation or inadequate information regarding the circumstances of collection and/or subsequent disposition of the samples (ie, chain of custody) may render any resulting data useless. Comprehensive, consistent and accurate documentation of field tests, field and calibration measurements, and field observations is also extremely important.

2. Sampling Plan

A written sampling plan should be prepared for each site. The plan should include:

- Procedures and equipment checklists
- Map of wells to be sampled and sampling order
- Well locations (up-gradient, down-gradient, lateral)
- Well construction details and boring logs
- Previous water level and field parameter data
- Pre-field equipment preparation and protocol
- Pre-purging field procedures
- Field measurements and reference points
- Purging protocol (including volume and purge recharge rates if known)
- Sampling equipment and collection protocol
- Decontamination procedures
- Number of trip blanks, field blanks and duplicate samples
- Sample preservation, handling and shipment
- Chain of custody control
- Analytical parameters and appropriate sample containers
- Any other information that will help ensure that sampling protocol is consistent and reliable

The purpose of the plan is to provide the necessary information so that field-sampling personnel understood and implemented the proper sampling strategy for the site. Since field personnel are typically involved in several investigations/monitoring programs concurrently, it is important that the objectives and protocol be clearly defined so that procedures unique to a particular site are not erroneously implemented at other sites. Furthermore, the plan allows different field personnel not previously familiar with a site to implement consistent purging and sampling methodology. Revisions to the sampling plan may be required as an investigation proceeds and new data on the site hydrogeology and the nature and distribution of contaminants are obtained, or changes in regulatory requirements occur. These revisions should be dated and inserted into the original sampling plan and the pages or sections, which include out of date information should be stamped "Revised (*date*), see page/section ...". This will provide documentation of changes and allow evaluation of groundwater quality data relative to changes in sampling protocol.

3. Equipment

Equipment needed to conduct a sampling event generally includes at a minimum:

- A purging device
- Sampling devices
- Water level measuring devices
- Metres to measure pH, electrical conductivity and temperature
- Calibration solutions
- Sample bottles and preservatives (if necessary)
- Decontamination materials
- Filtering apparatus
- Esky and ice or frozen ice packs
- Miscellaneous field supplies, forms, labels, etc.