Sampling and Analysis Quality Plan

Salt Ash Air Weapons Range Preliminary Site Investigation
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Client: Department of Defence

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Date: 09-Nov-2018
Prepared by: Ben Hunter
Reviewed by: Paul McCabe

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<th>Details</th>
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<td>PRELIMINARY DRAFT</td>
<td>Ben Hunter Senior Chemical Engineer</td>
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<td>DRAFT</td>
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<table>
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<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFF</td>
<td>Aqueous Film Forming Foam</td>
</tr>
<tr>
<td>ALS</td>
<td>Australian Laboratory Services Pty Ltd</td>
</tr>
<tr>
<td>ASC NEPM</td>
<td>Assessment of Site Contamination National Environment Protection Measure 1999 (as amended 2013)</td>
</tr>
<tr>
<td>BTEXN</td>
<td>Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene</td>
</tr>
<tr>
<td>CoC</td>
<td>Chain of Custody</td>
</tr>
<tr>
<td>CoPC</td>
<td>Contaminants of Potential Concern</td>
</tr>
<tr>
<td>CSM</td>
<td>Conceptual Site Model</td>
</tr>
<tr>
<td>CSR</td>
<td>Contaminated Sites Register</td>
</tr>
<tr>
<td>Defence</td>
<td>Department of Defence</td>
</tr>
<tr>
<td>DOC</td>
<td>Dissolved Organic Carbon</td>
</tr>
<tr>
<td>PSI</td>
<td>Preliminary Site Investigation</td>
</tr>
<tr>
<td>DQIs</td>
<td>Data Quality Indicators</td>
</tr>
<tr>
<td>DQOs</td>
<td>Data Quality Objectives</td>
</tr>
<tr>
<td>EC</td>
<td>Electrical Conductivity</td>
</tr>
<tr>
<td>ECC</td>
<td>Environmental Clearance Certification</td>
</tr>
<tr>
<td>EMP</td>
<td>Environmental Management Plan</td>
</tr>
<tr>
<td>HEPA</td>
<td>Heads of Environmental Protection Agencies</td>
</tr>
<tr>
<td>IBC</td>
<td>Intermediate Bulk Container</td>
</tr>
<tr>
<td>LDPE</td>
<td>Low Density Polyethylene</td>
</tr>
<tr>
<td>LOR</td>
<td>Limit of Reporting</td>
</tr>
<tr>
<td>MB</td>
<td>Monitoring Bore</td>
</tr>
<tr>
<td>m bgs</td>
<td>Meters below ground surface</td>
</tr>
<tr>
<td>NATA</td>
<td>National Association of Testing Authorities</td>
</tr>
<tr>
<td>NDD</td>
<td>Non-Destructive Drilling</td>
</tr>
<tr>
<td>NEMP</td>
<td>National Environmental Management Plan</td>
</tr>
<tr>
<td>PAH</td>
<td>Polycyclic Aromatic Hydrocarbon</td>
</tr>
<tr>
<td>PFAS</td>
<td>Per- and Poly-Fluorinated Alkyl Substances</td>
</tr>
<tr>
<td>PFHxS</td>
<td>Perfluorohexane Sulfonic Acid</td>
</tr>
<tr>
<td>PFOA</td>
<td>Perfluorooctanoic Acid</td>
</tr>
<tr>
<td>POP</td>
<td>Persistent Organic Pollutant</td>
</tr>
<tr>
<td>PFOS</td>
<td>Perfluorooctane Sulfonate</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality Assurance / Quality Control</td>
</tr>
<tr>
<td>RAAF</td>
<td>Royal Australian Air Force</td>
</tr>
<tr>
<td>RPD</td>
<td>Relative Percent Difference</td>
</tr>
</tbody>
</table>

A list of PFAS considered in this investigation is provided in Table 13.
## Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAQP</td>
<td>Sampling and Analysis Quality Plan</td>
</tr>
<tr>
<td>SHEMP</td>
<td>Safety Health and Environmental Management Plan</td>
</tr>
<tr>
<td>Site</td>
<td>Salt Ash Air Weapons Range</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>SWL</td>
<td>Standing Water Level</td>
</tr>
<tr>
<td>TPH</td>
<td>Total Petroleum Hydrocarbons</td>
</tr>
<tr>
<td>TRH</td>
<td>Total Recoverable Hydrocarbons</td>
</tr>
<tr>
<td>USCS</td>
<td>Unified Soil Classification System</td>
</tr>
<tr>
<td>US EPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
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</table>
1.0 Introduction

1.1 Preamble

AECOM Australia Pty Ltd (AECOM) has prepared this Sampling and Analysis Quality Plan (SAQP) to carry out the proposed Preliminary Site Investigation (PSI) as part of the Lead Consultant For Comprehensive Investigation of PFAS Site Conditions package of works at Salt Ash Air Weapons Range (SAAWR) (the Site) and Wide Bay Training Area (WBTA). The Site layout is presented on Figure 1 in Appendix A. The Site comprises two defined areas:

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Area</td>
<td>The Target Area comprises a relatively small 34 hectares and is surrounded by Moffats Swamp Nature Reserve and Tilligerry State Conservation Area, towards to the southern extent of the Site. Shown on Figure 1 in Appendix A with orange shade. Key features of the Target Area are shown in Figure 2 in Appendix A.</td>
</tr>
<tr>
<td>Buffer Zone</td>
<td>The Buffer Zone has an area of 2800 hectares and comprises the remaining portion of the Site surrounding the Target Area, with the largest portion of the safety buffer zone covering the northern portion of the Site. The Buffer Zone encompasses both Tilligerry State Conservation Area and Moffats Swamp Nature Reserve. Shown on Figure 1 in Appendix A with yellow hashing.</td>
</tr>
</tbody>
</table>

1.2 Background

Initial groundwater sampling conducted by Aurecon at SAAWR as part of routine monitoring in February and May 2017 identified per- and poly-flouroalkyl substances (PFAS) impacts in groundwater. AECOM completed sampling at the request of Defence at two targeted groundwater locations in June 2017 which confirmed PFAS impacts at those locations.

1.3 Summary of Previous Investigations

1.3.1 GHD, 2006

GHD was commissioned to undertake investigation of a priority list of previously identifiedordnance burial sites for remediation at the Site. Two anomalies showed evidence of ordnance burning (anomalies 81 and 88) both of which had concentrations of Total Petroleum Hydrocarbons (TPH) in soil above the chosen screening criteria.

Anomalies 81 and 88 were given the highest priority for remediation.

1.3.2 SMEC, 2006

Stage 1 desktop review of existing data, proposes a sampling plan for high risk areas and management strategies for the Site.

1.3.3 ENSR AECOM, 2009

Results of soil validation analysis, following remediation of waste burial sites (anomalies 81 and 88) at the Site, indicated that all CoPC were below the adopted assessment criteria. An assessment of the CRAT risk ranking was completed and the Site was considered “medium” risk. It is noted PFAS was not considered in this investigation or remediation.

1.3.4 ERM, 2010

Audit of ENSR AECOM remediation works completed on waste burial sites (anomalies 81 and 88) in 2009.
1.3.5 Aurecon, 2017.

Eleven groundwater monitoring wells were sampled on site and surrounding the site. Concentrations of Total Recoverable Hydrocarbons (TRH)/TPH, Benzene Toluene Ethylene Xylene Naphthalene (BTEXN), Polycyclic Aromatic Hydrocarbons (PAH) and phenols were below the laboratory limit of reporting (LOR) in all monitoring rounds. Wells, Monitoring Bore (MB) 1, MB3, MB4, MB7 were not in suitable conditions to be monitored. Of the eleven ground water samples collected from off-Site locations the following was identified:

- Perfluorooctanesulfonic Acid (PFOS) concentrations were largely recorded below the LOR. Recorded concentrations ranged from <0.01 µg/L to 0.16 µg/L (MB8);
- Perfluorooctanoic Acid (PFOA) concentration was only recorded for MB8. Remaining wells were less than the laboratory LOR; and
- The sum of PFOS and Perfluorohexane Sulfonic Acid (PFHxS) (PFOS + PFHxS) concentrations ranged from <0.01 to 0.24 µg/L.

1.3.6 AECOM, 2017

Two Monitoring wells (MB6 and MB8) were sampled at the Site by AECOM in June 2017 to verify the Aurecon 2017 results. One monitoring well (MB8) reported a PFOS + PFHxS concentration of 0.25 µg/L (AECOM, 2017).

1.3.7 GHD, 2017

No PFAS data was collected from the Site. However, monitoring well MB4 recorded elevated levels of Iron from unknown causes. Groundwater flow was interpreted to flow south east and north.

1.3.8 GHD, 2018

No PFAS data was collected from the Site. However, monitoring well MB2 recorded elevated levels of zinc from unknown causes. Groundwater flow was interpreted to flow south east and north.

1.4 Contaminants of Concern

Within this document, the primary Contaminants of Concern are defined as those PFAS referred to in Guidance Document E - PFAS Investigation and Management, Detailed Site Investigations (Department of Defence, 2018) and are specified in Table 13 below.

1.5 SAQP Sampling Tasks Breakdown

The sampling tasks covered by this SAQP include:

- Drilling program, with associated soil sampling and monitoring well installation;
- Groundwater sampling of existing and new wells; and
- Surface water and sediment sampling.

The data collected by completing these activities will enable a more detailed understanding of the nature and extent of PFAS presence across multiple media both on and off the Site, which will facilitate refining the Conceptual Site Model (CSM).

1.6 Preliminary Site Investigation Objectives

The objectives of the PSI for which this SAQP applies is to:

- Produce a PSI report that is consistent with scientific and professional standards (including the National Environment Protection (Assessment of Site Contamination) Measure, 2013 (ASC NEPM, 2013) and Heads of Environment Protection Authority (HEPA) PFAS National Environmental Management Plan (NEMP), 2018);
- Communicates an understanding of the CSM including potential sources of legacy PFAS contamination, potential and complete exposure pathways and receptors to groundwater and surface water; and
• Recommends further actions (if required).

1.7 SAQP Task Purpose

Each Task has been developed to meet the PSI objectives. These are outlined in Table 1.

Table 2 Task List and Purpose

<table>
<thead>
<tr>
<th>Sampling Tasks</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Program</td>
<td>• To enhance the existing groundwater monitoring well network to provide additional data to further understand potential risks to receptors.</td>
</tr>
<tr>
<td></td>
<td>• To refine the Preliminary CSM.</td>
</tr>
<tr>
<td></td>
<td>• To assess shallow soil conditions.</td>
</tr>
<tr>
<td>Groundwater Sampling</td>
<td>• To provide preliminary data as to the nature and extent of detectable PFAS concentrations in groundwater associated with Site operations.</td>
</tr>
<tr>
<td></td>
<td>• The initial focus is on potential for PFAS to migrate off the Site.</td>
</tr>
<tr>
<td></td>
<td>• To provide data on hydrogeological conditions that may influence PFAS fate and transport.</td>
</tr>
<tr>
<td>Surface Water / Sediment</td>
<td>To assess potential surface water and sediment contamination from PFAS through:</td>
</tr>
<tr>
<td>Sampling</td>
<td>• Understanding the potential interaction of the Site with the downstream surface water bodies including Racecourse Swamp, Moffats Creek,</td>
</tr>
<tr>
<td></td>
<td>Saltwater Creek and 12 Mile Creek.</td>
</tr>
<tr>
<td></td>
<td>• Collecting surface water and sediment samples for chemical analysis.</td>
</tr>
</tbody>
</table>
2.0 Conceptual Site Model

A preliminary CSM has been developed based on the outcome of a desktop review of the available data which have been collected to date. The preliminary CSM is presented under separate cover; refer to AECOM 2018 however a brief summary is presented below.

A historical review of prior Aqueous Film Forming Foam (AFFF) uses at the Site was conducted. No systematic use of AFFF was identified at the Site, however several activities that may have resulted in PFAS presence at the Site have been identified. These include:

- Past disposal practices, which include trench burning and burial of ordnance.
- Burial of AFFF-containing wastes such as fire extinguishers.
- Firefighting activities; for example suppression of spot fires from training activities.

There are a number of surface water bodies at the Site, these include Racecourse Swamp and its unnamed tributary, Saltwater Creek and Twelve Mile Creek which are located north of the Target Area, all of which ultimately discharge into Big Swan Bay (Port Stephens). South of the Target Area is Moffats Creek which is inferred to flow south and ultimately discharges into Tilligerry Creek.

Due to the very high infiltration rates of the soils (sands) and the fact that vegetation has been cleared on the Target Area, rainfall falling onto the Target Area is anticipated to act as a groundwater recharge zone, draining into the Tomago Aquifer. Directly underlying this groundwater recharge zone is an inferred groundwater drainage divide (refer to Figure 4 in Appendix A). Groundwater north of the divide flows in a northerly direction (towards Racecourse Swamp and 12 Mile Creek) and groundwater south of the divide flows in a south easterly direction (towards Tilligerry Creek).

Groundwater flowing north from the Target Area is inferred to be limited in extent by the presence of the Mulbring Siltstone unit (refer to Figure 7 in Appendix A). Due to the presence of the Mulbring Siltstone and the increased surface elevation northwest of the Target Area (refer to Figure 8 in Appendix A), groundwater is inferred to be interacting with the creek feeding Racecourse Swamp adjacent the northern boundary of the Target Area and migrating north east into Racecourse Swamp and Saltwater Creek (refer to Figure 6 in Appendix A).

PFAS was detected at the Site during 2017 in three groundwater monitoring wells (MB5, MB6 and MB8 [Aurecon, 2017 and AECOM, 2017]) and Hunter Water Pumping Station 14 (Fellner, 2017). PFAS concentrations ranged from 0.01 µg/L to 0.25 µg/L (refer to Figure 5 in Appendix A).

Based on a review of the activities, the historical use of AFFF at the Site, the physical characteristics of the Site and the historical PFAS results, it is considered unlikely that the source of historical detections of PFAS at the Site are attributable to a high frequency of discharge point source (such as a fire training area) and are more likely a result of either a single low concentration point source or an older possible higher concentration PFAS source within the Target Area, the locations (potential PFAS source areas associated with historical burial/burning pits are presented in Figure 3 in Appendix A). This source(s) while not specifically identified, are likely to be the result of previous activities carried out at the Site including:

- AFFF use potentially associated with the extinguishing trenches used for burning and the general burn area (GHD, 2006).
- Potential for AFFF to be contained within burial sites, e.g. buried fire extinguishers.
- Potential AFFF use associated with unidentified spot fires, bushfire and emergency response.
- Additionally the Medowie Waste Treatment Works, located west of the Site has been identified as a potential off-Site secondary source.

The major pathways where PFAS migration is likely to occur from the Site are considered to be:

- Groundwater migration from the Target Area (in south easterly and northerly directions).
- Surface water migration, particularly north of the target area where groundwater and surface water interaction is likely to be occurring.
The linkages between sources, exposure pathways and receptors and the likely risk to receptors were evaluated, and the highest risk receptors based on the preliminary CSM include:

- Users of abstracted groundwater produced from HWC PS14.
- Recreational users of Saltwater Creek and Racecourse Swamp (including people trespassing to four wheel drive or illegally fish) of the Site.
- Maintenance/Defence workers undertaking intrusive works on the Target Area or within Racecourse Swamp/Saltwater Creek.

The preliminary CSM developed for the Site is a dynamic tool that will be periodically challenged and updated throughout the assessment process as new information becomes available. Its development will be an iterative process. At the end of each phase of intrusive investigation or where key pieces of information become available, the CSM will be refined, as required.
3.0 Data Quality Assessment

3.1 Data Quality Objectives

The amended National Environmental Protection Measure (NEPM, Schedule B [2]) Guideline on Site Characterisation (2013) specifies that the nature and quality of the data produced in an investigation will be determined by the Data Quality Objectives (DQOs). As referenced by the NEPM, the DQO process is detailed in the United States Environmental Protection Agency (US EPA) Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4 : EPA/240/B-06/001), February 2006.

The US EPA defines the process as ‘a strategic planning approach based on the Scientific Method that is used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision errors for the study, and how many samples to collect’.

The process of establishing appropriate DQOs is defined according to the following seven steps:

<table>
<thead>
<tr>
<th>Step</th>
<th>Data Quality Objective Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>State the problem – Define the problem that necessitates the study; identify the planning team, examine budget, schedule.</td>
</tr>
<tr>
<td>2</td>
<td>Identify the goal of the study – State how environmental data will be used in meeting objectives and solving the problem, identify study questions, define alternative outcomes.</td>
</tr>
<tr>
<td>3</td>
<td>Identify information inputs – Identify data and information needed to answer study questions.</td>
</tr>
<tr>
<td>4</td>
<td>Define the boundaries of the study – Specify the target population and characteristics of interest, define spatial and temporal limits, scale of inference.</td>
</tr>
<tr>
<td>5</td>
<td>Develop the analytic approach – Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings.</td>
</tr>
<tr>
<td>6</td>
<td>Specify performance or acceptance criteria – Develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use.</td>
</tr>
<tr>
<td>7</td>
<td>Develop the plan for obtaining data – Select the resource-effective sampling and analysis plan that meets the performance criteria.</td>
</tr>
</tbody>
</table>

The approach adopted relative to the seven steps presented above is discussed below.

3.1.1 Step 1 – State the Problem

3.1.1.1 Define the Problem that Necessitates the Study

At the time of writing, no historical systematic uses of PFAS by Defence have been identified at the Site, never the less detections of PFAS have been reported in existing on-Site monitoring wells and Hunter Water Pumping Station 14. These detections may be related to a historical release of PFAS on the range or associated with buried waste which contain PFAS (such as fire extinguishers).

The Target Area, particularly the gunnery lanes being cleared of vegetation presents a likely area of groundwater recharge (refer to the preliminary CSM, AECOM 2018), i.e. where surface water infiltrates readily to groundwater. There is an inferred groundwater divide across the centre of the Target Area, where groundwater is interpreted to flow in both north and south easterly directions (refer to Figure 4 in Appendix A). Monitoring wells down gradient of the central portion of the Target Area are where historical detections have occurred (MB5, MB6 to the north and north east and MB8 to the south [refer to Figure 4 in Appendix A]). PFAS may be migrating with groundwater flow north and south east of the Target area, where it may interact with surface water bodies (Racecourse Swamp to the north and Moffatts Creek to the south) and subsequently may pose a risk to receptors.
The problem is:

- Land and water contamination are sensitive issues that trigger concerns within the community about impacts to human health, the environment, property values and business operations, which may be based on real or perceived risks. Left unmanaged, issues like these can activate community action groups, result in issues being escalated to elected representatives or the media and damage organisations’ key stakeholder and community relationships and reputation.

- The PFAS Expert Health Panel (2018) notes the following with regards to the health effects of PFAS “There is no current evidence that supports a large impact on an individual’s health. In particular, there is no current evidence that suggests an increase in overall cancer risk... However, because the evidence is very weak and inconsistent in many respects, some degree of important health effects for individuals exposed to PFAS cannot be ruled out based on the current evidence.”

- PFAS presence has previously been detected on-Site in groundwater and its nature and extent, and the consequent risks to on and off-Site receptors is currently not fully understood.

- The potential for northerly migration of PFAS from the Target Area into groundwater and subsequently into surface waters of Racecourse Swamp is not fully understood.

- The potential for southerly migration of PFAS from the Target Area into groundwater and subsequently towards PS14 and the Site boundary is not fully understood.

- There is currently no data to assess PFAS migration via on-Site surface water bodies to enable assessment of the risk to receptors.

- The exposure and uptake of PFAS in the environment by biological receptors is unknown.

- The exposure link between PFAS in the environment and human receptors is not fully understood.

The objectives of the PSI are to:

- Produce a PSI report that is consistent with scientific and professional standards (including the National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) and PFAS National Environmental Management Plan (PFAS NEMP).

- Communicate an understanding of the Conceptual Site Model (CSM) including potential sources of legacy PFAS contamination, potential and complete exposure pathways and receptors to groundwater and surface water.

- Recommend further actions (if required).

The groundwater, surface water, sediment, and soil data collected by implementing this SAQP discussed in the following sections is intended to generate data that will:

- Re-assess the historical concentrations of PFAS on the Site.

- evaluate whether the extent is limited to within the Site boundary.

- allow the preliminary assessment of risk to the most likely receptors (including humans and the environment)

- support and refine the preliminary CSM.

While the presence of PFAS in biota is currently not understood, assessment of this media is not presented in this SAQP and will not be considered as part of the scope of the PSI. The outcomes of the works undertaken as part of this PSI SAQP could be used to inform the design of any future SAQPs for human health and ecological risk assessment scopes.

### 3.1.1.2 Planning Team Members

The AECOM planning team members involved in the development of the SAQP and the delivery of the PSI report for Salt Ash are listed in Table 4 below.
Table 4  AECOM Planning Team Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natasha Blefari</td>
<td>Principal Environmental Scientist</td>
<td>Program Director</td>
</tr>
<tr>
<td>Ben Hunter:</td>
<td>Senior Chemical Engineer</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Jessica Byrne</td>
<td>Senior Environmental Engineer</td>
<td>Deputy Project Manager</td>
</tr>
<tr>
<td>Paul McCabe</td>
<td>Technical Director</td>
<td>Lead Consultant PFAS/Peer Review</td>
</tr>
<tr>
<td>Graham Hawkes</td>
<td>Associate Director – Principal Hydrogeologist</td>
<td>Lead Hydrogeologist</td>
</tr>
<tr>
<td>Shelbi Mancinelli</td>
<td>Environmental Scientist</td>
<td>PSI Works Lead/Field Investigation Lead</td>
</tr>
<tr>
<td>Sharon Suzor:</td>
<td>Technical Director – Communication &amp; Engagement</td>
<td>Stakeholder and Community Engagement Lead</td>
</tr>
<tr>
<td>Courtney Barnett</td>
<td>Senior Consultant – Communications &amp; Engagement</td>
<td>Stakeholder and Community Engagement Consultant</td>
</tr>
<tr>
<td>Julia Coates</td>
<td>Senior Consultant – Communication and Engagement</td>
<td>Stakeholder and Community Engagement Consultant</td>
</tr>
</tbody>
</table>

3.1.1.3  Summary of Available Resources and Schedule/

The team listed in Table 4 above is available to meet the deadlines related to the PSI presented in Table 5 below.

Table 5  Summary of Deadlines for the Study

<table>
<thead>
<tr>
<th>Task</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 2: Preliminaries, CSM, SAQP</td>
<td>25 July 2018</td>
</tr>
<tr>
<td>Information Gathering</td>
<td>10 July 2018</td>
</tr>
<tr>
<td>Site Inspection/Interviews</td>
<td>11 July 2018</td>
</tr>
<tr>
<td>Establish Preliminary CSM</td>
<td>17 July 2018</td>
</tr>
<tr>
<td>Prepare Draft SAQP</td>
<td>23 July 2018</td>
</tr>
<tr>
<td>Defence /SA Review of Draft SAQP</td>
<td>3 August 2018</td>
</tr>
<tr>
<td>Defence /SA Review of CSM</td>
<td>3 August 2018</td>
</tr>
<tr>
<td>CSM/SAQP Workshop</td>
<td>6 August 2018</td>
</tr>
<tr>
<td>Update and Finalise SAQP</td>
<td>10 August 2018</td>
</tr>
<tr>
<td>Task 3: PSI Works</td>
<td>24 September 2018</td>
</tr>
<tr>
<td>ECC Preparation and Approval</td>
<td>10 August 2018</td>
</tr>
<tr>
<td>Hunter Water Access Agreement</td>
<td>10 August 2018</td>
</tr>
<tr>
<td>Field Investigations (Service/UXO Clearance, Drilling, Sampling)</td>
<td>27 August 2018</td>
</tr>
<tr>
<td>Surveying of Groundwater Wells</td>
<td>7 September 2018</td>
</tr>
<tr>
<td>Laboratory Analysis</td>
<td>14 September 2018</td>
</tr>
</tbody>
</table>
### Task 4: PSI Report

<table>
<thead>
<tr>
<th>Task</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Draft PSI Report</td>
<td>5 October 2018</td>
</tr>
<tr>
<td>Defence /SA Review of PSI</td>
<td>12 October 2018</td>
</tr>
<tr>
<td>Update PSI and Finalise</td>
<td>23 October 2018</td>
</tr>
<tr>
<td>Update Existing CSR Database</td>
<td>29 October 2018</td>
</tr>
</tbody>
</table>

### Task 5: Stakeholder and Community Engagement

<table>
<thead>
<tr>
<th>Task</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder Management Plan</td>
<td>17 July 2018</td>
</tr>
<tr>
<td>Stakeholder Contact Management</td>
<td>26 October 2018</td>
</tr>
<tr>
<td>Other Stakeholder Tasks</td>
<td>26 October 2018</td>
</tr>
<tr>
<td>Project Completion</td>
<td>29 October 2018</td>
</tr>
</tbody>
</table>

### 3.1.1.4 Preliminary Conceptual Site Model

A summary of the preliminary Conceptual Site Model (CSM) developed for the Site (AECOM, 2018) is summarised in **Section 2.0**.

The CSM postulates that historical PFAS detections are a result of either a single or multiple low concentration point sources, or an older possibly higher concentration PFAS source within the Target Area and PFAS is migrating from the Target Area via groundwater north into Racecourse Swamp and south east towards PS14. The information presented in the preliminary CSM has been used to inform the design of this SAQP to enable the assessment of risk to the identified receptors and collection of representative samples.

### 3.1.2 Step 2 – Identify the Goal of the Study

The decision / goal represents the key steps/issues that need to be reviewed/considered in order to resolve the problem identified in Step 1.

The primary question to be addressed is the following:

- Is PFAS detectable in the groundwater, surface water, and/or sediment in association with potential sources of AFFF at the Site, do conditions at the Site boundary pose a risk to off-Site receptors, how do PFAS concentrations inform the understanding of the nature and extent of PFAS impact and what are the potential human and ecological risks?

The data collected to answer this question are intended to subsequently be used in refining the CSM, informing future on and off-Site investigation works, and will be utilised in the human health and/or ecological risk assessments.

Defence will use the information to establish whether further investigation is required to address potential risks associated with PFAS presence.

The key issues are:

1. Are the laboratory Limits of Reporting (LOR) appropriate for the objectives of the investigation?
2. Are concentrations of PFAS present within the boundaries of the investigation above laboratory LOR for PFAS?
3. Has the extent of the PFAS (as evidenced from presence in multiple sample media) been identified?
4. Is the investigation approach scientifically suitable and defensible?

3.1.3 Step 3 – Identify Information Inputs

To allow assessment of the data against the study goal listed in Step 2, the following will be considered:

- Previous results from sampling conducted by other parties, and other data collected at the Site and surrounding areas – Data will include historical land use information, hydrological and hydrogeological conditions, soil and water chemical and physical characteristics, and types and concentration of chemical contamination.
- New data collected and observations made during field works to be conducted as proposed in Section 6;
- Results of analysis of samples to be collected as proposed in Section 6.0.

3.1.4 Step 4 – Define the Boundaries of the Study

The spatial boundaries are:

- Lateral: on-Site areas defined by the Site boundary under Defence ownership. Off-Site areas include those indicated on figures in Appendix A, which are targeted to down gradient locations which could be affected by contaminant migration; and
- Vertical: groundwater samples will be collected from monitoring wells installed at various depths with the purpose of assessing hydrogeological conditions and the vertical extent of PFAS compounds. Sampling depths will vary spatially;
  - Soil will focus on the shallow subsurface, up to 2 m below ground surface (bgs);
  - Groundwater samples will generally be collected to a maximum depth of 5 m bgs, however one deeper sample from a maximum depth of 20 m bgs is proposed;
  - Deeper investigation may be required at some locations if data gaps (if any) are considered significant; and
  - Sediment samples will be collected from surface to shallow subsurface as defined in Section 6.0.

Temporal boundaries are limited to the proposed fieldwork timeframes, which will be between August and September 2018. Where possible, sampling of surface water post rainfall events will be conducted to assess potential variation in PFAS concentrations. Historical data will be considered in assessing temporal trends in contaminant concentration.

The final location of boreholes will be dependent on a number of factors, including; the presence of buried structures the presence of overhead wires, the presence of adequate flat, firm ground to place a drill rig safely, proximity to traffic, the presence of suspected Unexploded Ordnance (UXO) and incorporation of new data. The boundaries of the study area are subject to some alteration with each location presented as indicative. Any changes will consider the rationale of the location of the sampling location and endeavour to obtain the same information for the CSM from the alternate.

3.1.5 Step 5 – Develop the Analytical Approach

The decision rules can be defined as:

- If the laboratory quality assurance/quality control data are within the acceptable ranges, the data will be considered suitable for use;
- If PFAS are reported above the laboratory LOR in one or more samples, then it will be considered whether further assessment or management measures are required; and
- If PFAS are reported below the laboratory LOR in the samples applicable to a specific pathway, then it will be considered that there is no evidence of a potential complete source-pathway-receptor linkage and, therefore, inclusion of that pathway in the risk assessment may not be required. For example, if PFAS concentrations in shallow soils on-Site were reported as below the
laboratory detection limit, then the pathway to terrestrial ecological receptors from soil exposure may be considered incomplete.

The decision on the acceptance of the analytical data will be made on the basis of the Data Quality Indicators (DQIs) as follows:

- **Precision**: A quantitative measure of the variability (or reproducibility) of data;
- **Accuracy**: A quantitative measure of the closeness of reported data to the “true” value;
- **Representativeness**: The confidence (expressed qualitatively) that data are representative of each media sampled;
- **Completeness**: A measure of the amount of useable data from a data collection activity; and
- **Comparability**: The confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event.

### 3.1.5.1 Precision

Suitable criteria and/or performance indicators for assessment of precision include:

- Performance of intra-laboratory duplicate sample sets through calculation of relative percent differences (RPDs);
- Performance of inter-laboratory duplicate sample sets through calculation of RPDs; and
- The RPDs will be assessed as acceptable if less than or equal to 30% as per the NEPM Schedule B3. Where the results show greater than 30% difference, a review of the cause will be conducted (NEPM, 2013). It is noted that RPDs that exceed this range may be considered acceptable where:
  - Results are less than 10 times the LOR (no limit);
  - Results are less than 20 times the LOR and the RPD is less than 50%; and
  - Heterogeneous materials are encountered.

### 3.1.5.2 Accuracy (Bias)

The closeness of the reported data to the “true” value is assessed through review of performance of:

- Method blanks, which are analysed for the analytes requested for in the primary samples;
- Matrix spikes and surrogate recoveries; and
- Laboratory control samples.

### 3.1.5.3 Representativeness

To ensure the data produced by the laboratory are representative of conditions encountered in the field, the following steps will be taken by AECOM (in the field) and the analysing laboratory:

**AECOM**

- Sample locations have been designed to provide representative samples of the locations being sampled (refer to sample rationale provided in Appendix B). Soil samples will target the vadose zone i.e. above the standing water level, groundwater samples will generally be collected from the shallow aquifer (<5 m bgs) except at deep monitoring well locations (MW001S and MB9D) where samples are expected to be collected from approximately 19-19.5 m, sediment samples will be collected from less than 150 mm sub surface and surface water samples will be collected from the approximate midpoint of the surface water body generally 1-2 m from the bank.
- Descriptive as well as lithological logging to assist in identifying where encountered conditions or a collected sample may not be representative of the targeted media/location.
- The following sampling techniques will be employed to ensure representative samples are collected:
- Soil samples will be collected from the vadose zone only by push tubes or directly from a hand auger where samples are collected <1.5 m bgs. Push tubing can provide relatively undisturbed geological cores to enable collection of representative soil samples for detailed lithological description and installation of monitoring wells. To ensure representativeness when collecting samples from the hand auger samples will be collected from the centre mass of the soils within the auger where soils are less disturbed during the excavation process.

- Collection of groundwater samples following purging of sufficient volume and parameter stabilisation using low flow sampling techniques to collect representative samples of the aquifer.

- Surface water samples to be collected via sampling pole with dedicated sample bottle from the approximate mid-point of the water column unless if the creek or surface drain location to sample is shallow and the bank gradient allows easy access, the sample may be collected into the sample bottle by a gloved hand. To ensure sample are representative of the water body, if samples are collected too close to the bottom sediments may impact on the representativeness of the sample.

- Sediment samples will be collected by either a shovel, hand trowel or dormer piston sediment sampler. A dormer piston sediment sampler produces cores of sediment and samples can therefore samples can be accurately selected by depth from surface. Where a shovel or hand trowel is used samples will be collected from the centre mass of sediment on the trowel or shovel to ensure samples are representative of insitu sediments.

- Employ appropriate decontamination methodologies between locations, including the use of Liquinox, a phosphate free detergent and thorough rinse in clean water, to reduce the risks of cross contamination. Collection of rinsate samples to verify effective decontamination is occurring.

Analysing Laboratory

- Blank samples will be run in parallel with field samples to confirm there are no unacceptable instances of laboratory cross-contamination.

- Review of RPD values for field and laboratory duplicates to provide an indication that the samples are generally homogeneous, with no unacceptable instances of significant sample matrix heterogeneity.

The appropriateness of collection methodologies, handling, storage and preservation techniques will be assessed to ensure/confirn there was minimal opportunity for sample interference or degradation (e.g. volatile loss during transport due to incorrect preservation / transport methods).

3.1.5.4 Completeness

In validating the degree of completeness of the analytical data sets acquired during the program, the following is considered:

- Whether data been generated in accordance with the SAQP, to enable valid conclusions.
- Whether standard operating procedures (SOPs) for sampling protocols have been adhered to.
- Copies of all Chain of Custody (CoC) documentation are reviewed and presented.
- Whether the Data Quality Indicators have been met (refer to Table 6)

It can therefore be considered whether the proportion of “useable data” generated in the data collection activities is sufficient for the purposes of assessing the problem as stated in Step 1 above.

3.1.5.5 Comparability

Given that assessment data can comprise several data sets from separate sampling events (for example, the data from previous investigations mentioned in Section 1.3), issues of comparability between data sets are reduced through adherence to SOPs and regulator endorsed or made guidelines and standards on each data gathering activity.
In addition, the data will be collected by experienced AECOM field staff, and National Association of Testing Authorities (NATA) accredited laboratories will be employed in all laboratory programs for soil, sediment and water analysis.

3.1.6 Step 6 – Specify Performance or Acceptance Criteria

Specific limits for this project are in accordance with the appropriate guidance made or endorsed by state and national regulations, appropriate indicators of data quality, and standard procedures for field sampling and handling.

This step also examines the certainty of conclusive statements based on the available new site data collected. This should include the following points to quantify tolerable limits:

- A decision can be made based on a certainty assumption of 95% confidence in any given data set. A limit on the decision error will be 5% that a conclusive statement may be a false positive or false negative.

A decision error in the context of the decision rule presented above would lead to either underestimation or overestimation of the risk level associated with a particular sampling area. Decision errors may include:

- Sampling errors may occur when the sampling program does not adequately detect the variability of a contaminant from point to point across the Study Area. To address this, the SAQP outlines minimum numbers of samples proposed to be collected from each media. As such, there may be limitations in the data if aspects of the SAQP cannot be implemented. Some examples of this scenario include, but are not limited to:
  - Proposed surface water sample locations may be dry at the time of sampling; and
  - Proposed samples are not collected due to access being restricted to a given location.

- Limitations in ability to acquire useful and representative information from the data collected. The data are proposed to be collected from multiple locations and sample media. For example,
  - Inability to collect surface water and sediment samples at the same location.

- Measurement errors can occur during sample collection, handling, preparation, analysis and data reduction. To address this, the following measures are proposed:
  - Field staff to follow SOPs when undertaking samples, including decontamination of tools, removal of adhered sediment to avoid false positives in results, and use of appropriate sample containers and preservation methods;
  - Laboratories to follow a standard procedure when preparing samples for analysis and undertaking analysis; and
  - Laboratories to report quality assurance/ quality control data for comparison with the DQIs established for the project.

3.1.7 Step 7 – Optimise the Design for Obtaining Data

The methodology presented in this SAQP is designed to meet the objectives described in Section 1.6 and to achieve the nominated DQOs. Optimisation of the data collection process will be achieved by:

- Working closely with the analytical laboratories and sampling equipment suppliers to ensure that appropriate procedures and processes are developed and implemented prior to and during the field work, to ensure that sample handling, transport to and processing by the analytical laboratories is appropriate; and

- Conducting sampling according to set SOPs for the type of sampling being conducted (e.g. groundwater monitoring well sampling). SOPs are presented in Appendix C.

3.2 Assessment of Data Quality

The quality of data collected as part of the sampling will be assessed on a range of factors including:

- Documentation and data completeness; and
- Data quality – comparability, representativeness, precision and accuracy of the analytical data.

The project target for data completeness is to achieve 95% of data as suitable for use.

The acceptance criteria for DQIs for samples are specified in **Table 6**.

**Table 6**  Acceptance Criteria for Data Quality Indicators for Sample Analysis

<table>
<thead>
<tr>
<th>Data Quality Indicators</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water, Sediment and Soil Samples</strong></td>
<td></td>
</tr>
<tr>
<td>Rinsates (where sampling equipment is reused)</td>
<td>Less than the laboratory LOR.</td>
</tr>
<tr>
<td>Field duplicates/Inter-lab duplicates</td>
<td>The RPDs will be assessed as acceptable if less than or equal to 30% as per the NEPM Schedule B3. Where the results shows greater than 30% difference a review of the cause will be conducted (NEPM, 2013). It is noted that RPDs that exceed this range may be considered acceptable where:</td>
</tr>
<tr>
<td></td>
<td>• Results are less than 10 times the LOR (no limit);</td>
</tr>
<tr>
<td></td>
<td>• Results are less than 20 times the LOR and the RPD is less than 50%; and</td>
</tr>
<tr>
<td></td>
<td>• Heterogeneous materials are encountered.</td>
</tr>
<tr>
<td>Laboratory duplicates</td>
<td>RPDs less than:</td>
</tr>
<tr>
<td></td>
<td>• 20% for high level laboratory duplicates (i.e. &gt;20 x LOR); and</td>
</tr>
<tr>
<td></td>
<td>• 50% for medium level laboratory duplicates (i.e. 10 to 20 x LOR).</td>
</tr>
<tr>
<td>Matrix spikes</td>
<td>Recoveries between 70-130% of the theoretical recovery or as nominated in the laboratory’s QC report, based on their historical database.</td>
</tr>
<tr>
<td>Method blanks</td>
<td>Less than the laboratory LOR.</td>
</tr>
<tr>
<td>Laboratory control samples</td>
<td>Recoveries between laboratories specified range for each particular analyte / analytical suite.</td>
</tr>
</tbody>
</table>
4.0 Scope of Work

4.1 Drilling Program

Table 7 below details the Scope of Work for the drilling program to enhance the existing on-Site groundwater monitoring well network, and to assess off-Site groundwater conditions.

<table>
<thead>
<tr>
<th>Proposed Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Mobilisation Planning and Liaison</td>
</tr>
<tr>
<td>- The development of a task-specific Environmental Clearance Certificate (ECC) and Environmental Management Plan (EMP).</td>
</tr>
<tr>
<td>- The development of a Safety Health and Environment Management Plan (SHEMP) and associated Safe Work Method Statements (SWMS).</td>
</tr>
</tbody>
</table>

| Soil Sampling and Monitoring Well Installation |
| - Installation of monitoring wells to assess the extent of PFAS migration from Site. These wells will be installed to 2 m below the encountered groundwater table, with an anticipated maximum depth of 20 m bgs. |
| - All new monitoring wells will be surveyed by a registered surveyor for northing, easting and top of casing elevation. |
| - The proposed monitoring well locations are presented in Figures 9 and 9A in Appendix A and are summarised in Section 6.1. |
| - The monitoring well locations have been selected with the primary purpose of assessing the interpreted extent of detectable PFAS in groundwater. The spatial distribution of the proposed monitoring wells will also provide data to refine the groundwater flow and contaminant transport model in the future, if necessary. The proposed locations are indicative, and subject to change based on access constraints. |
| - All locations have been targeted to Defence-owned or publicly accessible land only. In selecting the locations, it is assumed unhindered access to all drilling locations. If access cannot be achieved, nearby accessible locations that will provide similar and suitable information will be considered. |
| - Drilling and installation of monitoring wells will be conducted using Geoprobe and hollow flight auger and push tube drilling techniques. Push tubing can provide relatively undisturbed geological cores to enable collection of representative soil samples for detailed lithological description and installation of monitoring wells. |
| - Monitoring wells will be constructed using 50 mm casing, with approximately 3 m long screens and bentonite seal. The screen depth and length will be determined based on field observations. |
| - All monitoring wells will be constructed in accordance with the National Water Commission, 2012. Minimum Construction Requirements for Water Bores in Australia |
| - All wells will be developed by pumping until the well is purged dry or groundwater parameter stabilisation is achieved. |
| - 2 soil samples confined to the vadose zone will be collected from the near surface to 2 m bgs. Soil samples will be analysed for the PFAS suite at each location. |

| Data Review and Interpretation |
| - Results of PFAS analyses will be used to evaluate the extent of PFAS presence in soil. |
4.2 Groundwater Sampling

Table 8 below details the scope of work for groundwater sampling to assess and characterise the possible extent of PFAS detection in groundwater.

### Table 8 Proposed scope for Groundwater Monitoring Investigation

<table>
<thead>
<tr>
<th>Proposed Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Mobilisation Planning and Liaison</strong></td>
</tr>
<tr>
<td>• The development of a task-specific ECC and EMP.</td>
</tr>
<tr>
<td>• The development of a SHEMP and SWMS.</td>
</tr>
<tr>
<td><strong>Sampling and Analysis of Groundwater</strong></td>
</tr>
<tr>
<td>• Gauging of the depth to standing water and the total depth of a selection of existing groundwater monitoring wells.</td>
</tr>
</tbody>
</table>
| • Purging of the selected monitoring wells using peristaltic pump or bladder pump until ex-situ measurement of groundwater field parameters demonstrates that field quality parameters have stabilised (Refer to AECOM standard operating procedure Q4AN(EV)-407-PR1 in Appendix C). It is noted that purge rates should be between 0.1-0.4 litres per minute and the removal of several well volumes of groundwater from each monitoring well may be required. Parameters will be considered stable when consecutive readings over four minutes are recorded within:
  - ± 10% for dissolved oxygen (DO)  
  - ± 3% for electrical conductivity (EC)  
  - ± 0.05 for pH  
  - ± 10mv for redox potential (ORP)  
  Should parameters not stabilise a minimum of three well volumes will be purged. |
| • Collection of representative groundwater samples from monitoring wells using low-flow sampling techniques (peristaltic pump or bladder pump). |
| • Submission of groundwater samples to ALS Environmental laboratory for primary analysis, and approximately one in 20 samples will be sent to the secondary laboratory (Envirolab) for inter-laboratory analysis. |
| **Aquifer Testing**                                                          |
| • 1 shallow/deep paired wells to be installed to the south of the Target Area and MB8 (highest onsite historical detections) to investigate to the depth of impact on the aquifer. |
| **Data Review and Interpretation**                                          |
| • Results of PFAS analyses will be used to evaluate the extent of PFAS presence in groundwater underlying the Site. |

4.3 Surface Water / Sediment Sampling

Table 9 below details the scope of work for surface water and sediment sampling, to investigate and assess the potential presence of PFAS compounds in surface water and sediment.
Table 9 Proposed scope for Surface Water and Sediment Investigation

<table>
<thead>
<tr>
<th>Proposed Scope</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Mobilisation Planning and Liaison</strong></td>
<td></td>
</tr>
<tr>
<td>• The development of a task-specific ECC and EMP.</td>
<td></td>
</tr>
<tr>
<td>• The development of a SHEMP and associated SWMS.</td>
<td></td>
</tr>
<tr>
<td>• Confirming access to the selected surface water and sediment investigation locations.</td>
<td></td>
</tr>
<tr>
<td><strong>Sampling and Analysis of Surface Water and Sediment</strong></td>
<td></td>
</tr>
<tr>
<td>• Collection of surface water and sediment samples, focusing primarily on drainage lines and creeks within the vicinity of the Target Area as well as down gradient locations.</td>
<td></td>
</tr>
<tr>
<td>• Surface water samples, where possible, will be collected from the approximate midpoint of the water column.</td>
<td></td>
</tr>
<tr>
<td>• Field measurements for surface water quality parameters: temperature, pH, EC, DO and ORP.</td>
<td></td>
</tr>
<tr>
<td>• 1 intra-laboratory duplicate sample and 1 inter-laboratory duplicate sample from each matrix will be collected and analysed.</td>
<td></td>
</tr>
<tr>
<td>• Submission of samples to ALS Environmental laboratory (ALS) for primary analysis, and approximately one in 20 samples will be sent to the secondary laboratory (Envirolab) for inter-laboratory analysis.</td>
<td></td>
</tr>
<tr>
<td><strong>Data Review and Interpretation</strong></td>
<td></td>
</tr>
<tr>
<td>• Results of the PFAS analyses will be used to evaluate the extent of PFAS presence in surface water and sediment.</td>
<td></td>
</tr>
</tbody>
</table>
5.0 Safety Health, Safety and Environmental Management

5.1 Health and Safety

A project-specific Safety Health and Environmental Management Plan will be developed for the project. The implementation of the SAQP must be undertaken in conjunction with the SHEMP, and AECOM SOPs (Appendix C). An activity-specific SWMS must be undertaken for all routine activities.

5.2 Environmental Management

An ECC and EMP will be developed for the project and staff/contractors will be inducted onto both documents.

The objective of the EMP is to document the managerial procedures and onsite environmental safeguard controls associated with the fieldwork to be conducted on-Site and at specified off-Site areas as part of the environmental investigations.
6.0 Fieldwork Tasks, Sampling and Analysis Methodologies

6.1 Sample Locations and Rationale

Table 10 below provides a breakdown of the proposed sample locations, the environmental media to be sampled, and the rationale behind the selection of the proposed sample locations. The proposed sample locations may vary, subject to:

- Additional information provided by Defence;
- The presence/absence of sample water at proposed sample locations;
- Access constraints along publically accessible roadways and waterways; and
- The granting of Defence access to the proposed sample locations on-Site.
Table 10 Proposed Sample Locations and Rationale for Location Selection

<table>
<thead>
<tr>
<th>Proposed Location</th>
<th>Sample Type</th>
<th>Location Description and Rationale for Location Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drilling Program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Primary Samples (10 locations) (refer to Figures 9 and 9A)</td>
<td>Soil</td>
<td>• At each monitoring well location, soil samples will be collected from the vadose zone (2 m maximum depth). Soil samples will be collected at approximately 0.5 m intervals within the vadose zone, 20 primary samples (2 per borehole) will be analysed at the laboratory for PFAS with additional samples submitted to the laboratory on hold. The purpose of the soil investigation is to assess the extent and concentration of PFAS in shallow soil.</td>
</tr>
</tbody>
</table>

| **Groundwater Monitoring** |             |                                                         |
| 19 Primary Samples (19 monitoring well locations) |             | • A total of 10 new monitoring wells will be installed and sampled. Monitoring wells will be installed using auguring techniques preceded by soil sampling using push tube techniques. Proposed monitoring well locations are presented in Figures 9 and 9A in Appendix A. A specific rationale for each new monitoring well location is provided in Table T 1 in Appendix B. |
| 19 Primary Samples (19 monitoring well locations) |             | • A total of 7 existing on-Site monitoring well locations and 1 on-Site Hunter Water monitoring well (SK3493) will be sampled. Refer to Figures 9 and 9A in Appendix A for sample locations. |
| 19 Primary Samples (19 monitoring well locations) |             | • 1 Hunter Water Pumping Station (PS 14) will be sampled; this location has previously reported detections of PFAS. |
| 19 Primary Samples (19 monitoring well locations) |             | • The purpose of sampling the locations mentioned above is to: |
| 19 Primary Samples (19 monitoring well locations) |             | - confirm the concentration of PFAS at the Site is of low concentration and limited in extent. |
| 19 Primary Samples (19 monitoring well locations) |             | - produce data pertaining to PFAS concentrations at the boundaries of the Site. |
| 19 Primary Samples (19 monitoring well locations) |             | - produce data that will allow the Preliminary CSM to be refined. |
| 19 Primary Samples (19 monitoring well locations) |             | - allow assessment of risk to the main pathways and receptors. |

| **Surface Water and Sediment Investigation** |             |                                                         |
| 15 Primary Samples (Figures 9 and 9A) | Surface Water | • A total of 15 surface water samples will be collected from locations presented on Figures 9 and 9A in Appendix A. The specific location of the samples may be adjusted based on field observations and will be targeted towards on-Site locations near to locations reporting historical PFAS presence, off-Site discharge points, receiving drains/pump station(s). |
| 15 Primary Samples (Figures 9 and 9A) | Surface Water | • The purpose of these locations is to: |
| 15 Primary Samples (Figures 9 and 9A) | Surface Water | - investigate potential PFAS presence in surface water both on and off-Site. |
| 15 Primary Samples (Figures 9 and 9A) | Surface Water | - produce data pertaining to PFAS concentrations in surface water at the boundaries of the Site. |
| 15 Primary Samples (Figures 9 and 9A) | Surface Water | - produce data that will allow the Preliminary CSM to be refined. |
| 15 Primary Samples (Figures 9 and 9A) | Surface Water | - allow assessment of risk to the main pathways and receptors. |
| 10 Primary Samples (Figures 9 and 9A) | Sediment | • A specific rationale for each surface water sampling location is provided in Table T 2 in Appendix B. |
| 10 Primary Samples (Figures 9 and 9A) | Sediment | • A total of up to 10 sediment samples will be collected from on-Site locations (locations are presented on Figures 9 and 9A in Appendix A). The specific locations will be collocated with the surface water samples. |
Collection points will focus on drainage lines and transport pathways.

The purpose of these locations is to:
- investigate potential PFAS presence in sediment on-Site.
- produce data pertaining to PFAS concentrations in sediment at the boundaries of the Site.
- produce data that will allow the Preliminary CSM to be refined.
- allow assessment of risk to the main pathways and receptors.

A specific rationale for each surface water sampling location is provided in Table T 2 in Appendix B.
6.2 Summary of Sample Numbers and Analytical Suites

Table 10 below provides a summary of the types of samples to be collected during the PSI, the number of those samples, and the laboratory analyses which will be requested.

**Table 11 Proposed Sample Analysis Suites**

<table>
<thead>
<tr>
<th>Matrix</th>
<th>PFAS</th>
<th>Non-PFAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>• 20 primary samples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1 intra-laboratory duplicates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1 inter-laboratory duplicates</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>• 19 primary samples</td>
<td>• 19 Primary Samples</td>
</tr>
<tr>
<td></td>
<td>• 1 intra-laboratory duplicates</td>
<td>• 1 intra-laboratory duplicates</td>
</tr>
<tr>
<td></td>
<td>• 1 inter-laboratory duplicates</td>
<td>• 1 inter-laboratory duplicates</td>
</tr>
<tr>
<td>Surface Water</td>
<td>• 14 primary samples</td>
<td>• 14 Primary Samples</td>
</tr>
<tr>
<td></td>
<td>• 1 intra-laboratory duplicates</td>
<td>• 1 intra-laboratory duplicates</td>
</tr>
<tr>
<td></td>
<td>• 1 inter-laboratory duplicates</td>
<td>• 1 inter-laboratory duplicates</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Up to 5 Primary Samples for Dissolved Organic Carbon (where tannins observed)</td>
</tr>
<tr>
<td>Sediment</td>
<td>• 10 primary samples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1 intra-laboratory duplicates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 1 inter-laboratory duplicates</td>
<td></td>
</tr>
</tbody>
</table>
6.3  Equipment Required for Sampling

The following equipment will be used by AECOM and its subcontractors during the fieldwork.

Table 12  Sampling Equipment

<table>
<thead>
<tr>
<th>Equipment Item</th>
<th>Reason for Equipment Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Location Equipment</td>
<td>Identification of underground surfaces (e.g. electrical, gas, water) so that suitable locations can be nominated for the groundwater wells.</td>
</tr>
<tr>
<td>Non-Destructive Drilling Rig</td>
<td>Clear each borehole to confirm they are clear of underground utilities.</td>
</tr>
<tr>
<td>Drill Rigs (Sonic and Geoprope equipped with push tube and augers)</td>
<td>Required to drill boreholes, collect soil samples and install groundwater wells.</td>
</tr>
<tr>
<td>Hand Auger</td>
<td>Collection of soil samples from near to the ground surface and clear each borehole to confirm they are clear of utilities.</td>
</tr>
<tr>
<td>Shovel/Hand Trowel/Petit Polar Sediment Sampler</td>
<td>Collection of sediment samples.</td>
</tr>
<tr>
<td>Sampling Pole, Waders</td>
<td>Collection of surface water samples.</td>
</tr>
<tr>
<td>Brush, Bucket and Deionised Water</td>
<td>Decontamination of hand auger, shovel and any other reusable sampling equipment between the collection of samples.</td>
</tr>
<tr>
<td>Water Quality Meter</td>
<td>Collection of field water quality parameters for each water sample. Parameters include: temperature, pH, electrical conductivity (EC), dissolved oxygen (DO) and oxidation-reduction potential (ORP).</td>
</tr>
<tr>
<td>Low-flow Pump (peristaltic/bladder)</td>
<td>Collection of groundwater samples from locations where there is no dedicated pump.</td>
</tr>
<tr>
<td>Surveying Equipment</td>
<td>Surveying of the location, surface elevation and top of casing of each groundwater well to infer potentiometric gradient and groundwater flow direction.</td>
</tr>
</tbody>
</table>

6.4  Sample Collection and Handling

6.4.1  Groundwater Sampling

A range of groundwater sampling techniques consistent with current best practice for PFAS assessment (discussed further below) will be employed, depending on the nature of the particular sample location. All sampling will be undertaken by appropriately qualified AECOM personnel, and samples will be collected and handled in a manner that ensures field personnel safety, and the integrity of the sample itself.

6.4.1.1  Monitoring Wells

Groundwater samples will be collected from monitoring wells in accordance with the AECOM SOP (Appendix C) so that they are representative of groundwater sampled until the time of their analysis. AECOM SOPs are derived from recommendations made in the National Environmental Protection Measure (NEPM, Schedule B [2]) Guideline on Site Characterisation (2013), which states:

An appropriate method of groundwater sampling should be selected in relation to the nature of the target analytes (PFOS / PFOA) and the hydraulic characteristics of the monitoring well. In general, the use of low-flow submersible pumps minimise purging requirements are the preferred methods of groundwater sampling for site characterisation purposes. No-purge sampling techniques may also be appropriate, particularly for long-term monitoring applications.

Groundwater monitoring wells will be gauged prior to sampling with an oil/water interface probe to measure the depth to groundwater and total depth of the wells. Each well will then be sampled using a low-flow pump (peristaltic or bladder pump). Samples will be collected directly from the new tubing before the flow through cell, to avoid cross contamination. Before and between sampling each well,
the interface probe and any other equipment which will be placed down well will be decontaminated using Liquinox, a phosphate free detergent and rinsed in clean water, to reduce the risks of cross contamination. New sample tubing will be used at each well.

The AECOM SOP states that the sample tubing may contain Teflon. For this investigation, AECOM will ensure non-Teflon containing tubing is used (made from low density polyethylene) in order to ensure sample integrity is maintained, given the samples will be analysed for PFOS/PFOA. Waste tubing will be collected by AECOM and disposed appropriately.

It is noted where existing wells are being sampled, DCD#7 compliant alternative names will be included which is further detailed in Section 6.11.

6.4.1.2 Sample Collection Methods for Groundwater

Groundwater quality parameters (temperature, pH, EC, DO and ORP) will be measured in the field and recorded immediately to demonstrate conditions of the groundwater in the well, which are representative of the groundwater conditions in the targeted aquifer.

While purging prior to sample collection using a low-flow pump, the tubing will be connected to a flow-through cell where field parameters are measured. Purging of the wells will continue until the field parameters demonstrate that field quality parameters have stabilised (Refer to Table 8 for specific parameter stabilisation thresholds).

Groundwater collected for sample analysis and water quality parameters will be collected in the sample containers that are appropriate for the specific analysis to be conducted (as recommended by the laboratories). (Note: this will include non-Teflon lined capped plastic bottle as provided by the laboratory for PFAS analysis).

For intra-laboratory samples (duplicate and inter-laboratory duplicate samples), AECOM personnel will attempt to reduce potential heterogeneity in the water collected by alternating between primary and intra-laboratory bottles during sampling.

Sample containers will be placed in a cooler with ice immediately after sampling and kept, if possible, at approximately 4°C during transit to the laboratory. Prior to sampling, assessment of the analytical holding times will be made and the sampling planned accordingly to ensure that holding times are not breached or minimised.

Samples will be transported directly to the laboratory for analytical testing under standard Chain of Custody (CoC) procedures. Primary and duplicate groundwater samples and associated Quality Assurance / Quality Control (QA/QC) samples will be analysed by ALS, a NATA accredited laboratory for the analytes being investigated. The inter-laboratory duplicate samples will be analysed by Envirolab.

Further information on groundwater monitoring well sampling methodologies is presented in the SOP (Appendix C).

6.4.2 Surface Water Sampling

The surface water sample collection method employed is dependent on the nature of the location (i.e. creek/river location, open channel drain location and depth of water to be sampled). A copy of the SOP is provided in Appendix C and is in accordance with Australian Standard AS5567.

At creek or drain locations, surface water samples will be collected using a sampling pole to retrieve water from the midpoint of the water column, and towards the centre of the drain (where possible to collect samples with consideration to hazards associated with working near a water body). If the creek or surface drain location to sample is shallow and the bank gradient allows easy access, the sample can be collected into the sample bottle by a gloved hand. Care will be taken to ensure the water column at the sampling location is not agitated during sampling.

Surface water sampled from within Racecourse Swamp, Tilligerry Creek, Saltwater Creek and Moffats Creek will be sampled using the same methodology for creek and drain sampling where samples will be collected from the midpoint of the water column adjacent the sampling location.
At each sample location, field personnel will note the drain/water body morphology, soil type and nature of surface water flow and photo document the location. Surface water samples will be collected in appropriate sample bottles.

### 6.4.3 Sediment Sampling and Soil Sampling

Sediment and soil samples will be collected and handled in a manner that ensures field personnel safety, and the integrity of the sample itself.

Soil samples to be collected near the ground surface (no greater than 1.5 m bgs) will be collected using a hand auger. Where hand augering may be impeded by the presence of large rocks, a crowbar can be used as an alternative; however, care will be taken to not damage potential subsurface utilities. Below 1.5 m bgs soil samples will be collected directly from push tube liners.

Sediment samples will be collected using a shovel, hand trowel or dormer piston sediment sampler from the base of the drain/creek (where it is safe to do so). Where a shovel or hand trowel is used samples will be collected from the centre mass of sediment on the trowel or shovel to ensure samples are representative of in situ sediments. Sediment samples will be collected from Racecourse Swamp and Moffats Creek using the above mentioned methods.

Field personnel will record a descriptive log including the nature of the lithology of each sediment and soil sample (soil type, colour, staining, etc.). Soil samples will be described consistent with Unified Soil Classification System (USCS) and AECOM SOP.

Further information on the use of a hand auger to collect samples is presented in the AECOM Manual Tasks Procedure (Appendix C).

Soil samples beyond 1.5 m bgs will be collected from plastic sleeves recovered from the Geoprobe rig with push tube as part of the soil sampling and monitoring well installations.

Sediment and soil samples for PFAS analysis will be collected in 150 mL unpreserved laboratory supplied PFAS specific sample containers.

The sediment or soil sample volume required by the laboratory is dependent upon the number of analytes requested to be analysed. AECOM will work with the laboratories to ensure that appropriate sample volumes are collected for the number of analytes requested.

### 6.4.4 Private Landholding Sampling

Should groundwater sampling on private property be required, abstraction bores on privately will not be gauged, as it is anticipated the bore construction at the well head will not allow down-well access (unless the infrastructure is removed as part of the scope). Groundwater samples collected from landholder bores will be collected directly from the bore outlet point by using the existing pump dedicated to each specific groundwater abstraction bore.

The objective is to collect the groundwater that is being pumped by the landholder, therefore purging before sampling is not proposed.

### 6.4.5 Sample Handling and Transport to Laboratory

AECOM personnel will attempt to reduce potential heterogeneity in the sample media matrix by dividing the sample collected between primary and intra-laboratory jars or bottles during sampling. All samples will be placed on ice in eskies immediately after sampling.

All samples will be kept, if possible, at approximately 4°C during transit to the laboratory. Prior to sampling, assessment of the analytical holding times will be made and the sampling planned accordingly to ensure that holding times are not breached or minimised.

Samples will be transported directly to the laboratory for analytical testing under standard CoC procedures. Primary and associated duplicate QA/QC samples will be analysed by ALS. The inter-laboratory duplicate samples will be analysed by Envirolab.

QA/QC sampling is discussed in Section 6.12.
6.5 Monitoring Well Installation

Monitoring wells will be installed to a maximum depth of 20 m bgs using a Geoprobe with hollow flight augers. Monitoring wells will be screened across the water table and the well depth will depend on the depth to groundwater at each location.

All wells will be constructed with approximately 3 m of 50 mm slotted uPVC to the target depth, although the screen length may vary depending on site conditions. A minimum of 500 mm of granular bentonite will be used above the filter pack to provide an adequate seal and prevent any cross contamination pathways. A grout-bentonite mix will be used above the bentonite seal and will span to the surface to ensure there is no pathway for surface water infiltration to groundwater. The monitoring wells will be installed with flush gatic covers to minimise the potential of damage from the public.

Following completion of drilling and monitoring well installation, wells will be developed using a submersible pump.

The drilling program will be directed by an experienced AECOM field engineer who will be present throughout the drilling program. The engineer will log the intersected geology and collect soil samples for laboratory analysis. Soil logging will be completed in general accordance with the Unified Soil Classification System (USCS) and AECOM SOPs (Appendix C).

6.6 Calibration

The water quality meter will be calibrated each day prior to the commencement of field activities with relevant solutions, including pH, EC and ORP. The calibration will be in accordance with manufacturers’ instructions or NATA publication “General Requirements for Registration: Supplementary Requirement: Chemical Testing (NATA 1993) and Technical Note N0. 19 (NATA 1994)”. Where satisfactory calibration cannot be achieved, the water quality data will not be used for interpretive purposes.

Calibration details will be recorded on field sheets and included in the PSI report.

6.7 Logistics

The laboratory sample containers will be shipped from the laboratory to the AECOM office in Sydney prior to the commencement of fieldwork. All primary samples will be transported by an ALS supplied courier at the completion of fieldwork. All inter-laboratory duplicate samples will be couriered directly to the secondary laboratory under a separate CoC for analysis.

6.8 Analytical Suite and Laboratory Analysis Methods

Analytical suites have been devised based on Department of Defence 2018, Guidance Document E. A summary of the laboratory analysis suites for the CoPC, methods and laboratory LOR for water and solid media are presented in Table 13 and
Table 14, respectively. Sample containers, volumes and holding times are presented in Table 15.

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Parameter</th>
<th>Technique/Method Reference</th>
<th>Limit of Reporting*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Minimum PFAS Suite:</td>
<td>LC/MS-MS</td>
<td>0.01 - 0.05 µg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluorobutanoic acid (PFBA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-lab</td>
<td>Perfluoro pentanoic acid (PFPeA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluoro-n-hexanoic acid (PFHxA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluoro-n-heptanoic acid (PFHpA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluoro-n-octanoic acid (PFOA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluoro-n-nonanoic acid (PFNA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluoro-n-decanoic acid (PFDA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-lab</td>
<td>Perfluoro-n-undecanoic acid (PFUnDA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>Perfluoro-n-dodecanoic acid (PFDoDA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>N-Methylperfluoro-1-octane sulphonamide (N-Me-FOSA)</td>
<td>LC/MS-MS</td>
<td>0.01 - 0.05 µg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>N-Ethylperfluoro-1-octane sulphonamide (N-EtFOSA)</td>
<td>LC/MS-MS</td>
<td>0.01 - 0.05 µg/L</td>
</tr>
<tr>
<td>Inter-lab</td>
<td>2-(N-Methylperfluoro-1-octane sulphonamide)-ethanol (N-MeFOSA)</td>
<td>LC/MS-MS</td>
<td>0.01 - 0.05 µg/L</td>
</tr>
<tr>
<td>Primary</td>
<td>N-methyl perfluoroctane sulfonamidoacetic acid (MEFOSAA)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>N-ethyl perfluoroctane sulfonamidoacetic acid (EtFOSAA)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Inter-lab</td>
<td>4:2 Fluorotelomer sulfonic Acid (4:2 FTS)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>6:2 Fluorotelomer sulfonic Acid (6:2 FTS)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>8:2 Fluorotelomer sulfonic Acid (8:2 FTS)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Primary</td>
<td>10:2 Fluorotelomer sulfonic Acid (10:2 FTS)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>Rinsate Minimum PFAS Suite</td>
<td>LC/MS-MS</td>
<td>0.01 - 0.05 µg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td>Dissolved Organic Carbon (Surface Water Only)</td>
<td>APHA 5310B</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Inter-lab</td>
<td>Dissolved Al, Br, Fe, Mn</td>
<td>ICP/MS/CV/FIMS/AES</td>
<td>Al (0.01), Fe (0.05), Others 0.001</td>
</tr>
<tr>
<td>Duplicate</td>
<td>Major Cations (Na, Ca, Mg, K) and Anions (Cl, SO₄, HCO₃, F), Total Dissolved Solids, pH</td>
<td>APHA 5310B or 3125B</td>
<td>10 - 1000 µg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td></td>
<td>APHA 4110B</td>
<td>10 - 1000 µg/L</td>
</tr>
<tr>
<td>Inter-lab</td>
<td></td>
<td>APHA 4500-CL, APHA 2540C</td>
<td>10 - 1000 µg/L</td>
</tr>
<tr>
<td>Duplicate</td>
<td></td>
<td>APHA 4500 H⁺ - B</td>
<td>10 - 1000 µg/L</td>
</tr>
</tbody>
</table>

Table 13 Sample Analysis Suites and Methods for Groundwater and Surface Water
### Table 14  Sample Analysis Suites and Methods for Soil and Sediment

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Parameter</th>
<th>Technique/Method Reference</th>
<th>Limit of Reporting*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Minimum PFAS Suite</td>
<td>LC/MS-MS</td>
<td>0.0002-0.005 mg/kg</td>
</tr>
<tr>
<td>Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Inter-lab Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Rinsate</td>
<td>Minimum PFAS Suite</td>
<td>As above</td>
<td>As above</td>
</tr>
</tbody>
</table>

*LOR for Australian Laboratory Services (ALS)

LC/MS-MS = Liquid chromatography–mass spectrometry

GC = Gas chromatography

FIMS = Fiber introduction mass spectrometry

ICP = Inductively coupled plasma,

AES = Atomic Emission Spectrometer

### Table 15  Sample Containers, Sample Volumes and Sample Holding Times

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Analysis Suite</th>
<th>Media</th>
<th>Container Type (Preservation)</th>
<th>Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>EP231X</td>
<td>Water</td>
<td>125 mL plastic bottle (grey labelled)</td>
<td>180 days</td>
</tr>
<tr>
<td>Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Inter-lab Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Rinsate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Primary</td>
<td>NT-01</td>
<td>Water</td>
<td>500 mL plastic (nil preservation)</td>
<td>Cations 7 to 14 days Anions 28 days</td>
</tr>
<tr>
<td>Duplicate</td>
<td>NT-02A</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Inter-lab Duplicate</td>
<td>NT-04</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Rinsate</td>
<td>EA015H</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Primary</td>
<td>EK071G</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Inter-lab Duplicate</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
<td>[⋯]</td>
</tr>
<tr>
<td>Rinsate</td>
<td>EP231X</td>
<td>Solid</td>
<td>250 mL HDPE soil jar (nil preservation)</td>
<td>180 days</td>
</tr>
</tbody>
</table>

*EP231X= Extended AFFF Suite (28 analytes)
6.9 Summary of Adopted Screening Criteria

The adopted PFAS screening criteria to assess the data generated are presented in Table 16 and are based on the criteria presented in the HEPA PFAS National Environmental Management Plan (NEMP) (January 2018).

The Limits of Reporting presented in table Table 13 are considered suitable to enable the assessment of the data generated.
<table>
<thead>
<tr>
<th>Media</th>
<th>Pathway</th>
<th>Compound</th>
<th>Criteria</th>
<th>Comment / Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Receptors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Drinking water - groundwater</td>
<td>PFOS + PFHxS</td>
<td>0.07 µg/L</td>
<td>The values presented in the PFAS NEMP, 2018 are from DoH 2017, which published final health based guidance values for PFAS for use in site investigations in Australia. DoH utilised the TDI for PFOS and PFOA from FSANZ, 2017 and the methodology described in Chapter 6.3.3 of the National Health and Medical Research Council’s (NHMRC) Australian Drinking Water Guidelines (ADWG), 2016 to determine drinking water values. For PFHxS, DoH 2017 noted that ‘FSANZ concluded that there was not enough toxicological and epidemiological information to justify establishing a tolerable daily intake. However, as a precaution, and for the purposes of site investigations, the PFOS tolerable daily intake should apply to PFHxS. In practice, this means that the level of PFHxS exposure should be added to the level of PFOS exposure; and this combined level be compared to the tolerable daily intake for PFOS’. The values are also presented in DCD8 (March 2018). All groundwater results will be compared to these criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PFOA</td>
<td>0.56 µg/L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recreational use – surface water</td>
<td>PFOS + PFHxS</td>
<td>0.7 µg/L</td>
<td>The values presented in the PFAS National Environmental Management Plan (NEMP), 2018 are from DoH 2017, which published final health based guidance values for PFAS for use in site investigations in Australia. As with the drinking water values, the DoH utilised the TDI for PFOS and PFOA from FSANZ, 2017 and ‘the methodology described in Chapter 6.3.3 of the NHMRC of the ADWG, 2016 to determine recreational water quality values’ (DoH 2017). AECOM notes that Chapter 6.3.3 specifically refers to the calculation of a drinking water value. It is assumed that DoH 2017, applied the approach presented in Chapter 9.3 of NHMRC 2008 and considered a concentration 10 times that of the drinking water criterion for each compound. The values are also presented in DCD8 (March 2018). All surface water results will be compared to these criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PFOA</td>
<td>5.6 µg/L</td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td>Residential with garden/</td>
<td>PFOS + PFHxS</td>
<td>0.009 mg/kg</td>
<td>The values presented in the PFAS National Environmental Management Plan (NEMP), 2018 are</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Media</td>
<td>Pathway</td>
<td>Compound</td>
<td>Criteria</td>
<td>Comment / Reference</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>----------</td>
<td>----------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Human Receptors</td>
<td>accessible soil</td>
<td>PFOA</td>
<td>0.1 mg/kg</td>
<td>based on 20% of FSANZ TDI, i.e. up to 80% of exposure is assumed to come from other pathways. National Environment Protection (Assessment of Site Contamination) Measure Health Investigation Level -A assumptions with home-grown produce providing up to 10% of fruit and vegetable intake (no poultry), also includes children’s day care centres, preschools and primary schools. Does not include home-grown poultry/egg. While not directly applicable to a Defence Base/Weapons Range, all soil results will be compared to these values as a conservative screening tool.</td>
</tr>
</tbody>
</table>
6.10 Waste Management

6.10.1 Soil

Excess soil cuttings generated during drilling will be stored in drums and transported to a location on-Site and stored for management in accordance with the Environmental Clearance Certificate (ECC).

6.10.2 Groundwater

Groundwater generated during the development and sampling of monitoring wells will be placed in containers, which will be transported to a location on-Site for storage in an Intermediate Bulk Container (IBC) for management in accordance with ECC.

6.11 Sample Nomenclature and Labelling

The following table outlines the sample nomenclature for each type of sample, which is in accordance with the Defence Contamination Directive #7. In general, the identification will be the Base identification number (e.g. 0909), followed by a three digit sample location (e.g. MW001, SW001), followed by the date in YYMMDD format.

Table 17 Sample Nomenclature

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Location (example)</th>
<th>Example ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>MW001</td>
<td>0909_MW001_180814</td>
</tr>
<tr>
<td>Surface Water</td>
<td>SW001</td>
<td>0909_SW001_180814</td>
</tr>
<tr>
<td>Sediment</td>
<td>SD001</td>
<td>0909_SD001_180814</td>
</tr>
<tr>
<td>Soil</td>
<td>MW001</td>
<td>0909_MW001_1.2_180814*</td>
</tr>
</tbody>
</table>

Note: * soil samples collected from monitoring well or borehole locations will additionally have their top of the sampling interval record, i.e.; 0909_MW001_1.2_221087. All borehole locations are to be converted to monitoring wells therefore the use of the borehole (BH) location code should not be required.

It is noted where existing wells are being sampled, alternative names are to be given to these monitoring wells to be compliant with DCD#7.

6.11.1 Quality Assurance / Quality Control Sample Nomenclature

The following table outlines the sample nomenclature for each type of QA/QC sample, which is in accordance with the Defence Contamination Directive #7. In general, the identification will be the Base identification number (e.g. 0902), followed by the QC number (e.g. QC100, QC200), followed by the date in YYMMDD format.

Table 18 QA/QC Sample Nomenclature

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>QC Series</th>
<th>Example ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicate</td>
<td>QC1xx</td>
<td>0909_QC100_180814</td>
</tr>
<tr>
<td>Triplicate</td>
<td>QC2xx</td>
<td>0909_QC200_180814</td>
</tr>
<tr>
<td>Rinsate</td>
<td>QC3xx</td>
<td>0909_QC300_180814</td>
</tr>
</tbody>
</table>

To ensure QA/QC sample information is correctly documented, a QA/QC Sample Register will be used to document:

- Date of sample collection;
- Name of person the sample was collected by;
- QA/QC sample number (e.g. QC100);
- QA/QC sample type (i.e. duplicate, inter-laboratory duplicate, rinsate, trip blank, field blank);
• Parent (or Primary) sample ID;
• Sample matrix (e.g. water or sediment); and
• Analysing laboratory name (e.g. ALS).

6.12 Quality Assurance/Quality Control Sampling

6.12.1 Field Duplicate and Inter-laboratory Duplicate Samples

Intra-laboratory field duplicate samples will be collected at a rate of one per 20 primary samples (or a minimum of one per batch). Inter-laboratory duplicate samples will be collected at a rate of one per 20 primary samples (or a minimum of one per batch).

6.12.2 Rinsate Samples

Rinsate samples are collected to assess the effectiveness of the equipment decontamination methods employed. The rinsate will be analysed for the same suite of analytes as the primary samples.

One rinsate sample will be collected per fieldwork day.

6.13 Fieldwork Documentation

6.13.1 Field Notes

Field notes will be maintained to record all field sampling events and include observations made at each sample location. Field notes will include information specific to the sample media as follows:

• Groundwater Samples – purge rates, volume purged, comments on the observed characteristics of the sample (e.g. colour, turbidity, odour, sheen) and reported field water quality parameters (pH, EC, DO, ORP, temperature) will be recorded at regular intervals;
• Surface Water Samples – comments on the observed characteristics of the sample (e.g. colour, turbidity, odour, sheen) and field water quality parameters (pH, EC, DO, ORP, temperature) will be recorded; and
• Sediment and Soil Samples and soil - comments on the morphology of the sample location, the depth, flow direction and strength of water flow (if water is present), the water and sediment/soil colour and odour, and the presence of flora and fauna. The soil/sediment types observed at each sample location will be described using the Unified Soil Classification System (USCS).

The geo-coordinates for each sample location will be noted. The location of quality control (e.g. duplicate and inter-laboratory duplicate) sample collection points will also be noted.

6.13.2 Sample Labels

Sample containers will be labelled, as a minimum, with the following information:

• AECOM project number;
• Name of sampler;
• Sample ID;
• Date of sample collection; and
• Filtered vs non-filtered (for water samples only).

An indelible felt pen will be used for labelling, to ensure that the lettering is not erased during transit to the laboratory.

6.13.3 Chain of Custody Forms

A CoC form will be completed, documenting the sample identification number and analytes. The CoC documents the chain of events from sample collection to delivery at the laboratory and provides a traceable account of sample handling. The CoC form will be signed by both the sample collector and the receiving laboratory.
The CoC form will include the following information:

- Job number (Note: the name of the site is not identified for confidentiality purposes);
- Date and time of sample collection;
- Sample ID;
- Type of containers;
- Name of sampler;
- Laboratory to be used;
- Analyses required;
- Defence's project ID;
- Esdat email address;
- Defence project manager and project email address;
- Any comments; and
- Signatures of the sampler and laboratory receiver.

In the event that additional samples are collected during the field investigations due to observations made by the Field Team, (i.e. samples not proposed in this SAQP), Defence will be provided the rationale for collection of those samples and proposed laboratory analyses. Defence approval will be sought to include these samples on the CoC and to dispatch these samples to the laboratory.

Upon receipt of the original documents accompanying the samples at the laboratory, the laboratory will provide a sample receipt document (noting the temperature of samples upon receipt, analyses required and any non-conformances) and return the signed CoC form to confirm analyses to be performed and the due date for the analytical results.

6.13.4 Sampling Documentation

Field sampling sheets will be completed for each location, and will include the following information (as appropriate for the media being sampled):

- Name of sampler;
- Sample location;
- Date /time of monitoring/sampling;
- Sampling method;
- Observations of the sampled media (as described in Section 6.13.1); and
- Calibration records.

Records of all equipment calibration will be included in the DSI report.
7.0 References

AECOM 2017, *WLM: Monitoring Well Sample Results – Salt Ash Air Weapons Range*, 16 June 2017 [email]

AECOM, 2018. DRAFT Preliminary Conceptual Site Model – Salt Ash Air Weapons Range – Preliminary Site Investigation. 18 July 2018

ANZECC / NHRMC, 1992. *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.

ANZECC/NHRMC, 2000. *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites*.


Department of Defence, 2018. *PFAS Guidance Documents A through to E – PFAS Investigations and Management (PFASIM), Detailed Site Investigations*. 21 March 2018


GHD 2018 RAAF Base Williamtown and Salt Ash Air Weapons Range Groundwater Monitoring Program – October 2017 Quarterly Monitoring Report, February 2018


Office of Environment and Heritage NSW (OEH) - Draft PFAS Screening Criteria (May 2017)


8.0 Limitations

AECOM Australia Pty Ltd (AECOM) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Department of Defence and only those third parties who have been authorised in writing by AECOM to rely on the report.

The report is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

This report has been prepared by AECOM, an independent consultant engaged by Defence, based on information and sources described in the report. The findings and interpretations set out in the report are based on data gathered by AECOM within the time available, including publicly available information, data reports prepared for the Site and inspection of on-Site and off-Site areas.

The report is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 04 May 2018.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

The methodology adopted and sources of information used by AECOM are outlined in the report.

Where this report indicates that information has been provided to AECOM by third parties, AECOM has made no independent verification of this information unless required as part of the agreed scope of work. AECOM assumes no liability for any inaccuracies in or omissions to that information.

The information in this report is considered to be accurate at the date of issue and is in accordance with conditions at the Site and surrounding areas at the dates sampled. Opinions and recommendations presented herein apply to the Site and surrounding areas existing at the time of our investigation and cannot necessarily apply to changes to Site and surrounding areas of which AECOM is not aware and has not had the opportunity to evaluate. This document and the information contained herein should only be regarded as validly representing the Site and surrounding area conditions at the time of the investigation unless otherwise explicitly stated in a preceding section of this report. AECOM disclaims responsibility for any changes that may have occurred after this time.

Except as required by law, no third party may use or rely on this report, unless otherwise agreed by AECOM in writing. Where such agreement is provided, AECOM will provide a letter of reliance to the agreed third party in the form required by AECOM.

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It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements.
Appendix A

Figures
Appendix A  Figures
POTENTIAL PFAS SOURCE ZONES

Preli
m
i
nary Site Investigation
SAQP Salt Ash Air Weapons Range
23 August 2018

FIGURE 3
Tilligerry State Conservation Area
Moffatts Swamp Nature Reserve
Salt Ash Air Weapons Range

FIGURE 5

HISTORICAL PFAS RESULTS
Preiliminary Site Investigation SAQP
Salt Ash Air Weapons Range
23 August 2018
Appendix B

Sample Location Rationale
Appendix B  Sample Location Rationale
<table>
<thead>
<tr>
<th>Location ID</th>
<th>Drilling Method</th>
<th>Aquifer</th>
<th>Anticipated Target Depth</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| MW001S      | Geoprobe        | Tomago  | 3-5 m                    | Location: Adjacent the entry road to the SAAWR.  
**Purpose:** This location is intended to enable the collection of representative groundwater samples of the Tomago Aquifer, down hydraulic gradient (where groundwater is expected to be travelling in a south east direction) of the potential source areas and known historical contamination detections (MB8).  
**Pathway:** Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
| MW001D      | Tomago          | 20 m    |                          | Location: Adjacent the entry road to the SAAWR.  
**Purpose:** This location is intended to enable the collection of representative groundwater samples of the Tomago Aquifer, down hydraulic gradient (where groundwater is expected to be travelling in a south east direction) of the Target Area and known historical contamination detections (MB8).  
**Pathway:** Vertical migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
<table>
<thead>
<tr>
<th>Location ID</th>
<th>Drilling Method</th>
<th>Aquifer</th>
<th>Anticipated Target Depth</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| MW002       |                 | Tomago  | 3-5 m                    | **Location:** Close to the southern boundary of the Site.  
**Purpose:** This location is intended to enable the collection of representative groundwater samples of the Tomago Aquifer, down hydraulic gradient (where groundwater is expected to be travelling in a south east direction) of the Target Area, MB8 and MW001S/D. This location may additionally provide insight into interactions of groundwater with Moffatts Creek and groundwater conditions leaving the Site.  
**Pathway:** Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion.  
Infiltration of PFAS impacted surface water from surface water bodies.  
Potential upward flow of PFAS impacted groundwater into creeks and swamps |
| MW003       |                 | Tomago  | 3-5 m                    | **Location:** Within the western portion of Target Area.  
**Purpose:** This location is intended to provide representative samples of the Tomago Aquifer and combined with existing locations provide information on groundwater conditions within the Target Area.  
**Pathway:** Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
<table>
<thead>
<tr>
<th>Location ID</th>
<th>Drilling Method</th>
<th>Aquifer</th>
<th>Anticipated Target Depth</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| MW004       |                 | Tomago                   | 3-5 m                    | **Location:** Western Site Boundary  
**Purpose:** Located up hydraulic gradient of the Target Area, this location is intended to provide representative samples of the Tomago Aquifer and provide information on groundwater conditions entering the Site. Based on review of the topography and surface geology, this location is also interpreted to be down gradient of the Medowie Waste Treatment Works.  
**Pathway:** Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
| MW005       |                 | Mulbring Siltstone or Tomago | 3-5 m                    | **Location:** Western Site Boundary  
**Purpose:** Located up hydraulic gradient of the Target Area, adjacent the Site boundary, this location, though potentially located in the Mulbring Siltstone, is intended to provide representative samples of the groundwater conditions entering the Site. This location is also interpreted to be down gradient of the Medowie Waste Treatment Works.  
**Pathway:** Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
| MW006       |                 | Tomago                   | 3-5 m                    | **Location:** Eastern Site Boundary  
**Purpose:** Located down hydraulic gradient (where groundwater is expected to be travelling) of MB6 in a north easterly direction, this location is intended to provide representative samples of the Tomago Aquifer adjacent to the Site boundary. This location will provide information on the groundwater conditions leaving the Site  
**Pathway:** Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
<table>
<thead>
<tr>
<th>Location ID</th>
<th>Drilling Method</th>
<th>Aquifer</th>
<th>Anticipated Target Depth</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| MW007       |                 | Tomago   | 3-5 m                    | **Location**: Western Site Boundary  
**Purpose**: Located up hydraulic gradient of the Target Area, adjacent the Site boundary, this location is intended to provide representative samples of the Tomago Aquifer and provide information on the groundwater conditions entering the Site.  
**Pathway**: Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
| MW008       |                 | Tomago   | 3-5 m                    | **Location**: Eastern Site Boundary  
**Purpose**: Located down gradient of MB8 (location with highest reported historical results) and cross gradient of HWC PS14 (historical PFAS detection), this location is intended to provide representative samples of the Tomago Aquifer adjacent to the Site boundary. This location will provide information on the groundwater conditions leaving the Site.  
**Pathway**: Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
| MW009       |                 | Tomago   | 3-5 m                    | **Location**: Eastern Site Boundary  
**Purpose**: Located down gradient of MB8 (location with highest reported historical results) and HWC PS14 (historical PFAS detection), The purpose of this location is to enable collection of representative groundwater samples of the Tomago Sandbeds, further down gradient (where groundwater is expected to be travelling in a south east direction) of the potential source areas and known historical contamination detections (MB8 and PS14) to assist in determining groundwater conditions leaving the Site.  
**Pathway**: Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion. |
<table>
<thead>
<tr>
<th>Location ID</th>
<th>Drilling Method</th>
<th>Aquifer</th>
<th>Anticipated Target Depth</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>SK3493</td>
<td>HWC existing infrastructure</td>
<td>Tomago</td>
<td>5m</td>
<td><strong>Purpose:</strong> Existing location with no PFAS data, located close to the Site boundary, this location is intended to provide representative groundwater samples of the Tomago Aquifer and provide information on groundwater conditions leaving the Site. <strong>Pathway:</strong> Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion.</td>
</tr>
<tr>
<td>PS14</td>
<td>HWC existing infrastructure</td>
<td>Tomago</td>
<td>10m</td>
<td><strong>Purpose:</strong> Location of Historical PFAS detection, re-test to evaluate any change in conditions. <strong>Pathway:</strong> Lateral migration of PFAS impacted groundwater under the influence of groundwater flow and PFAS dispersion.</td>
</tr>
</tbody>
</table>
### Table T 2: Co-located Surface Water and Sediment Location Rationale

<table>
<thead>
<tr>
<th>Sample/Location ID</th>
<th>Location</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW001/SD001</td>
<td>Moffats Creek</td>
<td>Assess surface water and sediment conditions of surface water flowing onto the Site</td>
</tr>
<tr>
<td>SW002/SD002</td>
<td></td>
<td>Assess surface water and sediment conditions adjacent to PS14 before discharging off Site</td>
</tr>
<tr>
<td>SW003/SD003</td>
<td>Moffats Swamp / Racecourse Swamp</td>
<td>Assess surface water and sediment conditions coming onto the Site.</td>
</tr>
<tr>
<td>SW004/SD004</td>
<td>Racecourse Swamp</td>
<td>Assess surface water and sediment conditions within Racecourse Swamp, down gradient of the Target Area. Intended to identify if there is any change in concentrations as water passes the Target Area.</td>
</tr>
<tr>
<td>SW005/SD005</td>
<td>Moffats Creek</td>
<td>Assess surface water and sediment conditions adjacent the off Site discharge point.</td>
</tr>
<tr>
<td>SW006/SD006</td>
<td>Saltwater Creek</td>
<td>Assess surface water and sediment conditions within the estuarine setting of Saltwater Creek.</td>
</tr>
<tr>
<td>SW007/SD007</td>
<td>Racecourse Swamp</td>
<td>Assess surface water and sediment conditions within Racecourse Swamp, down gradient of the Target Area. Intended to identify if there is any change in concentrations down gradient of the Target Area.</td>
</tr>
<tr>
<td>SW008/SD008</td>
<td>Racecourse Swamp</td>
<td>Assess surface water and sediment conditions within Racecourse Swamp, down gradient of the Target Area. Intended to identify if there is any change in concentrations at the interface of saltwater and fresh water boundaries.</td>
</tr>
<tr>
<td>SW009/SD009</td>
<td>Target Area</td>
<td>Assess standing water and sediment if present on the Target Area. If standing water contains PFAS it would be a line of evidence to include in updated CSM that AFFF may have historically been applied to surface of the Target Area.</td>
</tr>
<tr>
<td>SW0010/SD0010</td>
<td>Target Area</td>
<td>Assess standing water and sediment if present on the Target Area. If standing water contains PFAS it would be a line of evidence to include in updated CSM that AFFF may have historically been applied to surface of the Target Area.</td>
</tr>
<tr>
<td>SW0011</td>
<td>Tilligerry Creek</td>
<td>Assess surface water conditions of</td>
</tr>
<tr>
<td>Sample/Location ID</td>
<td>Location</td>
<td>Rationale</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SW0012</td>
<td>Moffats Swamp / Racecourse Swamp</td>
<td>Assess surface water conditions as surface water passes the Target Area.</td>
</tr>
<tr>
<td>SW0013</td>
<td>12 Mile Creek</td>
<td>Background Sample</td>
</tr>
<tr>
<td>SW0014</td>
<td>Moffats SwampSAQP</td>
<td>Sample to be collected if a publicly accessible location can be found. SW0014 is not shown of Figure 9 or 9A in Appendix A. This location is intended to assess surface water conditions down gradient of Medowie Waste Treatment Works.</td>
</tr>
</tbody>
</table>
Appendix C

Standard Operating Procedures
1.0 Purpose and Scope

1.1 The purpose of this procedure is to ensure that manual tasks are eliminated or minimised so far as is reasonably practicable. If the manual task is required then it should be conducted in a manner that prevents injury or adverse health effects to employees and subcontractors.

1.2 This procedure is applicable for all Australia New Zealand (ANZ) employees and subcontractors, and covers the requirements associated with the identification, assessment and control of risks arising from manual tasks.

2.0 Terms and Definitions

2.1 Hazardous Manual Task - Any task in which forces are exerted, loads handled, repetitive movement, awkward postures, sustained postures and equipment and tools that expose workers to vibration.

2.2 Manual Handling - Defined as any activity requiring a person to use force to lift, lower, push, carry, hold or restrain an animate or inanimate object.

2.3 Musculoskeletal Disorders (MSD) - Include a wide range of inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels. Examples of disorders arising out of work include carpal tunnel syndrome, vibration white finger, sciatica as well as musculo-ligamentous strains, sprains and tears. Musculoskeletal disorders may result from an acute one off event or exposure over a period of time to physical and psychosocial factors that are present in the work environment or are otherwise encountered in the course of conducting work.

2.4 Whole Body Vibration - Shaking of the body as a whole unit in the vertical plane (up & down), transverse plane (side to side) or the linear plane (back & forth).

2.5 Hand-arm vibration - The oscillation of the hand and arm by the operation of hand-held equipment that has either oscillating parts or unbalanced rotating parts.

2.6 Vibration White Finger - This is a condition in which the smallest arteries that bring blood to the fingers or toes constrict (go into spasm) when exposed to cold and/or working with vibrating machinery. The result is that the fingers become pale, cold and numb. The potential for this type of disorder is increased when working at reduced temperatures.

3.0 References

3.1 Hazard Recognition and Risk Assessment S3AN-700-PR1

4.0 Procedure

4.1 Hazard Identification - Managers will identify and assess all manual tasks of a hazardous nature performed in the work environments using the Hazardous Manual Tasks Checklist S4AN-761-FM1. Where a manual handling risk is assessed as posing a significant risk, specific controls must be implemented to eliminate or minimise the associated risks. The Manager/Supervisor in conjunction with workplace employees shall record manual handling tasks using the hazard identification process.

4.2 Load Weight for Manual Handling Tasks

4.2.1 Figure 1, below, shows 9 lifting zones in relation to the human body with the risk varying from extreme and high to moderate. The illustration assumes that the object can be carried close to the body. Any object which is held away from the body should be considered an extreme risk and the maximum weight reduced accordingly.

4.2.2 Personnel are not to lift objects beyond their physical capacity. Manual handling tasks should be carried out while operating within the moderate risk area as shown below. Higher
risks will be experienced if moving the object into the other zones or moving across multiple zones as outlined in the diagram. If manual handling of an object is required from the high and extreme zones, the weight must be reduced at least by ½ and a ¾ respectively as compared to an acceptable load within the moderate zone.

Figure 1  Load Weight

4.3 Heavy Load Marking

Loads which are above 20kg should be marked with “Heavy Load” tag or sticker. Standard loads should have their weight marked in a visible location, wherever possible.

4.4 Vibration – Hand-arm vibration

- Wear suitable vibration dampening gloves where possible or applicable
- Maintain body warmth
- Limit the amount of time (hours per day and days per week) vibrating tools are used.
- Take a 10 minute break for every hour spent working with a vibrating tool
- Alternate work with vibrating and non-vibrating tools.
- Let the tool do the work. Use as light a grip as possible to keep the tool under control. A tight grip restricts blood flow in the hands and fingers and allows more vibration to pass from the tool to the body.
- Maintain tools in accordance with manufacturers’ direction. Tools that are worn, blunt or misaligned vibrate more.
- Limit cigarettes as nicotine reduces the peripheral blood flow.

4.5 Health impacts and monitoring of vibration - Medical examinations shall be conducted where persons are considered for segmental vibration exposures (where the person is expected to encounter exposure of the upper limbs to vibratory motion within the frequencies of 5Hz to 1500 Hz at suspected weighted at or above 2.9 m/s²).

5.0 Training

5.1 Training will be provided on the correct use of equipment that presents a risk of vibration based on the outcomes of the associated risk assessment.
6.0 Records

6.1 Hazardous Manual Tasks Checklist S4AN-761-FM1

6.2 Associated Medical Examination Results: Maintain for 30 years after date of last entry.
1.0 Purpose
This procedure describes the methods for collecting direct or representative surface water samples from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface. If followed properly, use of this procedure will promote consistency in each of the above areas and ensure regulatory compliance across Australia and New Zealand where best practice guidelines have been developed.

2.0 Scope
The following samplers and sampling techniques result in the collection of representative samples from the majority of surface waters and impoundments encountered.
- Kemmerer bottle
- Van Dorn sampler
- Bacon bomb sampler
- Dip Sampler
- Direct method

3.0 Health and Safety
3.1 Health and Safety Plan and Site Specific Safe Work Method Statements (SWMS) should be prepared prior to field work in accordance with the SWMS Development Procedure and in the Project Specific Health and Safety Plan Template.

3.2 When sampling from water bodies, physical hazards must be identified and adequate precautions must be taken to ensure the safety of the sampling team. The team member collecting the samples should stay away from the edge of the water body, where bank failure may cause loss of balance. When collecting samples near the edge of water bodies, personnel should wear a lifeline or use a buddy system for added safety. All sampling personnel must wear personal flotation devices (life vests). If sampling from a boat, appropriate protective measures must be identified and implemented in accordance with reviewed and approved Health and Safety Plans and Site Specific Safe Work Method Statements (SWMS).

4.0 Terms and Definitions
**Morphometry**: The measurement of the form characteristics, including area depth, length, width, volume, bottom gradients, of a surface water body.

**Impoundments**: A body of water formed by the collection or confinement of water, as if in a reservoir.

**Boat wake**: The visible track of turbulence left by a boat moving through water.

**Substrate**: Stream substrate (sediment) is the material that rests at the bottom of a stream, including mud (silt and clay), sand, granules, pebbles, cobbles and boulders.

5.0 References
5.1 SWMS Development Procedure S4AN-701-PR1
5.2 Project Specific Health and Safety Plan Template S4AN-702-TP1
6.0 Equipment

Equipment needed for collection of surface water samples may include (depending on the chosen technique):

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kemmerer bottles</td>
<td>Field data sheets</td>
</tr>
<tr>
<td>Van Dorn sampler</td>
<td>Decontamination equipment / supplies</td>
</tr>
<tr>
<td>Bacon bomb sampler</td>
<td>Maps / plot plan</td>
</tr>
<tr>
<td>Dip sampler</td>
<td>Safety equipment</td>
</tr>
<tr>
<td>Line and messengers</td>
<td>GPS</td>
</tr>
<tr>
<td>Peristaltic pump</td>
<td>Tape measurer</td>
</tr>
<tr>
<td>Tygon tubing</td>
<td>Camera</td>
</tr>
<tr>
<td>0.45 micron filters</td>
<td>Logbook</td>
</tr>
<tr>
<td>Sample bottles / preservatives</td>
<td>Personal protective equipment (including personal flotation devices, as needed)</td>
</tr>
<tr>
<td>Water quality meter including calibration fluids</td>
<td>Ice</td>
</tr>
<tr>
<td>Chain of custody records, custody seals</td>
<td>Eskies, packing material</td>
</tr>
<tr>
<td>Long water quality cables may be required if stratification is being measured</td>
<td></td>
</tr>
</tbody>
</table>

7.0 Best Practice Guidelines

A number of guidelines have been developed across the ANZ region outlining best practice methods for surface water sampling. Consideration of these must be made when designing and implementing surface water sampling within the ANZ region. Key documents noted include those detailed in Table 2 below:

<table>
<thead>
<tr>
<th>Level</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>National / Federal</td>
<td>ANZ Standard 5667.1:1998 Part 1: Guidance on the design of sampling programmes, sampling techniques and the preservation and handling of samples</td>
</tr>
<tr>
<td></td>
<td>ANZ Standard 5667.6.1998 Part 6: Guidance on sampling rivers and streams</td>
</tr>
</tbody>
</table>

It should also be noted that specific guidance documents or advisory notes for surface water sampling may also exist across ANZ and state to state for specific industries. For instance in the Northern Territories (NT) the Department of Mines and Energy have provided an advisory note outlining good practice for sampling of surface waters at mine sites in the NT.

8.0 Procedure

8.1 Planning

The extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed should be outlines in the project-specific sampling plan. Sampling and monitoring equipment should be properly decontaminated prior to initial use, between sampling locations, and following completion of the sampling event. General locations for sampling should be marked or identified on a site map with a geo-reference to landmarks/topography, GPS coordinates or measured from a fixed feature. If required, the proposed locations may be adjusted based on site
access, property boundaries, and obstructions. Final sample locations should be documented using topographic maps/site plans or a GPS unit to identify and record sample location coordinates.

8.2 Sampling Considerations

In order to collect a representative sample, the hydrology and morphometry of a stream, river, pond, lake or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths. Water quality data should be collected in ponds, lakes and impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, conductivity, oxidation-potential, temperature and turbidity can indicate if strata exist that would affect analytical results. Measurements should be collected at one-meter intervals from the surface to the bottom using the appropriate instrument.

These water quality measurements can assist in the interpretation of analytical data, and the selection of sampling sites and depths when surface water samples are collected. Factors that contribute to the selection of a sampling device used for sampling surface waters in streams, rivers, lakes, ponds, lagoons, and surface impoundments include:

- width, depth, flow and accessibility of the location being sampled; and,
- whether the sample will be collected onshore or offshore.

The appropriate sampling device must be of a proper composition. Selection of samplers constructed of glass, stainless steel, polyvinyl chloride (PVC) or PTFE (Teflon®) should be based upon the suspected contaminants and the analyses to be performed.

8.3 Sample Collection

8.3.1 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples directly into the sample container(s). Health and safety considerations must be addressed when sampling lagoons or other impoundments where specific conditions may exist that warrant the use of additional safety equipment. Using adequate protective clothing, access the sampling station by appropriate means.

For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream; the container must be upstream of the collector. When possible, collect samples in a downstream to upstream direction and avoid disturbing the substrate beneath the water.

For lakes and other impoundments, collect the sample under the water surface (10 to 20 cm) while avoiding surface debris or boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation. Use a non preserved bottle, rinse it three times with the surface water, collect the sample, then transfer the surface water to the appropriately preserved bottles. Details of suitable preservatives and bottles

8.3.2 Kemmerer Bottles
A Kemmerer bottle may be used in most situations where site access is from a boat or structure, such as a bridge or pier, and where samples at specific depths are required. Sampling procedures are as follows:

- **a)** Use a properly decontaminated Kemmerer bottle. Set the sampling device so that the upper and lower stoppers are pulled away from the body, allowing the surface water to enter tube.
- **b)** Lower the pre-set sampling device to the predetermined depth. Avoid disturbance of the bottom.
- **c)** When the Kemmerer bottle is at the required depth, send the weighted messenger down the suspension line, closing the sampling device.
- **d)** Retrieve the sampler and discharge the first 10-20 milliliters (mL) from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

**8.3.3 Van Dorn Sampler**

A Van Dorn sampler is used to collect a surface water sample from a specific sampling depth or from a shallow water body. Since the sampler is suspended horizontally, the depth interval sampled is the diameter of the sampling tube. The sampling procedure is as follows:

- **a)** Use a properly decontaminated Van Dorn sampler. Set the device so that the end stoppers are pulled away from the body allowing surface water to enter the tube.
- **b)** Lower the pre-set sampling device to the predetermined depth. Avoid disturbance of the bottom.
- **c)** When the Van Dorn is at the required depth, send the weighted messenger down the suspension line, closing the sampling device.
- **d)** Retrieve the sampler and discharge the first 10-20 mL from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

**8.3.4 Bacon Bomb Sampler**

A bacon bomb sampler may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

- **a)** Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut. This will allow the sampler to fill.
- **b)** Release the trigger line and retrieve the sampler.
- **c)** Discharge the first 10-20 mL from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements.

**8.3.5 Dip Sampler**
A dip sampler is useful in situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

a) Assemble the device following manufacturer's instructions.
b) Collect the sample by dipping the sampler into the water.
c) Transfer the sample to the appropriate sample container(s).

8.4 Sample Preservation, Containers, Handling and Storage

Once samples have been collected, the following procedures should be followed:

- Transfer the sample(s) into suitable, labelled sample containers specific for the analyses to be performed.
- Measure field parameters with a calibrated water quality meter.
- Filter the sample on site if required (for example, as is required for dissolved metals analysis).
- Preserve the sample, if appropriate. Do not overfill bottles if they are pre-preserved.
- Cap the container securely, place in a resealable plastic bag, and cool to 4°C.
- Record all pertinent data in the site logbook and/or on field data sheets.
- Complete the Chain of Custody record.
- Attach custody seals to esky prior to shipment.
- Decontaminate all non-dedicated sampling equipment prior to the collection of additional samples.

9.0 Records

The following records will be maintained:

9.1 sample collection records, including a record of the surface water sampling locations on a site map with a geo-reference to landmarks/topography, GPS coordinates, or measured from a fixed feature;

9.2 field notebook;

9.3 chain-of-custody forms; and,

9.4 shipping receipts.

All documentation will be placed in the project files and retained following completion of the project.
1.0 Purpose and Scope

The purpose of this Field Instruction is to provide guidance on the methodology and considerations necessary to facilitate the collection of accurate and representative shallow sediment material samples (less than 0.25 mbgs) from the intertidal zone or shallow water bodies. Laboratory analysis of the collected samples may be used to assess the potential presence of chemicals of potential concern (COPC) or provide characterisation of sediment conditions.

This Field Instruction describes a suitable methodology for the collection of shallow sediment material samples. Shallow sediment material is defined as being currently or formerly located beneath a body of water. This Field Instruction is limited to the collection of samples within the intertidal zone or in bodies of water shallow enough for the sampler to wade into using hand held sampling devices. It does not include the sampling of sediments from boats, platforms or other watercraft.

2.0 References


b. AS5667.12-1999 Water quality - Sampling - Guidance on sampling of bottom sediments

c. ANZECC and National Health and Medical Research Council (NHMRC) (January, 1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites


g. Soil Logging and Classification Q4AN(EV)-113-PR1.

h. Sediment Sampling Record Q4AN(EV)-301-FM1.

3.0 Responsibilities

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this Field Instruction. To ensure equipment is in good working order prior to use; that equipment is maintained according to supplier’s advice and is appropriately calibrated or verified. Any faults shall be reported to the Project Manager (PM) or the equipment supplier as soon as they are identified.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>The PM is responsible for ensuring fit for purpose equipment and in developing work scope and services to be delivered to a client within the designated timeline. The PM should check (or designate another to check) to see if borings have been undertaken at or in the vicinity of the Site in the past and to check applicable geological maps.</td>
</tr>
<tr>
<td>Office HSE Advisor</td>
<td>The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving HSE Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, and investigating reports of incidents or accidents.</td>
</tr>
</tbody>
</table>
4.0 Equipment and Materials

4.1 Equipment

One or more of the following sediment collection tools may be used to collect shallow sediment samples:
- Van Veen Grab Sampler (small) and rope;
- Stainless steel or plastic trowel; and
- Stainless steel or plastic container.

4.2 Materials

Materials and consumables that may be required to complete this task include:
- Sample jars and bottles;
- Scrubbing brush;
- Phosphate free detergent (e.g. Decon 90);
- Deionised water and spray bottle;
- Potable water;
- Paper towel;
- Waste disposal containers/drums;
- Esry;
- Ice;
- Sediment description logs (water proof paper);
- Permanent Marker Pens;
- Pencils;
- Digital Camera; and
- Snap Lock Bags.

Note that the use of chrome plated instruments should be avoided, particularly with respect to the trowel, spatula and containers.

5.0 Background

This section provides context to the Field Instruction and highlights limitations in the procedure or equipment.

Disturbance of sediments during the collection process may significantly impact the chemistry of the samples. Therefore, the following precautionary measures should be observed to limit any potential effects:
- Samples should be transferred to the sample jars as soon as possible, prolonged exposure of the sample may result in the loss of Volatile Organic Compounds (VOCs) and changes in the sample chemistry.
- Elimination of headspace from the sample containers to limit the loss of VOCs during storage and transport of samples.
- When sampling from a moving water body, approach from downstream and sample upstream of your location to limit any disturbed sediments from flowing into the sample area.
- Sample requirements may vary depending upon the analytical suite and the nature of the analysis, it is important to check the laboratory sample requirements to ensure sufficient material is collected. Consideration of storing on ice or freezing samples should be made depending on analytical suite and holding time requirements.

6.0 Fieldwork Instruction

(PRINT THIS SECTION FOR USE IN THE FIELD)

Any variations to this Fieldwork Instruction that are required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

6.1 General

Work surfaces should be covered with clean plastic sheeting. When sampling, contact with zinc anodes, surfaces coated with antifouling paint, metal-containing sunscreens or engine exhausts must be rigorously avoided. Disposable nitrile gloves should be used and changed after each sample and disposed of into a designated consumable waste drum.
6.2 Decontamination

Any equipment that is to be used between sample locations (such as Van Veen grab or trowel) shall be decontaminated prior to use and between each sample location in accordance with the following procedure.

1. Remove excess dirt with a scrubbing brush prior to decontamination, disposing of any sediment into a waste disposal drum.
2. Wipe the surfaces of the equipment using a paper towel and dispose into a contaminated waste bag.
3. Wash the equipment using a plastic scrubbing brush in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).
4. Rinse the equipment with potable water.

6.3 Procedure

This step provides the methodology for the sampling of shallow sediments (up to 0.25 mbgs).

1. Wherever possible, commence sampling from areas of least impact to greatest impact (if known) so as to reduce the effect of any potential cross-contamination that may occur between sample locations.
2. If the sample is to be collected directly into the laboratory sample jar than be sure to label the container prior to use given it is likely to become wet when scooping material.
3. When sampling from beneath shallow water, approach the sample location from downstream and collect the sample by lowering the Van Veen grab or by scooping the trowel from the sediment bed in an upstream direction.
4. While sampling, attempts should be made to collect the sediment sample in as undisturbed state as possible so as to minimise any potential changes in sample chemistry. Carefully transfer the sediment sample to the sample jar(s) as soon as possible to reduce the likelihood of VOC loss. If a duplicate or triplicate sample is being taken, sediment material should be distributed between each sample jar evenly to reduce any inconsistencies between samples associated with sample heterogeneity. Where VOC are not included in the analytical suite, the sample may be homogenised in a stainless steel or plastic container prior to being distributed into the sample containers.
5. A description of the sediment profile should be logged at each sample location. All sediment types, changes in colour or texture, evidence of impacts, presence of shell and/or organic material, depths, odours, depth to sediment beneath water if applicable should be recorded on the sediment log. Please refer to Q4AN(EV)-113-PR1 for further information as to the minimum requirements for information to be logged.
6. Sediment samples should be immediately sealed and labelled then packed appropriately in an esky containing ice or ice bricks (or frozen), for delivery to the laboratory. A copy of the Chain of Custody (COC) should be placed in a snap lock bag and put inside the esky prior to sealing the esky. Ensure the lids of the jars are sealed tight to prevent the ingress of any water associated with melting of the ice, consider placing the jars in individual snap lock bags.
7. Care should be taken not to overfill the esky with samples as the samples will not cool sufficiently for analysis. A security seal should be attached to the esky together with the sampler’s details including a job number, date sampled, sampler and phone number and details of any short holding times.
8. Excess sediment should be disposed of in the appropriate manner depending on the level of contamination. Contaminated wastes should be collected in waste drums or skips and removed from site by a licensed waste contractor. Ensure the waste drums are appropriately labelled, sealed and placed in a secure area.

7.0 Troubleshooting

The following troubleshooting guide has been prepared for some common problems encountered during the sampling of sediment. The equipment manufacturer’s user guide should always been available in the field and referred to as necessary.

Fine sediments may be difficult to collect from beneath the water using a trowel. Consideration should be given to the use of a coring device or other sampling devices to ensure the collection of a representative sample.
The decision tree for equipment selection shown in Figure 1 can provide some assistance.

Review the sample locations and the conditions at the Site

Are samples being collected from the intertidal zone?

Yes

No

Does the depth of the water body allow for the manual collection of samples?

Yes

Is the sediment to be collected likely to be consolidated rather than light, fine and mobile?

No

Core samplers should be considered

No

Use of trowel or scoop is likely to be suitable for the purpose of sample collection

Yes

Consideration should be given to alternative sampling methodologies

Figure 1 Decision tree for selection of equipment

8.0 Revision History

<table>
<thead>
<tr>
<th>Revision date</th>
<th>Affected sections</th>
<th>Description of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2, 2016</td>
<td>All</td>
<td>Conversion to AECOM Australia Pty ltd.</td>
</tr>
</tbody>
</table>
1.0 Purpose and Scope

The purpose of this Fieldwork Instruction (FI) is to introduce to AECOM field staff how to obtain accurate and representative measurements of standing water levels (SWL) in groundwater monitoring wells. This FI describes the methodology for gauging relative groundwater levels in groundwater monitoring wells. This applies to the use of electronic dip meters or interface probes for the measurement of groundwater levels only. This document does not provide instructions for the measurement of light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquid (DNAPL) in monitoring wells. Refer to for NAPL gauging instructions Q4AN(EV)-414-PR1.

2.0 References


d. Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1.

e. Lower Explosive Limit (LEL) Monitor Q4AN(EV)-004-PR1.

f. NAPL and Groundwater Level Gauging Q4AN(EV)-414-PR1.

g. PID Daily Calibration Record Q4AN(EV)-003-FM1.

h. NAPL and Groundwater Level Gauging Record Q4AN(EV)-414-FM1.

3.0 Responsibilities

<table>
<thead>
<tr>
<th>Role</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Fieldwork Staff</td>
<td>To apply the methodology detailed in this FI. To ensure equipment is in good working order prior to use and is maintained according to supplier’s advice. Report all anomalies to the Project Manager or the equipment supplier as soon as they are identified. Maintain accurate fieldwork data and observation records and provide to the Project Manager for review and filing in the project central file.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Define the task objectives and provide all relevant information to field staff prior to mobilisation into the field. The Project Manager should check (or designate another to check) the gauging data recorded by the fieldwork staff for anomalies such as measurements inconsistent with historical groundwater level fluctuations or well construction records.</td>
</tr>
<tr>
<td>Office HSE Advisor</td>
<td>The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving Health, Safety and Environment (HSE) Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, investigating reports of incidents or accidents and approving drilling contractors to undertake the proposed works.</td>
</tr>
</tbody>
</table>

4.0 Equipment and Materials

4.1 Equipment

Equipment required to complete this task include:

- Electronic dip meter; or
- Oil/water interface probe.

Optional or supplemental equipment may include a Photo-Ionisation Detector (PID) and Lower Explosive Limit (LEL) Monitor.
4.1.1 Electronic Dip Meter

An electronic dip meter is suitable for the measurement of groundwater levels only. Where NAPL is expected or suspected to be present in groundwater wells an oil/water interface meter should be used. A short beeping sound is made when the electronic dip meter intersects the standing water level.

4.1.2 Oil/Water Interface Meter

The oil/water interface probe should be used where LNAPL or DNAPL are expected or suspected to be present in the wells. The probe emits two different sounds for distinguishing the depth to NAPL (continuous tone) and the standing water level (short beeping). In the case of LNAPL, the continuous tone will occur typically before the beeping tone; with DNAPL, the continuous tone would occur towards the base of the well, after the beeping tone.

4.1.3 Photo Ionisation Detector (PID)

Refer to Photo-Ionisation Detector (PID) Q4AN(EV)-003-PR1, for applicability, operation and calibration of a PID.

4.1.4 Lower Explosive Limit (LEL) Monitor

Refer to Lower Explosive Limit (LEL) Monitor Q4AN(EV)-004-PR1 for applicability, operation and calibration of a LEL.

4.2 Materials

Materials and consumables that may be required to complete this task include:

- Buckets;
- Potable water;
- Phosphate free detergent (e.g. Decon 90);
- Scrubbing brush;
- Cable ties;
- Contaminated waste bags;
- AB(E) fire extinguishers;
- Oil/fuel spill kit;
- Spare batteries; and
- Liquid contaminated waste container (IBC);
- Paper towel;
- Alcohol wipes;
- Allen key set;
- Tools for opening well covers;
- Spare O-rings and hex bolts;
- Bailers for confirming presence of NAPL;
- Twine;
- Steel measuring tape;
- Contaminated waste bags; - Bailers for confirming presence of NAPL;
- AB(E) fire extinguishers; - Steel measuring tape;
- Liquid contaminated waste container (IBC);

5.0 Background

Accurate and reliable groundwater level measurements are essential in determining the hydraulic head, hydraulic gradients (vertical or along the water table), and the likely direction for groundwater flow and contaminant transport at a site. Before commencing a groundwater gauging round, some important factors should be considered, including:

- The groundwater level may take some time to stabilise after installation and development of new wells.
- Groundwater levels fluctuate naturally (e.g. rainfall infiltration and tidal influences) and anthropogenically (e.g. pumping and irrigation), therefore groundwater gauging of a site should be completed in as short a time as possible. If a site is influenced by tidal variations, gauging should ideally be completed within a single tidal stage.
- Effervescent groundwater such as in mineral spring areas or at landfills may cause difficulties in acquiring accurate gauging results.
- Highly saline groundwater can cause the alarm of a dip meter or oil/water interface probe to sound even when the probe is lifted out of the water in the well. This usually occurs if the probe has been initially lowered below the water level in the well. The probe may need to be washed, dried and the water level re-measured.
- Highly turbid wells and highly saline groundwater can cause the continuous tone of an oil-water interface meter to sound even when NAPL is absent. If the occurrence of NAPL is unlikely or new, its presence should be checked using a new dedicated disposable bailer or by looking for evidence of oils/fuel on the tape of the meter.
- Electronic dip meters and oil/water interface probes have co-axial conductive wires within a graduated plastic tape. A damaged tape may result in stretching of the graduations and inaccurate measurements. The tape should be calibrated for length against a steel tape prior to use and markings should be checked for legibility, if these are not hire equipment.
6.0 Fieldwork Instruction

(Print this section for use in the field)

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

An explosive atmosphere may be present in the vicinity of an open monitoring well due to vapours emanating from a well with LNAPL floating on groundwater. Refer to the project Health, Safety and Environment Plan (HSEP) for specific controls to manage the potential acute safety hazard.

6.1 Decontamination

The measurement equipment (dip meter/interface probe) shall be decontaminated prior to use and between measuring each monitoring well by the following procedure.

1. Wipe the probe and measuring tape (the length that comes into contact with groundwater) using disposable alcohol wipes. Dispose of the alcohol wipes into a contaminated waste bag.
2. Wash the probe and measuring tape (the length that comes into contact with groundwater) using a disposable wipe or paper towel in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).
3. Rinse the probe and washed section of the measuring tape with potable water over another bucket and collect the rinse water for later disposal as contaminated waste.
4. The wash solution needs to be renewed when the decontamination process becomes ineffective, e.g. product remains on the probe after rinsing or sheen is present in the wash solution buckets.

6.2 Calibration

Check the length of the probe and measuring tape of the electronic dip meter/oil/water interface probe in the field against a steel measuring tape to ensure that the tape has not been stretched through use. The length of tape to be checked is dependent upon the depth of groundwater level or the depth to the base of well to be gauged. The tape length should match the steel measuring tape length. Record this ‘calibration’ in field notes.

6.3 Groundwater Level Gauging

This section provides the methodology for the measurement of groundwater levels only. For the measurement of NAPL levels and thickness refer to Q4AN(EV)-414-PR1.

Groundwater level gauging should be undertaken on all wells as quickly as possible and before groundwater sampling is started. Wells should be gauged in sequence from clean to contaminated wells. Plate 1 below shows a typical flush fitted gatic cover for a groundwater monitoring well.

Plate 1 Flush fitted gatic cover for a groundwater monitoring well

1. Open the monitoring well cover by (a) unlocking the flush mount well gatic with an Allen key (typically 7 mm) or (b) lifting the hinge lid on the monument/stick up well cover or (c) removing the lid on any other well cover as required (e.g. quarter turn well covers). Remove padlocks if present.
Monitoring well covers can cut/injure hands. Use cut resistant gloves to open well covers.

Biological hazards (e.g. spiders, ants) may be present within gatic covers, exercise caution when opening wells. Wear gloves and remove cobwebs before placing hands into the well.

2. Remove the well cap (e.g. J-plug), PVC end cap, torque cap from an upwind direction. Do not stand directly over well when removing cap.

Plate 2 Well cap with vegetation growth and sediment

High concentrations of hydrocarbon vapours can build up in the well and be released into the breathing zone when the well cap is removed. Implement appropriate work space monitoring (e.g. LEL, PID, colorimetric gas detection tubes) and HSE procedures (e.g. maintain appropriate fire extinguishers in work area) prior to removal of well cap.

3. If applicable, measure the concentration of vapours emanating from the well using a PID by placing the intake nozzle above the well casing. Record the highest concentration measured by the PID and also the general condition of the monitoring well (e.g. missing or broken cover or well cap, well head filled with surface water) in Q4AN(EV)-414-FM1

4. Electrically ground the interface probe by attaching the earthing clip to the well casing or to a steel rod (e.g. screwdriver) inserted into the ground.

Static electricity may cause a spark and ignite vapours if the interface probe is not suitably earthed.

5. Slowly lower the dip meter/interface probe down the well until the probe intersects groundwater as indicated by the tone made by the equipment (refer to equipment user guide for details).

6. Measure the depth to groundwater in metres (to three decimal places) from the measurement tape by holding the tape next to the top of casing. The top of casing may be the highest point on the well casing or a point that was previously marked on the casing for surveying. It is imperative to ensure that measurements are taken from a consistent point on the monitoring wells to ensure that the information recorded is directly comparable between individual gauging events.

7. Confirm the measured depth to groundwater by repeating Point 6 until three consistent measurements are taken (i.e. ± 0.01 m). Record the depth to groundwater in metres below top of casing (m BTOC) on Q4AN(EV)-414-FM1.

8. If historical water levels are available for the monitoring well, compare the water level measurements with previous results for a reality check. That is, if groundwater levels have decreased in most wells since the previous gauging event but increased in one or two, then the anomalous water level measurements should be re-measured to confirm.
9. Measure the total depth of the well by turning off the dip meter / interface probe and lowering the probe to the bottom of the well. This is usually determined by the point where there is no tension on the measurement tape.

10. Measure the total depth of the well in metres (to three decimal places) by holding the measurement tape next to the measuring point at the top of casing. Record the total well depth on Q4AN(EV)-414-FM1.

11. TIP: It may be required to measure the height of the riser pipe in stick up wells. Check with your PM.

12. Close and secure the well by (a) locking the flush mount well gatic with an Allen key (typically 7 mm) or (b) lowering the hinge lid on the monument/stick up well cover or (c) replacing the lid on any other well cover as required (e.g. quarter turn wall covers). Fasten padlocks as necessary.

13. Caution: Monitoring well covers can cut / injure hands. Use cut resistant gloves to close well covers.

14. Once back in the office, all water levels measured in the field should be reduced to a common datum (e.g. M AHD), using the formula:

\[
\text{Reduced Groundwater Level (m AHD)} = \text{Survey Data for Height of Casing (m AHD)} - \text{Depth to Groundwater (m BTOC)}.
\]

7.0 Troubleshooting

I can’t find the monitoring well I am supposed to sample
- Use the figure to identify nearby features and attempt to triangulate its location.
- Ask field staff involved in previous monitoring events.
- Use a metal detector to sweep the general area.
- Request GPS co-ordinates from the GIS team and use a GPS to locate the well. If possible have a surveyor locate well position.
- Check the project folder (and historical project folders) for any photographs of the well location.

The stickup well has a padlock
- Check with the PM to ensure AECOM does not hold a key for the well.
- Check with client / land owner that a key is not available for the well.
- Cut the lock off.
- Re-secure the stickup using a cable tie unless client/PM indicates a lock should be replaced on the stickup.

The well is dry
- Confirm that the measured depth to bottom matches the information in the well log / historical gauging logs.
- Check to see if the well is seasonally dry
- If blocked, unblock the well using appropriate means.

I can’t get the well cover open or the well cap off
- Check that the tool is right for the job i.e. the right size Allen key is being used. A welders magnet may be useful in opening flush mounted well covers.
- Gently tap the well cover with a hammer to loosen.
- Replace O-rings and cover plate bolts as necessary to avoid the same problem next gauging round.
- Do not overexert and risk an injury or damage to the well head. Make a note on the gauging record and contact the Project Manager.

I can’t get three stable measurements
- Atmospheric pressure has the potential to affect the SWL. Wait a few minutes after opening the well cap for the SWL to stabilise and confirm again after an hour.
- Inspect the measurement tape (whole length) for damage.
- Check the tip of the probe for damage, dirt or NAPL.
- Try the probe in a bucket of water.
- Check the battery.
- Refer to the dip meter / interface probe user manual.

There's an apparent layer of NAPL in the well when it has not been recorded in this well historically.

- Check the probe for indications of NAPL (e.g. oily residue, colour and odour).
- Clean and dry the probe tip and try again.
- Confirm the presence of NAPL by using a bailer and note the thickness of NAPL (if present) or evidence of staining, globules, or sheen in the bailer.

8.0 Revision History

<table>
<thead>
<tr>
<th>Revision date</th>
<th>Affected sections</th>
<th>Description of change</th>
</tr>
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<tr>
<td>May 2, 2016</td>
<td>All</td>
<td>Conversion to AECOM Australia Pty Ltd.</td>
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</table>
1.0 Purpose and Scope

To instruct field staff on how to collect representative site-specific groundwater samples from the aquifer formation, with minimal disturbance to the water column.

This Field Instruction (FI) describes the methodology for the collection of groundwater samples using a bladder pump (low flow technique). This procedure should be read in conjunction with the following Australian/New Zealand Standards:

- AS NZS 5667.1.1998 – Water Quality Sampling – Part 1 Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; and

2.0 References


g. US EPA, 1996. Low stress (low flow) purging and sampling procedure for the collection of ground water samples from monitoring wells, Revision 2.

h. Photo-Ionisation Detector (PID) Q4AN(EV)-003-PR1.

i. Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1.

j. Groundwater Monitoring Well Installation Q4AN(EV)-401-PR1.

k. Groundwater Well Development Q4AN(EV)-402-PR1.

l. Groundwater Level Gauging Q4AN(EV)-403-PR1.

m. Groundwater Quality Measurements Q4AN(EV)-410-PR1.

n. Groundwater Sampling and Purge Record Q4AN(EV)-405-FM1.
3.0 Responsibilities

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this FI. To ensure equipment is in good working order prior to use, is maintained according to supplier’s advice and is appropriately calibrated or verified, have a basic understanding of common faults and field based repairs. Any faults shall be reported to the Project Manager (PM) or the equipment supplier as soon as they are identified. To ensure Quality Assurance/Quality Control and Health and Safety Compliance.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Define the objectives and appropriate methodology to field staff prior to mobilisation into the field. The Project Manager should check (or designate another to check) the gauging data recorded by the fieldwork staff for anomalies such as measurements inconsistent with historical groundwater level fluctuations or well construction records. To ensure Quality Assurance/Quality Control and Health and Safety Compliance.</td>
</tr>
<tr>
<td>Office HSE Advisor</td>
<td>The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving Health, Safety and Environment (HSE) Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, investigating reports of incidents or accidents.</td>
</tr>
</tbody>
</table>

4.0 Equipment and Materials

4.1 Equipment

Equipment required to complete this task includes:

- Low Flow (Bladder) Pump Casing;
- Wire hanger;
- Control Box;
- Compressor (Air or CO₂ Gas cylinder, Regulator and Hose);
- Water Quality Meter and Flow-through-cell; and
- Oil-water Interface Meter or Electronic Dip Meter drawdown meter.

Optional or supplemental equipment:

- Lower Explosive Limit (LEL) Detector; and
- Photo Ionisation Detector (PID).

For remote sites consideration should be given to providing a backup set of equipment, if the cost of remobilization is high, and there is no access to technical repair facilities.

4.1.1 Water Level Meter

A water level meter, also called electric dip meter, is used to measure the depth to standing water. Where Non Aqueous Phase Liquid (NAPL) is expected or suspected to be present in groundwater wells an oil/water interface meter should be used. A beeping sound is made when the electronic dip meter intersects the standing water level.

4.1.2 Drawdown Meter

A drawdown meter works differently to a water level meter: it makes a beeping sound when exposed to air and is silent in water. The probe should be locked in place in the water column above the pump inlet approximately 10 cm below the pre-pumping water level. As the water level drops during pumping the probe will beep when it is exposed to air. The probe can then be lowered until the beeping stops and the process repeated. The water levels will be recorded against time during the pumping on the field sheets.

4.1.3 Oil/Water Interface Meter

The oil/water interface probe should be used where Light Non Aqueous Phase Liquid (LNAPL) or Dense Non Aqueous Phase Liquid (DNAPL) are expected or suspected to be present in the wells. The probe emits two different sounds for distinguishing the depth to NAPL (continuous tone) and the standing water level (short beeping). Because LNAPL floats on top of water, the continuous tone will occur typically before the beeping tone; with DNAPL, the continuous tone would occur towards the base of the well, after the beeping tone of the water.
column. As the water level drops during pumping the probe will stop beeping when it is exposed to air. The probe can then be lowered until the beeping starts to gauge water level and the process repeated. The water levels will be recorded against time during the pumping on the field sheets.

4.1.4 Water Quality Meter

A water quality meter will typically comprise instrument probes to measure electrical conductivity (EC), pH, temperature, oxidation reduction potential (ORP) and dissolved oxygen (DO). Common water quality meters include YSI and TPS FLMV. When renting a water quality meter, the rental company should supply a calibration certificate indicating that the equipment has been cleaned, calibrated and is ready for use. Ensure that a flow-through cell is included with the water quality meter.

4.1.5 Low Flow Pump Casing/Wire Hanger

Casing which is lowered down the well to pump groundwater. Holds the bladder that is used to pump water, one bladder is used per well and replaced during decontamination. The pump is connected to both the discharge line and airline. Both these lines must be securely in place with a tight seal for the pump to work properly. The pump contains o-rings that must be checked each time before the pump is used, for if one is missing or worn the pump will not operate properly.

A wire cable/hanger is connected to the pump from the surface, to hold the pump in place as a safe guard to stop it falling down the well. The D-bolt on the hanger should be checked between each well during the decontamination process to prevent it from loosening and dropping the pump down the well.

4.1.6 Low Flow Control Box

Used to control the rate at which water is pumped (Cycle per Minute) and the pressure that the water is pumped out of the well. The control box (shown in Figure 1) may contain a compressor or is connected to the gas cylinder through the hose and regulator, and also the pump through the air line. Low flow controller may be connected via 12v cables to a battery.

4.1.7 Compressor, Gas Cylinder, Regulator & Hose (if required)

CO₂ gas cylinder can be used to pump groundwater. This is connected to a regulator and regulator is connected to the hose.

Note the pressure on the gas bottle. A full gas bottle should read 5,000 kpa (1,900 psi), and will allow you to sample approximately 20 wells (varying with well depth). If the bottle reads 500 kpa or less it should be marked empty and replaced.

Compressors can be either battery powered or powered using a combustion engine, make sure the pressures are appropriately controlled and that a clear knowledge of operation and the HSEP reflects compressor use prior to mobilization.
4.1.8 **Photo Ionisation Detector (PID)**
Refer to Operating a Photo-Ionisation Detector (PID) Q4AN(EV)-003-PR1, for applicability, operation and calibration of a PID.

4.1.9 **Lower Explosive Limit (LEL) Detector**
Refer to Operating a Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1, for applicability, operation and calibration of a LEL.

4.2 **Materials**
Materials and consumables that may be required to complete this task include:

- Appropriate Buckets (based on COPC)
- Potable water
- Hex keys
- Phosphate free detergent (e.g. Decon 90)
- Deionised water
- Spare o-rings and hex bolts
- Scrubbing brush
- Scissors/Tube Cutters
- Funnel
- Paper towel
- Tubing – Air & Discharge line (enough metres for all wells include spares)
- Alcohol Wipes
- Waste water container (e.g. jerry can)
- Ice/ice blocks
- Laboratory supplied sampling containers
- Low-flow bladders (1 per well with spares)
- Laboratory supplied rinse water
- Adjustable spanner
- Garbage bags
- Permanent markers and pens
- Duct tape
- Permanent markers
- Stericup Filters or in-line filters (if required for COPCs)
- Nitrile gloves
- Hand pump (if Stericup filters are used);
- Esky/cool box
- Field book
- Laboratory supplied sampling containers
- Stericup Filters or in-line filters (if required for COPCs)

5.0 **Background**
The objective of groundwater sampling is to obtain water samples that best represent natural undisturbed hydrogeological conditions. Low flow sampling is one of the techniques used to achieve this. It works by lowering the pump to a specified depth in the bore screen, thus pumping water coming into the bore from the aquifer, to achieve representative samples of the aquifer with minimal disturbance to the standing water in the well.

Before commencing low flow sampling, some important factors should be considered including, the method used historically on the site for sample collection. The groundwater characteristics may take some time to stabilise after installation and development of new wells. Refer to Q4AN(EV)-401-PR1 and Q4AN(EV)-402-PR1 for further information regarding the monitoring well installation and development.

Pumping should be done in a manner that minimises stress (drawdown) to the system to the extent practical.

6.0 **Fieldwork Instruction**

*(PRINT THIS SECTION FOR USE IN THE FIELD)*

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

6.1 **Decontamination**
The equipment (low flow pump/interface probe) shall be decontaminated prior to use and between sampling each surface sample location by the following procedure.

1. Wipe the probe and measuring tape (the length that comes into contact with groundwater) using disposable alcohol wipes. Dispose of the alcohol wipes into a contaminated waste bag.
2. Empty pump bladder and leftover groundwater in waste water container using a funnel.
3. Wash the low flow pump, suspension wire, probe and associated tape using a scrubbing brush in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).
4. Rinse the low flow pump, probe, wire and tape with potable water in another bucket.

5. Final rinse of all apparatus using deionised water in a spray bottle/bucket or directly from the deionized water container.

6. The wash solution needs to be renewed when the decontamination process becomes ineffective, e.g. product on the probe after rinsing or sheen in the wash solution buckets.

6.2 Low Flow Groundwater Sampling

- YSI model WQMs should be turned on 30 minutes before sampling to allow sensors to stabilise.
  Ensure protective covers are removed from probe;
- Check the pressure on the gas cylinder – a full cylinder should read initially on the regulator 5000 kpa; and
- Check for leakage of CO\textsubscript{2} or air in the system, if identified immediately turn off CO\textsubscript{2}/compressor and undertake repair/change equipment with apparatus isolated and de-energized.

1. The wells on the site least likely to be contaminated should be targeted first so as to reduce the risk of potential cross contamination between sample locations.

2. (If using CO\textsubscript{2}) Connect gas cylinder/compressor to regulator, the regulator to hose and the hose to the control box.

3. Turn on the gas/start compressor, control box and Water Quality Meter (WQM).

4. Ensure pump casing and hanger cable have been decontaminated. Install new disposable bladder in pump, check o-rings are all in place correctly and undamaged. Connect hanger cable to pump casing, ensuring d-bolt is tightly secured.

5. Connect the tubing line to the pump casing, discharge line (larger diameter) and air line (thinner diameter). If using twin tubing (joined tubing), ensure the excess glue has been removed from tubing line using scissors or tube cutters before connecting to pump and controller to prevent damage to inlets and o-rings. Once connected pull on the tubing to test they are secure.

6. Open the monitoring well cover by (a) unlocking the flush mount well gatic with a hex key or (b) lifting the hinge lid on the monument/stick up well cover or (c) removing the lid on any other well cover as required (e.g. quarter turn well covers).

- Monitoring well covers can cut / injure hands. Use cut resistant gloves to open well covers. Be careful for wells with positive pressure (such as landfill leachate bores that could pop off the loosened well cap. Keep body parts clear of well when opening).

- Biological hazards (e.g. spiders, ants) may be present within gatic covers, exercise caution when opening wells. Wear gloves and remove cobwebs before placing hands into the well.

7. Remove the well cap (e.g. J-plug), PVC end cap, torque cap.

- High concentrations of vapours can build up in the well and be released into the breathing zone when the well cap is removed. Implement appropriate work space monitoring (e.g. LEL, PID, colorimetric gas detection tubes) and HSE procedures (e.g. maintain appropriate fire extinguishers in work area) prior to removal of well cap.

8. Measure the SWL in the well with the interface probe. This depth will be taken as the original SWL on your purging sheet.

- Wells should be gauged prior to the commencement of any sampling, where possible.

9. Lower pump into well slowly to avoid water column disturbance (pump should not be lowered to the bottom of well as this could cause resuspension of solids which will have collected at the bottom of the well). Lower tubing and wire carefully together to prevent tangling which can lead to the pump becoming lodged in the well. Review each well completion log to select the depth to which the pump inlet will be set. The pump should be positioned dependent on the contaminant of concern or to target high permeability zones. Where this is not known, the pump inlet should be located approximately in the middle of the screened interval so as not to disturb the bottom of the well and allow for sufficient water above the pump. Ensure the hanger cable is tight and that the cable reel has been locked in place. The depth of the pump inlet can be measured by using the interface probe / water meter to measure the depth to the top of the pump. Record depth to pump on purging sheet.
10. Attach the tubing airline to the control box (see Figure 1). Attach discharge line (larger diameter) to the flow cell in the bottom outlet to allow flow cell to fill with water before discharge. Place flow cell into a bucket to ensure overflow from discharge is contained.

11. Remeasure the SWL in the well, or use the drawdown meter to monitor any drawdown during pumping. The difference in depth between the SWL recorded before the pump was lowered into the well and after will give a rough estimate of how quick the well will recharge if no historical data is available (the larger the difference in depths the slower the recharge as a general rule).

12. Measure depth to top of pump and record as purging depth on purge sheet. If this is not possible i.e. in wells with a diameter greater than 50 mm, an estimate can be made.

13. For CO₂ setup - Set the air pressure on the gas cylinder regulator and control box throttle to required pressure. Using the formula

\[
\text{Purging Depth (1 metre = 1 psi)} + 10 \text{ psi} = \text{Air Pressure}
\]

E.g. 15m depth = (15x1) +10 = 25. The pressure should be slightly greater on the gas cylinder regulator compared to the control throttle. Watch the rate at which water is discharged and adjust pressure as necessary.

Review previous sampling sheets to obtain an idea of the appropriate pumping rate. Set the controller to the estimated flow rate or if unknown start on 100 ml/min (CPM 1). One cycle yields approximately 100 ml of water. Groundwater flow should be between 0.1-0.4 L/ min.

14. For O₂ setup – set the fill and discharge times. Discharge times are the time it takes to squeeze the bladder and fill time is the time allowed for the bladder to refill. Fill and discharge rates depend on hydrostatic pressure (i.e. water above the pump). The airline pressure gauge should not exceed the equivalent depth to water 1 PSI = 0.7 m of water.

Review previous sampling sheets to obtain an idea of the appropriate flow rate. If discharge falls off before the discharge cycle is complete, the discharge time can be lowered. If drawdown is significant, fill time can be increased.

15. Start the pump. Allow purged water to overflow (into a container) the flow-through cell before starting to take water quality parameter readings and standing water level readings, once this occurs take readings every three minutes (where sampling rate is 100ml/minute or more) or five minutes (if flow rate is less than 100ml/minute).

16. Fill in data on CPM or fill/discharge rate, SWL readings and water quality parameters on the field purging sheet;

The drawdown should not exceed 10 cm difference from the original SWL at any time. However it is more important that the groundwater quality parameters stabilise before sampling. If the drawdown is dropping continuously lower the flow rate to see if the SWL will stabilise. Once the SWL stabilises wait for three successive stable parameter readings before sampling (at 3 to 5 minute interval between each successive reading).

If you are still getting drawdown with the very low pump rates, contact PM for advice.

17. Once field parameters have stabilised samples can be collected (a minimum of 1 L of groundwater should be removed prior to sampling). The water quality parameters are considered stable when for three successive readings the parameters are within the following: ±10% Dissolved Oxygen; ±3% Electrical Conductivity; ±0.05 pH; ±10 mV Redox Potential; and ±0.2°C Temperature. Pay attention to water quality parameters and check that readings are as expected based on site knowledge and chemistry. Issues often occur with WQMs. Parameters can also be easily recorded incorrectly if the wrong units or parameter is referenced. Taking time to set-up WQM display screen with the required parameters and units may help as parameters that are not recorded (e.g. salinity) are not displayed. Contact PM and/or equipment supplier if unsure of readings or experiencing issues with WQM.

If water quality parameters have changed significantly since last GME call the PM.

18. Maintain the same pumping rate for sampling. Disconnect the pump’s tubing from the flow-through-cell so that the samples are collected from the pump’s discharge tubing. Air pressure on the gas cylinder can be turned down so samples can be filled with minimal turbulence (if applicable).

19. Fill samples over a bucket/basin to minimise spillage.

20. Store samples in esky with sufficient ice or ice bricks. Ice should form a bed beneath samples and cover samples. Glass vials and bottles should be stored in bubble wrap and eskies should not be over-filled.

21. Turn the controller off. Remove the pump from the monitoring well. Decontaminate the pump and probe following steps decontamination steps in section 6.1 and dispose of the tubing, bladder and other waste.
The flow-through cell doesn’t need to be rinsed between wells (unless a sheen, strong hydrocarbon odour or sediment is noticed to keep it in good working condition). Water quality sensors should be rinsed with tap water.

- If SWL varied during purging, measure the SWL after sampling to ensure that levels did not exceed 10 cm difference from the original SWL.
- If this is the last well for the day, or before a break, the gas line should be turned off and depressurised before leaving by turning the gas off at the cylinder and running the controller through one or two cycles. All caps should be replaced on the WQM.

22. Replace cap on well, lock gatic. Check area for anything left behind before leaving.

7.0 Troubleshooting

7.1 Water isn’t discharging from the pump:
1. Check gas bottle is not empty/compressor is operating.
2. Check air pressure gauges on the gas bottle and controller are at appropriate levels (if applicable).
3. Re-connect air hose to compressor to ensure there isn’t a leak.
4. Remove pump from well.
5. Check water and air lines connecting pump to ensure there isn’t a leak.
6. Check o-rings are in place in pump; replace any worn o-rings.
7. Check bladder hasn’t broken and is in good condition.
8. Decon or clean pump and inlet to remove sediment.

7.2 There are air bubbles (observed audibly from the well head) in the water discharge tube:
1. O-rings are missing or worn, check and replace if needed.
2. Air line connecting to pump is leaking causing water bubble in discharge line, re-connect both air and water tubes connecting to pump.
3. Bladder is missing or not sealed.

7.3 The water level keeps fluctuating up and down rapidly:
1. O-rings are missing or worn, check and replace if needed.
2. Air line connecting to pump is leaking causing water to bubble in well, re-connect both air and water tubes connecting to pump.
3. Bladder is missing or not sealed.

8.0 Revision History

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<td>All</td>
<td>Conversion to AECOM Australia Pty Ltd.</td>
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</table>
1.0 Purpose and Scope

The purpose of this Fieldwork Procedure (FP) is to introduce AECOM field staff to the collection of soil samples using hand augering from near surface materials to characterise the potential human health and environmental risk.

This FP describes the methodology for the collection of soil samples during hand augering. It does not include the description of the hand augering drilling process.

2.0 Terms and Definitions

a. COC  Chain of Custody
b. FP   Field Procedures
c. LEL  Lower Explosive Limit
d. PID  Photo Ionisation Detector
e. PM   Project Manager
f. SWMS Safe Work Method Statement
g. SH&E Safety, Health & Environment
h. VOCs Volatile Organic Compounds

3.0 References

a. ANZECC and National Health and Medical Research Council (NH&MRC) (January, 1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites
b. AS4482.1-2005 Guide to the sampling and investigation of potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds
c. EPA Publication 441 (A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes)
d. EPA Victoria, SEPP, Prevention and Management of Contamination of Land, State Government of Victoria, June 2002
f. Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1.
g. Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1.
h. Soil: Logging and Classification Q4AN(EV)-113-PR1.
j. QA/QC Tracking Sheet Q4AN(EV)-011-FM1.
k. Borehole Monitoring/ Bore Field Log Q4AN(EV)-101-FM1.
4.0 Responsibilities

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<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this FP. To ensure equipment is in good working order prior to use, maintained according to supplier directions and is appropriately calibrated or verified. Any faults shall be reported to the Project Manager (PM) or the equipment supplier as soon as they are identified.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>The PM is responsible for ensuring that fit for purpose equipment is used, that personnel are adequately trained and to develop work scope and services to be delivered to the client within the designated timeline. The PM should check prior to site works (or designate another to check) to see if borings have already been undertaken at or in the vicinity of the site in the past, check applicable geological maps, and communicate anticipated ground conditions to field staff.</td>
</tr>
<tr>
<td>SH&amp;E Manager</td>
<td>The Safety, Health &amp; Environment (SH&amp;E) Manager is an assigned person for each office and is available for reviewing Safe Work Method Statements (SWMS) and Project Safety Plans, monitoring the implementation of SH&amp;E requirements, interface with project managers in matters of SH&amp;E, and investigating reports of incidents or accidents.</td>
</tr>
</tbody>
</table>

5.0 Equipment and Materials

5.1 Equipment

Equipment required to complete this task include:
- Photo Ionisation Detector (PID)
- Hand Auger (including unlocking key)

Optional or supplemental equipment:
- Lower Explosive Limit (LEL) Detector

5.1.1 Photo Ionisation Detector (PID)

Refer to Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1 for applicability, operation and calibration of a PID.

5.1.2 Lower Explosive Limit (LEL) Detector

Refer to Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1, for applicability, operation and calibration of a LEL Detector.

5.2 Materials

Materials and consumables that may be required to complete this task include:
- Buckets
- Potable water
- Phosphate free detergent (e.g. Decon 90)
- Deionised water
- Scrubbing brush
- Paper towel
- Steel brush
- Permanent Marker Pens (thick and thin)
- Aluminium mixing bowl
- Ice
- Nitrite gloves
- Hard stick/branch or wooden handle
- Screw driver
- Snap lock bags
- Spray bottle for deionised water
- Steel measuring tape
- Solid contaminated waste bags
- Bentonite or grout seal
- Alcohol wipes
- Sample jars and bottles
- Contaminated liquid waste container
- Digital Camera
- Digital thermometer
- Esky (portable insulated container)
- Hand trowel
- Cut resistant gloves (as required)
6.0 Fieldwork Procedure

(PRINT THIS SECTION FOR USE IN THE FIELD)

Olfactory assessment (smelling) of soil samples shall not be undertaken due to the potential for atmospheric hazards of unknown type and concentration to be present. Only ambient odours should be recorded.

6.1 Decontamination

Drilling Equipment

All extension rods and the auger head/bucket should be decontaminated prior to drilling, between each location and at the end of the drilling program. Decontamination should involve:

- Removing large soil fragments using a brush or scraping technique. The dirt should be collected over a waste bag/drum and disposed of in the bag.
- High pressure water, preferably with decon 90 solution, should be used to thoroughly wash the auger head and rods. Alternatively a wire brush may be used in a bucket of decon 90 solution in the absence of high pressure water.
- Potable water should be used for a final rinse. The water used for decontamination purposes should be collected for disposal in approved wash down area such as on grass where no runoff is possible (un-impacted soils) or in a designated area (such as an interceptor system or contaminated waste if soils are highly impacted).

6.2 Soil Sampling

This section provides the methodology for collecting soil samples while hand augering.

- The areas of the site least likely to be contaminated should be targeted first so as to minimise any potential cross-contamination between sampling locations.
- Prior to augering, make sure that a service clearance has been completed by a licensed service location contractor.
- Count the number of extension rods available and ascertain the lengths of the rods and auger head so that the depth of drilling can be confirmed periodically.
- Setup a clear area for the sample cores to be placed, such as a soil logging tray.
- Soil samples should be collected at intervals as outlined in the work plan. Samples should also be collected: from the surface or immediately below any concrete/asphalt, at any change in lithology or where visual evidence of contamination is observed (staining or odours).
- Once the full augering bucket has been brought to the surface and one of the conditions described has been observed, perform the following:
  - Record the sampling depth.
  - Using the hand trowel, place a small quantity of the soil material into a snap lock bag.
  - Homogenise the sample (if required), i.e. without opening the snap lock bag, manually crush the soil particles to the extent practicable.
  - Using a PID, measure the concentration of Volatile Organic Compounds (VOCs) close to the augering bucket (note: these results could potentially be biased low due to the heat generated during drilling causing volatilisation).
  - After homogenisation, the sample should be left for 1 minute to allow volatiles to accumulate.
  - Pierce the bag with the PID tip, ensuring that soil does not block the tip, and record the maximum PID reading obtained for the sample interval on the geologic log.
- If VOCs are not part of the compounds to be analysed, collect another sample from the augering bucket using the trowel and place into an aluminium mixing bowl. Homogenise the sample, removing any stone or bark material prior to transfer to sample jars.
- Split homogenised sample in equal mass fractions for primary, duplicate and/or triplicate sampling if required. If sampled lithology is loose i.e. sand, samples can be collected and homogenised by hand using clean gloves.

- If VOCs are part of the analytical suite, an attempt should be made to keep the soil sample relatively undisturbed so that VOCs do not volatilise. Gently collect the sample from the augering bucket and carefully place them in the jar(s). If duplicate and/or triplicate samples are required, an attempt to put equal quantities of soil material into each jar should be made from each soil horizon. Make sure the jar(s) is completely full and cap the jar immediately to minimise volatile losses.

- The soil profile should be logged as sampling occurs. All soil types, changes in colour or texture, evidence of fill material, depths, drilling difficulty, water inflow or loss, core loss, soil sample intervals, PID readings etc. should be recorded on the soil bore log. Please refer to Q4AN(EV)-113-PR1 for further information as to the minimum requirements for information to be logged.

- Soil samples should be immediately sealed and labelled, then packed appropriately in ice (picked up prior to the sampling event) in an Esky for delivery to the laboratory.

- A copy of the Chain of Custody (COC) should be placed in a separate snap lock bag and put inside the Esky prior to sealing it. The temperature of several soil samples should be taken using a digital thermometer for later comparison with the laboratory records. Ensure the lids of the jars are sealed tight to prevent the ingress of any water associated with melting of the ice. Consider placing the jars in individual snap lock bags.

- Care should be taken not to overfill the Esky with samples as they might not cool sufficiently for analysis. A security seal should be applied to the Esky together with sampling information, including a project number, date sampled, sampler name and phone number and details of any short holding times.

- Waste soil cuttings should be collected in waste drums or skip bins and removed from site by a licensed waste contractor. Ensure the waste drums are appropriately labelled, sealed and placed in a secure area.

- Soil cuttings may be replaced within the borehole and tamped down even to the ground surface where in accordance with the scope/client requirements if visual, olfactory and screening suggests that the soil is not impacted.

- Boreholes must be backfilled with clean, imported fill material (preferably analysed before site works) and tamped down to reduce the chance of the borehole being a trip hazard.

7.0 Troubleshooting

I have encountered stiff clays which are difficult to sample

Use a trowel or other harder tool (e.g. screwdriver) to break open the clay core, making sure that this tool is decontaminated between sample intervals.

If clays are hard/wet and will not come out from the auger head, by using a hard stick/branch or wooden handle and striking the auger head while rotating the head clays should come loose and be easier to sample.

There is extensive smearing on the outside of the core

Ensure that the smearing is removed by scraping it with a trowel so as not to contaminate the soil samples collected.

I can’t obtain sufficient sample

Collect as much as possible, discuss the analytical requirements with the PM.

Refusal on gravels/rocks

Move to a location close by (services permitting). If refusal is encountered at the second location, contact PM for advice.

8.0 Revision History

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<thead>
<tr>
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<tr>
<td>Aug 15, 2105</td>
<td>Section 6</td>
<td>Cautionary Note</td>
</tr>
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</table>
1.0 Purpose and Scope

The purpose of this Fieldwork Instruction (FI) is to introduce to URS field staff how to collect soil samples from the subsurface using sonic drilling.

This FI describes the methodology for sonic drilling for the purposes of collecting soil samples and installing groundwater monitoring wells.

2.0 References

a. ANZECC and National Health and Medical Research Council (NH&MRC) (January, 1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites
b. AS4482.1-2005 Guide to the sampling and investigation of potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds
d. EPA Victoria, SEPP, Prevention and Management of Contamination of Land, State Government of Victoria, June 2002
g. Planning a Fieldwork Program Q4AN(EV)-001-PR1
h. Fieldwork Notes and Records Q4AN(EV)-002-PR1
i. Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1
j. Lower Explosive Limit (LEL) Monitor Q4AN(EV)-004-PR1
k. Utility Clearance and Isolation Q4AN(EV)-006-PR1
l. Soil Logging and Classification Q4AN(EV)-113-PR1
m. Fieldwork Equipment Checklist Q4AN(EV)-001-FM1
n. Daily Activity Report Q4AN(EV)-002-FM1
o. Gas Monitoring Instrument Calibration Record Q4AN(EV)-003-FM1
p. QA/QC Tracking Sheet Q4AN(EV)-003-FM1
q. Borehole / Monitoring Bore Field Log Q4AN(EV)-101-FM1.
3.0 Responsibilities

<table>
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<tr>
<th>Role</th>
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<tbody>
<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this Field Instruction. To ensure equipment is in good working order prior to use, is maintained according to supplier’s advice and is appropriately calibrated or verified. Any faults shall be reported to the Project Manager (PM) or the equipment supplier as soon as they are identified</td>
</tr>
<tr>
<td>Project Manager</td>
<td>The PM is responsible for using fit for purpose equipment and in developing work scope and services to be delivered to a client within the designated timeline. The PM should check (or designate another to check) to see if borings have been undertaken at or in the vicinity of the Site in the past and to check applicable geological maps.</td>
</tr>
<tr>
<td>Office HSE Advisor</td>
<td>The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving Health, Safety and Environment (HSE) Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, investigating reports of incidents or accidents and approving drilling contractors to undertake the proposed works.</td>
</tr>
</tbody>
</table>

4.0 Equipment and Materials

4.1 Equipment

Equipment required to complete this task includes:
- Photo Ionisation Detector (PID);
- Lower Explosive Limit (LEL) Detector; and
- Digital thermometer.

4.1.1 *Photo Ionisation Detector (PID)*

Photo-Ionisation Detector (PID) Q4AN(EV)-003-PR1 for applicability, operation and calibration of a PID.

4.1.2 *Lower Explosive Limit (LEL) Detector*

Refer to Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1, for applicability, operation and calibration of a LEL Detector.

4.2 Materials

Materials and consumables that may be required to complete this task include:
- Snap lock bags
- Potable water
- Deionised water
- Paper towel
- Buckets
- Scrubbing brush
- Steel brush
- Aluminium mixing bowl
- Esky
- Ice
- Permanent marker pens (thick and thin)
- Alcohol wipes
- Sample jars and bottles
- Spray bottle for deionised water
- Contaminated waste drums (soil and liquid)
- Steel measuring tape
- Stainless steel hand trowel
- Phosphate free detergent (e.g. Decon 90);
5.0 Background Information

Sonic drilling is a relatively new drilling method and there are only a few drilling companies which use this method. It can be an appropriate drilling method in certain geologies such as landfills, where large river gravels are present, where there is a change between hard and soft lithologies, where very stiff clays are present or where it is necessary to install casing as the drilling progresses (to prevent contaminant ingress or hole collapse). However, it may not be an appropriate method of drilling for all geologies or sites. A discussion should be held with the driller regarding the inferred geology prior to selecting sonic as the drilling method.

Sonic drilling involves advancing a core barrel (usually without circulating water) to a certain depth. Larger diameter casing is then advanced outside the core barrel to the same depth to keep the borehole open and stable. Core barrels and casing are available in a range of diameters. Once the target depth is encountered, a groundwater well can be installed inside the casing and the casing progressively removed. The advantages and disadvantages of sonic drilling are listed below in Table 1.

Table 1 Sonic Drilling Characteristics

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No fluids are required down hole,</td>
<td>- Expensive;</td>
</tr>
<tr>
<td>which means that the analysis and logging of the sample are more accurate;</td>
<td>- When drilling harder formations samples are recovered at elevated temperature so can lose volatiles;</td>
</tr>
<tr>
<td>- Often faster than other forms of drilling such as diamond or percussion drilling;</td>
<td>- Water is often introduced to stabilise the formation;</td>
</tr>
<tr>
<td>- Can drill through rock.</td>
<td>- Can require a lot of room to accommodate the rig and support vehicle.</td>
</tr>
</tbody>
</table>

Sonic drilling can be slow, due to the need to remove all the drill string from the borehole each time a sample is required. Consequently, the speed of drilling decreases as the hole is advanced to depth.

Sonic drilling is very effective in difficult lithologies and is not impeded by large gravels, cobbles or very stiff clays which enable an accurate estimate of metres drilled per day or wells installed per day. This is also influenced by the size of the drill rig; however, it is an expensive drilling option.

During drilling, the cores obtained may appear to expand or contract, so that shorter or longer core samples are obtained compared to the expected core run. For this reason, sonic may not be the appropriate method when exact depth measurements are required.

If volatile organic compounds (VOCs) are a contaminant of concern at the site, sonic drilling may not be the best methodology. Heat generated during the drilling process may cause VOCs to be released when core bags are cut open, resulting in negative concentration bias to the samples.

6.0 Fieldwork Instruction

(Print this section for use in the field)

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

Prior to intrusive works commencing,

DBYD plans and all available private above ground and underground service plans for the Site are to be requested. Refer to Q4AN(EV)-006-PR1 Utility Clearances and Isolation, and Service Identification and Clearance Checklist S4AN-783-FM1; and

Drill Inspection checklist MUST be completed by the drill operators and an inspection of the equipment undertaken to ensure it is suitable for use.

Olfactory assessment (smelling) of soil samples shall not be undertaken due to the potential for atmospheric hazards of unknown type and concentration to be present. Only ambient odours should be recorded.
6.1 Decontamination

Any equipment that is to be used between sample locations (such as drill bit, auger and sampling shoe) shall be decontaminated prior to use and between each sample location in accordance with the following procedure.

1. Remove excess dirt with a stiff steel brush prior to decontamination, collecting any soil over a contaminated waste bag for disposal.
2. Wipe the surfaces of the equipment using a disposable alcohol wipe and dispose into a contaminated waste bag.
3. Wash the equipment using a plastic scrubbing brush in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).
4. Rinse the equipment with potable water over another bucket and collect the rinse water for later disposal as contaminated waste.
5. The wash solution needs to be renewed when the decontamination process becomes ineffective, e.g. product on the equipment after rinsing or sheen in the wash solution buckets.
6. The water used for decontamination purposes should be collected in a bunded area (permanent or portable) and pumped into a liquid container for disposal offsite as a contaminated liquid if appropriate.

6.2 Detailed Procedure

This stepped guide provides the methodology for the sampling of soils utilising sonic drilling methods.

- Wherever possible, commence sampling from areas of least impact to greatest impact so as to reduce the effect of any potential cross-contamination that may occur between sample locations.

- At least the first 1.2 metres of the borehole must be advanced using non-destructive digging (NDD) techniques (hand auger, high pressure air or water knifing etc.) to confirm the absence of services at the borehole location. Check with the drillers the outer diameter of the drill string to be used and ensure that the NDD hole diameter is consistently 130% of the drill string from ground level to 1.2mbgs. The actual depth requirement of NDD may be greater depending on client requirements or proximity to services (i.e. within a critical zone). Refer to Q4AN(EV)-006-PR1 for information on Service Identification and Clearance.

- Set up a clear area for soil samples to be placed for sampling and logging. Ensure it is a safe distance from the drilling operations, site traffic, pedestrian traffic and members of the public. The work area should be clearly demarcated to prevent unauthorized and/or accidental incursions by plant or personnel. Ensure that the area is as clean as possible (laying out clean plastic is often a good idea in wet/muddy environments).

- Agree with the drillers before works start on communication signals when the rig is in operation and undergo a rig induction with the drillers. Ensure the drillers go through their pre works rig inspection and check all items on the check are complete before works commence. Clarify with the drilling contractor the intended sampling depths before drilling commences so that they can plan their works.

The drillers will begin drilling from a minimum depth of 1.2 mbgs, or from whatever depth the NDD was done to.

**Caution:** If NDD unable to achieve the minimum requirement of 1.2 mbgs then work will proceed cautiously in accordance with Service Identification and Clearance Variation Form S4AN-783-FM2 and agreed methodology as approved by the PM and HSE Advisor.

- Setup a clear, safe work area for the sample cores to be placed. When sonic core is removed from the core barrel (either by vibration or vibration and high pressure water) it is collected in plastic core bags/trays. The bag/tray should be placed on the ground in a logical and consistent order and the top and bottom of each bag/tray should be labelled with a permanent marker pen. The lengths of each core run should be marked on the field logs for reference and photos taken of each core run (if camera equipment allowed onsite). Clean plastic sheeting can be placed upon which the core bags/trays can be placed to minimise any potential cross-contamination between the soil in the bag/tray and surrounding environment.

- Use a measuring tape to measure the whole core length, note that sonic drilling can cause certain formations to compact or expand so that the length of the core obtained may not match the length of the core barrel. Communication with the driller will also allow determination of any core losses.
Caution: Only approach the driller when it is safe to do so, follow pre-arranged signals to attract the driller’s attention from outside of the exclusion zone and only enter when given approval.

6.3 Sample Collection Procedure

- During sample collection disturbance to the soil matrix should be kept to a minimum when collecting the material and placing into the sample jar(s) such that the potential for volatile organic compounds (VOCs) to volatilize is minimized during acquisition. If duplicate and triplicate samples are being taken, equal quantities of soil material should be placed into each jar from the corresponding soil horizon. This will ensure soil material from the same depth is tested by the laboratory.

- If VOCs are not part of the analytical suite, remove a sample using the trowel and place into an aluminium mixing bowl. Homogenise the sample, removing any stone or bark material prior to transfer to sample jars. Split homogenised sample mass by 33:33:33 for primary, duplicate and triplicate sampling as required. If sampled lithology is loose i.e. sand, samples can be collected and homogenised by hand using clean nitrile gloves.

- To provide an indication of potential organic contaminants within the soils, place a small quantity of the soil into a snap lock bag prior to homogenisation (if required). Headspace measurements can be taken using a PID from the soil samples to provide an indication of volatile contamination. Soil samples should be left to volatise for a consistent amount of time between samples to ensure repeatability.

- Cut open the plastic core bags, being mindful of the potential for vapours to be released due to heat generated when drilling. For this reason, sonic drilling is not recommended where VOCs are the contaminant of concern. Representative soil sampling during sonic drilling may also be affected by circulation of water when running casing to keep the casing cool and lubricated as well as the use of water to force samples out of the core barrel and into the sample bags/trays.

- Depending on the scope of the works (e.g. high profile site/auditor) take photographs of the soil cores and collect representative soil samples from each change in lithology and place in plastic “chip trays” with depths marked for review by a suitably qualified senior environmental engineer.

- The soil profile should be logged as sampling is occurring. All soil types, changes in colour or texture, evidence of fill material, visual or olfactory indications of contamination, depths, drilling difficulty, water inflow or loss, core loss, soil sample intervals, PID readings etc. should be recorded on a the soil bore log. Please refer to Q4AN(EV)-113-PR1 for further information as to the requirements for information to be logged.

- Soil samples should be collected at intervals as outlined in the work plan. Samples should also be collected: from the surface or immediately below any concrete/asphalt, at any change in lithology or where visual/olfactory evidence of contamination is observed (staining or odours).

- Soil samples should be immediately sealed and labelled then packed appropriately in ice, which has been picked up prior to the sampling event, in an esky for delivery to the laboratory. A copy of the Chain of Custody (COC) should be placed in a snap lock bag and put inside the esky prior to sealing the esky. Ensure the lids of the jars are sealed tight to prevent the ingress of any water associated with melting of the ice; consider placing the jars in individual snap lock bags.

- Care should be taken not to overfill the esky with samples as the samples will not cool sufficiently for analysis. A security seal should be applied to the esky together with the sampler’s details including a job number, date sampled, sampler and phone number and details of any short holding times.

- Soil cuttings should be disposed of in the appropriate manner depending on the level of contamination. Contaminated wastes should be collected in waste drums or skips and removed from site by a licensed waste contractor. Ensure the waste drums are appropriately labelled, sealed and placed in a secure area preferably on a sealed hardstand surface.

- If the borehole is for soil sampling only, backfill the borehole in order to reduce the potential for vertical migration of contamination via this pathway. Backfilling should be completed using cement grout or dry bentonite granules. If groundwater was encountered, place sand in the saturated zone. Cuttings can be used for backfill if they are uncontaminated (which is deemed as having no olfactory or visual field evidence of contamination).
- If the borehole is designated as a monitoring well installation, begin the well installation process (refer to Groundwater Monitoring Well Installation Q4AN(EV)-401-PR1). This is particularly effective in hollow stem drilling as the void in the centre of the drill line can be used to install the well, without the walls of the bore hole collapsing.

7.0 Troubleshooting

I have encountered stiff clays which are difficult to sample

Use a trowel or other tool to prise open the clay core, making sure that this tool is decontaminated between sample intervals.

There is extensive smearing on the outside of the core

Ensure that the smearing is removed by scraping with a trowel so as not to contaminate the soil sample collected.

I can’t obtain sufficient sample

Collect as much as possible, discuss the analytical requirements with the PM.

The PID is not working

Refer to PID manual and/or contact rental company for assistance.

The PID tip is full of soil

Change the tip using spares provided by rental company. Otherwise, the soil prevents that PID from obtaining an accurate indication of VOC presence.

Drill depth is uncertain

Count the number of drill rods available at the drill pad and ascertain the lengths of the rods and initial drill string (including subs and bits) so that the depth of drilling can be confirmed with the driller periodically.

8.0 Records

a. Service Identification and Clearance Checklist S4AN-783-FM1
b. Service Identification and Clearance Variation Form S4AN-783-FM2

9.0 Revision History

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<tr>
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<td>Aug 15, 2016</td>
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</tr>
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</table>
1.0 Purpose and Scope

The purpose of this Fieldwork Instruction (FI) is to introduce to AECOM field staff how to collect soil samples from the subsurface using direct push drilling (also referred to as direct push, push sleeves or push tube drilling).

This FI describes the methodology for collecting soil samples using direct push sleeves for the purposes of logging soil profiles, collecting soil samples and installing monitoring wells.

2.0 References

a. ANZECC and National Health and Medical Research Council (NH&MRC) (January, 1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites
b. AS4482.1-2005 Guide to the sampling and investigation of potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds
c. EPA Publication 441 (A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes)
d. EPA Victoria, SEPP, Prevention and Management of Contamination of Land, State Government of Victoria, June 2002
g. Planning a Fieldwork Program Q4AN(EV)-001-PR1.
h. Fieldwork Notes and Records Q4AN(EV)-002-PR1.
i. Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1.
j. Lower Explosive Limit (LEL) Monitor Q4AN(EV)-004-PR1.
k. Utility Clearance and Isolation Q4AN(EV)-006-PR1.
l. Soil Logging and Classification Q4AN(EV)-113-PR1.
m. Fieldwork Equipment Checklist Q4AN(EV)-001-FM1.
o. Gas Monitoring Instrument Calibration Record Q4AN(EV)-003-FM1.
p. QA/QC Tracking Sheet Q4AN(EV)-003-FM1.
q. Borehole / Monitoring Bore Field Log Q4AN(EV)-101-FM1.
3.0 Responsibilities

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<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this FI. To ensure equipment is in good working order prior to use and is maintained according to supplier's advice. Report all anomalies to the Project Manager or the equipment supplier as soon as they are identified. Maintain accurate fieldwork data and observation records and provide to the Project Manager for review.</td>
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<tr>
<td>Project Manager</td>
<td>Define the objectives and appropriate methodology to field staff prior to mobilisation into the field.</td>
</tr>
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<td>Office HSE Advisor</td>
<td>The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving Health, Safety and Environment (HSE) Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, investigating reports of incidents or accidents and approving drilling contractors to undertake the proposed works.</td>
</tr>
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4.0 Equipment and Materials

4.1 Equipment

Equipment required to complete this task includes:
- Photo Ionisation Detector (PID);
- Lower Explosive Limit (LEL) Detector.

4.1.1 Photo Ionisation Detector (PID)

Refer to Photo-Ionisation Detector (PID) Q4AN(EV)-003-PR1, for applicability, operation and calibration of a PID.

4.2 Materials

The materials required to appropriately characterise soil as a result of direct push tube sampling include:
- Snap lock bags
- Potable water
- Deionised water
- Paper towel
- Buckets
- Scrubbing brush
- Steel brush
- Aluminium mixing bowl
- Esky
- Plastic sleeve cutter (driller)
- Sample jars and bottles
- Chip trays
- Cut-resistant gloves (as required)
- Ice
- Permanent marker pens (thick and thin)
- Alcohol wipes
- Sample jars and bottles
- Spray bottle for deionised water
- Contaminated waste drums (soil and liquid)
- Digital thermometer
- Steel measuring tape
- Contaminated Drum Labels
- Stainless steel hand trowel
- Nitrile gloves
- Phosphate free detergent (e.g. Decon 90)
- Hearing protection

5.0 Background Information

Direct push, push tube or push sleeve drilling uses a disposable tube contained within a stainless steel casing, which is then pushed through the soil profile. The push tube is extracted and the sample cut out of the plastic casing.

The most commonly used push tube liner produces a core with a diameter of 29mm. If a larger core size is required (for example to allow installation of a monitoring well in the push tube hole), drillers may be able to accommodate this by using a larger liner that produces a 49mm diameter core.

This sampling method is only considered suitable in unconsolidated or soft formations, and in shallow soil investigations. Push tube refusal is common on rock, large gravels, large artificially derived fill materials, peat, and stiff clays. Sample loss may occur via loose or wet sands and wet clays may stick inside the sample sleeve. The advantages and disadvantages of push tube drilling are listed below in Table 1.
Table 1  Push Tube Characteristics

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provides continuous, relatively undisturbed samples/core of the soil profile;</td>
<td>Depth restriction (&lt;20m);</td>
</tr>
<tr>
<td>Fast (up to 50-75m per day), compact and mobile;</td>
<td>Unable to penetrate rock;</td>
</tr>
<tr>
<td>Can ream out afterwards with augers or larger direct push to install a monitoring well;</td>
<td>May have sample loss in loose and wet sands or unconsolidated materials;</td>
</tr>
<tr>
<td>Can usually combine with other drilling methods if necessary;</td>
<td>Sticking of moist to wet soft clays/peat within tube.</td>
</tr>
<tr>
<td>Newer rigs are often compact and remote controlled, allowing access to difficult and sensitive sites;</td>
<td></td>
</tr>
<tr>
<td>No fluids are required down the hole, which means that the analysis and logging of the samples are more accurate.</td>
<td></td>
</tr>
</tbody>
</table>

A hand auger can also be used as a non-destructive digging technique to advance the borehole depth to check for underground services; however, due to the nature of augering, services can still be ruptured using this technique. Care should be taken when using this technique (refer to Q4AN(EV)-103-PR1 for further information).

6.0 Fieldwork Instruction

(PRINT THIS SECTION FOR USE IN THE FIELD)

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

Prior to intrusive works commencing,

DBYD plans and all available private above ground and underground service plans for the Site are to be requested. Refer to Q4AN(EV)-006-PR1 Utility Clearances and Isolation, and Service Identification and Clearance Checklist S4AN-783-FM1; and

Drill Inspection checklist MUST be completed by the drill operators and an inspection of the equipment undertaken to ensure it is suitable for use.

Olfactory assessment (smelling) of soil samples shall not be undertaken due to the potential for atmospheric hazards of unknown type and concentration to be present. Only ambient odours should be recorded.

6.1 Decontamination

Any equipment that is to be used between sample locations (such as drill bit, auger and sampling shoe) shall be decontaminated prior to use and between each sample location in accordance with the following procedure.

1. Remove excess dirt with a stiff steel brush prior to decontamination, collecting any soil over a contaminated waste bag for disposal.

2. Wipe the surfaces of the equipment using a disposable alcohol wipe and dispose into a contaminated waste bag.

3. Wash the equipment using a plastic scrubbing brush in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).

4. Rinse the equipment with potable water, then with deionised water over another bucket and collect the rinse water for later disposal as contaminated waste.

5. The wash solution needs to be renewed when the decontamination process becomes ineffective, e.g. product on the equipment after rinsing or sheen in the wash solution buckets.
6. The water used for decontamination purposes should be collected in a bunded area (permanent or portable) and pumped into a liquid container for disposal offsite as a contaminated liquid if appropriate.

6.2 Detailed Procedure

This stepped guide provides the methodology for the sampling of soils utilising direct push sleeve drilling methods.

- Wherever possible, commence sampling from areas of least impact to greatest impact so as to reduce the effect of any potential cross-contamination that may occur between sample locations.

- At least the first 1.2 metres of the borehole must be advanced using non-destructive digging (NDD) techniques (hand auger, high pressure air or water knifing etc.) to confirm the absence of services at the borehole location. Check with the drillers the outer diameter of the drill string to be used and ensure that the NDD hole diameter is consistently 130% of the drill string from ground level to 1.2mbgs. The actual depth requirement of NDD may be greater depending on client requirements or proximity to services (i.e. within a critical zone). Refer to Q4AN(EV)-006-PR1 for information on Service Identification and Clearance.

- Set up a clear area for soil samples to be placed for sampling and logging. Ensure it is a safe distance from the drilling operations, site traffic, pedestrian traffic and members of the public. The work area should be clearly demarcated to prevent unauthorized and/or accidental incursions by plant or personnel. Ensure that the area is as clean as possible (laying out clean plastic is often a good idea in wet/muddy environments).

- Agree with the drillers before works start on communication signals when the rig is in operation and undergo a rig induction with the drillers. Ensure the drillers go through their pre works rig inspection and check all items on the check are complete before works commence. Clarify with the drilling contractor the intended sampling depths before drilling commences so that they can plan their works.

- The drilling contractor will place a clean disposable plastic tube (sleeve) onto the push tube inner extension rods, insert them inside the outer steel casing (rods) and then push the rods to the full length of the sleeve (1.2 m).

  **Mechanical parts may cause “pinch points” and/or entanglement of loose clothes, equipment or hair. Push tube advancement is noisy, so hearing protection must be worn.**

- Once the push tube has been advanced to the extent of a single rod length, the inner extension rods will then be withdrawn. The driller will detach the plastic sleeve containing the continuous soil core and place it in the nominated area. The driller will cut the sleeve open along its length using a designated cutter to allow logging and sampling by the site supervisor.

  **Ensure driller uses a specialised cutting tool when opening the plastic sleeves and is wearing appropriate PPE**

- A new clean plastic sleeve is inserted onto the end of the inner extension rods and reinserted into the outer steel rods to the base of the borehole.

- Continue pushing at single rod intervals, retrieving the inner sleeve after each rod. Confirm with the driller what interval he has drilled and get them to indicate the top of the sampled soil profile (some material from higher up the hole may fall into the soil bore during removal of the inner rods, and this material will sit at the top of the next soil core and should be discounted from assessment and sampling).

- Measure length of sample to determine if sample compression or expansion has occurred. If so, document this on the borehole logs and take this into consideration when logging the profile depths. See Fieldwork Notes and Records Q4AN(EV)-002-PR1 and Soil – Logging and Classification Q4AN(EV)-113-PR1 for details on field notes and logging requirements.

6.3 Sample Collection Procedure

- During sample collection disturbance to the soil matrix should be kept to a minimum when collecting the material and placing in to the sample jar(s) such that the potential for volatile organic compounds (VOCs) to volatilize is minimized during acquisition. If duplicate and triplicate samples are being taken, equal quantities of soil material should be placed into each jar from the corresponding soil horizon. This will ensure soil material from the same depth is tested by the laboratory.

- If VOCs are not part of the analytical suite, remove a sample using the trowel and place into an aluminium mixing bowl. Homogenise the sample, removing any stone or bark material prior to transfer to sample jars. Split homogenised sample mass by 33:33:33 for primary, duplicate and triplicate sampling as required. If
sampled lithology is loose i.e. sand, samples can be collected and homogenised by hand using clean nitrile gloves.

- To provide an indication of potential organic contaminants within the soils, place a small quantity of the soil into a snap lock bag prior to homogenisation (if required). Headspace measurements can be taken using a PID from the soil samples to provide an indication of volatile contamination. Soil samples should be left to volatise for a consistent amount of time between samples to ensure repeatability.

- Depending on the scope of the works (e.g. high profile site/auditor) take photographs of the soil cores and collect representative soil samples from each change in lithology and place in plastic "chip trays" with depths marked for review by a suitably qualified senior environmental engineer.

- The soil profile should be logged as sampling is occurring. All soil types, changes in colour or texture, evidence of fill material, visual or olfactory indications of contamination, depths, drilling difficulty, water inflow or loss, core loss, soil sample intervals, PID readings etc. should be recorded on a the soil bore log. Please refer to Q4AN(EV)-113-PR1 for further information as to the requirements for information to be logged.

- Soil samples should be collected at intervals as outlined in the work plan. Samples should also be collected: from the surface or immediately below any concrete/asphalt, at any change in lithology or where visual/olfactory evidence of contamination is observed (staining or odours).

- Soil samples should be immediately sealed and labelled then packed appropriately in ice, which has been picked up prior to the sampling event, in an esky for delivery to the laboratory. A copy of the Chain of Custody (COC) should be placed in a snap lock bag and put inside the esky prior to sealing the esky. Ensure the lids of the jars are sealed tight to prevent the ingress of any water associated with melting of the ice; consider placing the jars in individual snap lock bags.

- Care should be taken not to overfill the esky with samples as the samples will not cool sufficiently for analysis. A security seal should be applied to the esky together with the sampler’s details including a job number, date sampled, sampler and phone number and details of any short holding times.

**Caution**

Don’t remove compacted material such as clay from the push tube with your fingers as the push tube sleeving can have sharp edges. Use a stainless steel spatula/trowel instead. Ensure correct use of PPE (i.e. cut resistant and nitrile gloves).

- Soil cuttings should be disposed of in the appropriate manner depending on the level of contamination. Contaminated wastes should be collected in waste drums or skips and removed from site by a licensed waste contractor. Ensure the waste drums are appropriately labelled, sealed and placed in a secure area preferably on a sealed hardstand surface.

- If the borehole is for soil sampling only, backfill the borehole in order to reduce the potential for vertical migration of contamination via this pathway. Backfilling should be completed using cement grout or dry bentonite granules. If groundwater was encountered, place sand in the saturated zone. Cuttings can be used for backfill if they are uncontaminated (which is deemed as having no olfactory or visual field evidence of contamination).

- If the borehole is designated as a monitoring well installation, begin the well installation process (refer to Groundwater Monitoring Well Installation Q4AN(EV)-401-PR1). This is particularly effective in hollow stem drilling as the void in the center of the drill line can be used to install the well, without the walls of the bore hole collapsing.

**Caution**

Olfactory assessment (smelling) of soil samples shall not be undertaken due to the potential for atmospheric hazards of unknown type and concentration to be present. Only ambient odours should be recorded.
7.0 Troubleshooting

I have encountered stiff clays which are difficult to sample

Use a trowel or other tool to prise open the clay core, making sure that this tool is decontaminated between sample intervals.

**There is extensive smearing on the outside of the core**

Ensure that the smearing is removed by scraping with a trowel so as not to contaminate the soil sample collected.

I can’t obtain sufficient sample

Collect as much as possible, discuss the analytical requirements with the PM.

8.0 Revision History

<table>
<thead>
<tr>
<th>Revision date</th>
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<tr>
<td>May 2, 2016</td>
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</tr>
<tr>
<td>Aug 15, 2016</td>
<td>Section 6</td>
<td>Cautionary Note</td>
</tr>
</tbody>
</table>
1.0 Purpose and Scope
The purpose of this Fieldwork Procedure (FP) is to introduce to AECOM field staff how to collect soil samples from the subsurface using hollow auger (hollow stem) auger drilling and solid auger (solid stem) auger drilling. This FI describes the methodology of hollow and solid stem auger drilling for the purposes of collecting soil samples and installing groundwater monitoring wells.

2.0 Terms and Definitions
a. FP Fieldwork Procedure
b. LEL Lower Explosive Limit
c. NDN Non-Destructive Digging
d. PID Photo Ionisation Detector
e. PM Project Manager
f. SH&E Safety, Health & Environment

3.0 References
Standard References
a. ANZECC and National Health and Medical Research Council (NH&MRC) (January, 1992) Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites
b. AS4482.1-2005 Guide to the sampling and investigation of potentially contaminated soil Part 1: Non-volatile and semi-volatile compounds
c. EPA Publication 441 (A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes)
d. EPA Victoria, SEPP, Prevention and Management of Contamination of Land, State Government of Victoria, June 2002
g. Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1.
h. Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1.
i. Utility Clearances and Isolation Q4AN(EV)-006-PR1.
j. Introduction to Drilling Methodologies Q4AN(EV)-101-PR1.
k. Soil: Logging and Classification Q4AN(EV)-113-PR1.
l. Groundwater Monitoring Well Installation Q4AN(EV)-401-PR1.
m. Fieldwork Equipment Checklist Q4AN(EV)-001-FM1.
o. Gas Monitoring Calibration Record Q4AN(EV)-003-FM1.
p. QA/QC Tracking Sheet Q4AN(EV)-011-FM1 and
q. Borehole Monitoring/ Bore Field Log Q4AN(EV)-101-FM1.
4.0 Responsibilities

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this FP. To ensure equipment is in good working order prior to use and is maintained according to supplier’s advice. Report all anomalies to the Project Manager (PM) or the equipment supplier as soon as they are identified. Maintain accurate fieldwork data and observation records and provide to the PM for review.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Define the objectives and appropriate methodology to field staff prior to mobilisation into the field.</td>
</tr>
<tr>
<td>SH&amp;E Manager</td>
<td>The Safety, Health &amp; Environment (SH&amp;E) Manager is an assigned person for each office and is available for reviewing Safe Work Method Statements (SWMS) and Project Safety Plans, monitoring the implementation of SH&amp;E requirements, interface with project managers in matters of SH&amp;E, and investigating reports of incidents or accidents.</td>
</tr>
</tbody>
</table>

5.0 Equipment and Materials

5.1 Equipment

Equipment required to complete this task includes:
- Auger drilling rig
- Photo Ionisation Detector (PID)
- Lower Explosive Limit (LEL) Detector.

5.1.1 Photo Ionisation Detector (PID)

Refer to Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1, for applicability, operation and calibration of a PID.

5.1.2 Lower Explosive Limit (LEL) Detector

Refer to Lower Explosive Limit (LEL) Detector Q4AN(EV)-004-PR1, for applicability, operation and calibration of a LEL Detector.

5.2 Materials

Materials and consumables that may be required to complete this task include:
- Buckets
- Snap lock bags
- Potable water
- Spray bottle for deionised water
- Phosphate free detergent (e.g. Decon 90)
- Steel spatula
- Deionised water
- Solid contaminated waste bags
- Scrubbing brush
- Stainless steel trowel
- Paper towel
- Alcohol wipes
- Steel brush
- Sample jars and bottles
- Permanent Marker Pens (thick and thin)
- Contaminated waste container (for soils and liquids)
- Aluminium mixing bowl
- Digital Camera
- Ice
- Tarpaulin or pads for washing down equipment
- Pressure washer
- Esky
- Photo Board
6.0 Background

6.1 Hollow Stem Auger Drilling

Hollow auger drilling is similar to solid stem auger drilling, but can be utilised to recover ‘split spoon’ soil samples with the use of a wire-line system similar to that used in diamond drilling. Although this technique is slower and creates more spoil than direct push sampling, it is useful in formations such as sand where push tube sampling often meets with shallow refusal. Once the sample is removed the spoon is decontaminated ready for the next sample. The advantages of hollow auger drilling is that good quality samples can be obtained at depths greater than those of direct push drilling, at a reasonable cost, and the installation of monitoring wells can be performed in unconsolidated and caving sediments or fill (i.e. wet or loose sands). The advantages and disadvantages of hollow stem auger drilling are listed below in Table 1.

Table 1 Hollow Stem Auger Characteristics

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Quick and cheap</td>
<td>- Depth restriction (&lt;30m)</td>
</tr>
<tr>
<td>- Easily decontaminated</td>
<td>- Unable to penetrate rock</td>
</tr>
<tr>
<td>- Applicable on a variety of scales (large scale used in mining)</td>
<td>- Lag time between cutting and retrieval at surface results in less accurate logging of soils</td>
</tr>
<tr>
<td>- Soil sampling and installation of monitoring wells in unconsolidated and caving sediments or fill (i.e. wet or loose sands)</td>
<td>- Heaving sands (i.e. wet sands that “suck” up the auger centrepiece as the central bit is removed) can be an issue.</td>
</tr>
<tr>
<td>- Split spoon samples can be collected continually during drilling.</td>
<td></td>
</tr>
</tbody>
</table>

6.2 Solid Stem Auger Drilling

Solid augers are effective in drilling soft to medium formations such as clays and weathered sedimentary rocks. Solid augering often follows direct push sampling to increase bore diameter and allow the installation of conventional PVC monitoring wells. It is a fast and efficient method of drilling small diameter bores without introducing any drilling fluids. This method does not involve using any drilling fluid within the bore hole. Although effective to depths of 30m, solid augering is not effective in formations that are prone to collapse as there is no means of keeping the bore hole open for well installation. The advantages and disadvantages of solid stem auger drilling are listed below in Table 2.

Table 2 Solid Stem Auger Characteristics

<table>
<thead>
<tr>
<th>Advantages</th>
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</tr>
</thead>
<tbody>
<tr>
<td>- Quick and cheap</td>
<td>- Depth restriction (&lt;30m)</td>
</tr>
<tr>
<td>Solid stems are easily decontaminated</td>
<td>- Unable to penetrate rock</td>
</tr>
<tr>
<td>Applicable on a variety of scales (large scale used in mining).</td>
<td>- Difficulty installing monitoring wells in unconsolidated materials due to risk of borehole collapse</td>
</tr>
<tr>
<td></td>
<td>- Lower quality samples due to contamination / contact with outer rocks</td>
</tr>
<tr>
<td></td>
<td>- Split spoon samples can be collected, but requires the removal of augers. Lag time between cutting and retrieval at surface results in less accurate logging of soils and slowing the sampling rate down.</td>
</tr>
</tbody>
</table>
7.0 Fieldwork Procedure

(PRINT THIS SECTION FOR USE IN THE FIELD)

Any variations to this FP required to meet project specific objectives should be identified by the PM prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the PM.

Prior to intrusive works commencing:

Dial Before You Dig plans and all available private above ground and underground service plans for the Site are to be requested. Refer to Q4AN(EV)-006-PR1 – Utility Clearances and Isolation, and S4AN-721-FM1– Underground Utilities Checklist Form.

Drill Inspection checklist MUST be completed by the drill operators and an inspection of the equipment undertaken to ensure it is suitable for use.

Olfactory assessment (smelling) of soil samples shall not be undertaken due to the potential for atmospheric hazards of unknown type and concentration to be present. Only ambient odours should be recorded.

7.1 Decontamination

Any equipment that is to be used between sample locations (such as drill bit, auger and sampling shoe) shall be decontaminated prior to use and between each sample location in accordance with the following procedure.

1. Remove excess dirt with a stiff steel brush prior to decontamination, collecting any soil over a contaminated waste bag for disposal.
2. Wipe the surfaces of the equipment using a disposable alcohol wipe and dispose into a contaminated waste bag.
3. Wash the equipment using a plastic scrubbing brush in a bucket with a solution of potable water and detergent (phosphate free and biodegradable, e.g. Decon 90).
4. Rinse the equipment with potable water over another bucket and collect the rinse water for later disposal as contaminated waste.
5. The wash solution needs to be renewed when the decontamination process becomes ineffective, e.g. product on the equipment after rinsing or sheen in the wash solution buckets.

7.2 Detailed Procedure

This stepped guide provides the methodology for the sampling of soils utilising a hollow stem auger.

- Wherever possible, commence sampling from areas of least impact to greatest impact so as to reduce the effect of any potential cross-contamination that may occur between sample locations.
- At least the first 1.2 metres of the borehole must be advanced using Non-Destructive Digging (NDD) techniques (hand auger, high pressure air or water knifing etc.) to confirm the absence of services at the borehole location. Check with the drillers the outer diameter of the drill string to be used and ensure that the NDD hole diameter is consistently 130% of the drill string from ground level to 1.2mbgs. The actual depth requirement of NDD may be greater depending on client requirements or proximity to services (i.e. within a critical zone). Refer to Q4AN(EV)-006-PR1 for information on Service Identification and Clearance.
- Set up a clear area for soil samples to be placed for sampling and logging. Ensure it is a safe distance from the drilling operations, site traffic, pedestrian traffic and members of the public. The work area should be clearly demarcated to prevent unauthorized and/or accidental incursions by plant or personnel. Ensure that the area is as clean as possible (laying out clean plastic is often a good idea in wet/muddy environments).
- Agree with the drillers before works start on communication signals when the rig is in operation and undergo a rig induction with the drillers. Ensure the drillers go through their pre works rig inspection and check all items on the check are complete before works commence. Clarify with the drilling contractor the intended sampling depths before drilling commences so that they can plan their works.
- The drillers will begin augering from a minimum depth of 1.2 mbgs, or from whatever depth the NDD was done to.
Caution: If NDD unable to achieve the minimum requirement of 1.2 mbgs then work will proceed cautiously in accordance with Service Identification and Clearance Variation Form S4AN-783-FM2 and agreed methodology as approved by the PM and HSE Advisor.

As the augers rotate downwards, the soil will be spiralled up into a pile surrounding the augers. The offside is to regularly remove these piles with a shovel as drilling progresses, and dispose of via approved means (usually soil drums).

Caution: Removing the cage whilst rotating the augers is strictly forbidden. Placing hands or any part of the body past the cage is strictly forbidden.

8.0 Revision History

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<td>Aug 15, 2016</td>
<td>Section 7</td>
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</tbody>
</table>
1.0 Purpose and Scope

The purpose of this Fieldwork Instruction (FI) is to provide guidance to field staff in their supervision of the installation of groundwater monitoring wells in Australia.

This FI considers the design, materials, reporting, and recording requirements for all aspects of drilling operations. In doing so, these requirements aim to ensure:

- Well installation is completed safely and effectively;
- Well design, installation and reporting meets Australian Regulatory requirements;
- The most appropriate drilling technique is selected;
- Groundwater is protected through the installation of properly constructed wells;
- Wells are fit for purpose.

This FI applies to the installation of groundwater monitoring wells in Australia supervised by field staff. It includes groundwater monitoring wells installed by auger (solid/hollow stem), air hammer, diamond core and other drilling techniques. This FI applies to works from the time of drill rig mast raising. Due to the complexity and magnitude of the theme, this instruction does not include:

- Instructions and processes for drilling and installation of monitoring wells through gas bearing formations;
- Drilling methodologies involving primary and secondary Well Control Techniques (mud barriers and Blow Out Preventers - BOPs);
- Procurement and installation techniques for steel / stainless steel casing; and
- Pressure cement and casing perforation processes.

In this FI there are instructions for completing deep wells, which for the intent of this Instruction, the boundary between shallow and deep has been settled at 50 mBGL.

2.0 References

The following table summarises the variety of sources from which this Fieldwork Instruction is based on.

<table>
<thead>
<tr>
<th>Area</th>
<th>Title</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Minimum Construction Requirements for Water Bores in Australia</td>
<td>National Uniform Drillers Licensing Committee 2011</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>Methodology for the sampling of groundwaters</td>
<td>NT Department of Resources</td>
</tr>
<tr>
<td>Queensland</td>
<td>Monitoring Management 2009 v2</td>
<td>Queensland Department of Environment and Resource Management</td>
</tr>
<tr>
<td>General</td>
<td>Minimum Construction Requirements for Water Bores in Australia (2012)</td>
<td>National Uniform Drillers Licensing Committee</td>
</tr>
<tr>
<td></td>
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</table>


b. Photo Ionisation Detector (PID) Q4AN(EV)-003-PR1.

c. Lower Explosive Limit (LEL) Monitor Q4AN(EV)-004-PR1.

d. Planning a Fieldwork Program Q4AN(EV)-001-PR1.

e. Introduction to Drilling Methodologies Q4AN(EV)-101-PR1.
f. Soil Logging and Classification Q4AN(EV)-113-PR1.
g. Groundwater Well Development Q4AN(EV)-402-PR1.

3.0 Responsibilities

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling Contractor (non-AECOM)</td>
<td>To follow the standards of the groundwater drilling industry as expected of someone who holds a drillers license. And to follow all reasonable instructions as issued by the AECOM Fieldwork Staff.</td>
</tr>
<tr>
<td>Fieldwork Staff</td>
<td>To apply the methods detailed in this FI. To ensure equipment is in good working order prior to use and is maintained and calibrated (if required) according to supplier’s advice. To report all anomalies to the Project Manager or the equipment supplier as soon as they are identified. Maintain accurate fieldwork data and observation records and provide to the Project Manager for review. Oversee the safe execution of all field activities.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>To define the objectives and appropriate methodology to field staff prior to mobilisation into the field. The Project Manager should select the drilling contractor most suitable for the well installation works being undertaken. The Project Manager is also to have a sound understanding of the groundwater conditions on the site. Lead the health and safety expectations and culture for the project. Emphasise the safe completion of wells as being the primary project objective.</td>
</tr>
<tr>
<td>Office HSE Advisor</td>
<td>The Office Health, Safety and Environment (HSE) Advisor is an assigned person in each office and is responsible for reviewing and approving Health, Safety and Environment (HSE) Plans, monitoring the implementation of HSE Plans, interface with PMs in matters of health and safety, investigating reports of incidents or accidents and approving drilling contractors to undertake the proposed works.</td>
</tr>
</tbody>
</table>

4.0 Equipment and Materials

4.1 Equipment

Drilling and completion equipment required to complete this task includes:

- Drill rig;
- Compressor;
- Dust suppression systems (e.g. cyclones for air drilling);
- Water / mud containment systems (for coring and chips drilling);
- Cuttings containment system (e.g. removable skips); and
- Mixing tools for concrete and/or bentonite.

Optional or supplemental equipment may include a Photo-Ionisation Detector (PID) and Lower Explosive Limit (LEL) Monitor; including calibration gases for PID / LEL (regulator and hosing).

4.1.1 Photo Ionisation Detector (PID)

Refer to Photo-Ionisation Detector (PID) Q4AN(EV)-003-PR1 for applicability, operation and calibration of a PID.

4.1.2 Lower Explosive Limit (LEL) Monitor

Refer to Lower Explosive Limit (LEL) Monitor Q4AN(EV)-004-PR1 for applicability, operation and calibration of a LEL.
4.2 Materials

Groundwater monitoring well materials should be supplied by the drilling contractor. All materials must be new, clean, undamaged and wrapped in plastic. To keep consumables clean, drillers must use gloves and casing must be kept off the ground.

The materials required to perform the task includes:

- Associated drilling paraphernalia and consumables, such as:
  - Plastic sleeves
  - Slotted/blind PVC
  - Gravel, bentonite and other grouting materials
  - Tremie line
  - Measuring tape
  - Hand saw
  - Bollards and caution tape / road cones

- Fieldwork Staff material/consumables, such as:
  - First Aid Kit
  - Measuring tape
  - Disposable and cut resistant gloves
  - Decontamination fluid
  - Water Quality Meter

5.0 Background

There are five steps in the broader context of installing a groundwater monitoring well. These are:

1. Pre-mobilisation planning
2. Utility clearance
3. Drilling and sampling
4. Groundwater monitoring well installation and
5. Well development.

The ‘Minimum Construction Requirements for Water Bores in Australia’ (Ed 3, 2012) outlines some 27 principles across 18 chapters. Developed by the National Uniform Drillers Licensing Committee, the document outlines the minimum requirements for constructing, maintaining, rehabilitating, and decommissioning water bores in Australia. This edition separates these requirements into mandatory and recommendations for good industry practice.

5.1 Pre-Mobilisation Planning

Planning is critical in installing groundwater monitoring wells. Items to address prior to fieldwork mobilisation include:

- Selection of appropriate drilling methodology;
- Selection of sampling techniques and methodology;
- Conceptual understanding of the site and geological setting – the potential for site specific health and safety issues;
- Conceptual design of well;
- Application and receiving of relevant driller licenses (Class I, II, III);
- Finalisation of the AECOM Work Plan;
- Application and receiving of relevant bore construction license;
- Application and receiving of relevant road closure or other access-based permits or licenses;
- Sourcing and engagement of appropriate drilling contractor through Single Use Supplier Evaluation and Preferred Supplier processes;
- Completion of Client induction programme for all personnel involved in site operations;
- Investigate Client/Site specific requirement disposal of:
  - Derived waste (cuttings);
  - Groundwater drilling water; and
  - Development associated water.
- Organise waste/water disposal means and service providers as per site requirement;
- Development and approval of Health Safety and Environment Plan (HSEP);
- Organising equipment and contractors as outlined within the HSEP;
- Undertake office-based utility clearance processes, including obtaining Dial Before You Dig (DBYD) and other relevant service plans;
- Investigate availability of site facilities including water, power and toilets, and advise contractors of subsequent requirements (i.e. water connection fittings, generators); and
- Completion of a Procurement List containing all the necessary drilling and completion consumables (plus some contingencies) and transmit to the drilling contractor.

The hydrogeological, lithological and potential contaminant conditions, as well as the project objectives, will determine the design of the monitoring well. It is normal practice to commence the field programme with a well construction plan that can be modified based upon field observations. Fieldwork staff should make provisions to either telephone or email the lithological records to the Project Manager before well construction decisions are finalised.

For further information, refer to Planning a Fieldwork Program Q4AN(EV)-001-PR1.

5.2 Utility Clearance

The processes in which sub-surface utility clearance are outlined are detailed in Utility Clearances and Isolation Q4AN(EV)-006-PR1.

5.3 Drilling and Sampling

In terms of both Health and Safety and data quality it is important for field staff unfamiliar with drilling techniques to discuss the rig set-up and drilling method with the PM and with the driller prior to the commencement of work.

There is a wide range of drilling techniques to drill boreholes, with the selection of an individual technique, or combination of techniques depends upon the purpose of the borehole. These could include; soil sampling only, well installation, geophysical logging, monitoring in place, the geological conditions (consolidated or unconsolidated materials), sample quality objectives, health and safety considerations, and other issues such as access constraints and public disturbance (the principal drilling techniques commonly used are described later in this Section).

The ‘Minimum Construction Requirements for Water Bores in Australia’ (Ed 3, 2012), developed by the National Uniform Drillers Licensing Committee, outlines the minimum requirements for constructing, maintaining, rehabilitating, and decommissioning water bores in Australia. This edition separates these requirements into mandatory and recommendations for good industry practice.

The New Zealand Environmental Standard for Drilling of Soil and Rock (NZS 4411:2001) should be consulted when undertaking drilling work in NZ. This document includes information on regulatory requirements, drilling methodologies, and bore design and construction.

Drilling diameters should be carefully selected in the planning and design phase in order to have enough allowance in the annulus to allocate casing/screen assembly and the gravel/bentonite package. Good industry practices suggest that the hole diameter should be at least \(1\frac{1}{2} - 2\) times larger than the final casing OD.

Use of drilling additives must be in accordance with the State/Local Environmental Policies and approved by the Client. Additives must also be documented in the HSEP and in the Work Plan along with their Safety Manuals (MSDSs).

Geological logging should be undertaken in accordance with Soil Logging and Classification Q4AN(EV)-113-PR1.
5.4 Groundwater Monitoring Well Installation

For a detailed discussion on the advantages and disadvantages of various drilling methods, refer to Introduction to Drilling Methods Q4AN(EV)-101-PR1.

Groundwater monitoring well materials may be supplied by the drilling contractor. All materials should be new and undamaged (it is good practice to inspect all well materials upon delivery to the site and again immediately prior to use). All equipment and materials (except for new materials such as sand and cement grouts) should be decontaminated prior to use and stored in a fashion that should adequately protect them from contamination or damage prior to use. A site inventory checklist should be maintained and updated to make sure the required amount of consumables are available onsite. This checklist should be reviewed in conjunction with drillers and consumables ordered well in advance.

A monitoring bore well construction form must be kept on the bore log for every completed well. Specific well materials include: casing, screens, gravel pack and fine sand, bentonite seal and protective casing. A water monitoring bore (non-flowing) is shown below in Figure 1.

5.4.1 Casing

Depending on bore scope, site ground conditions, targeted formation and final proposed well TD, the monitoring bore construction should comprise a casing ranging from 50.8 mm (2 inches) to 101.6 mm (4 inches) ID, Class 18, threaded, flush jointed unplasticised polyvinylchloride (uPVC) pipe. (Conform to AS/NZS 1477 – PVC pipes and fittings for pressure applications). Casing and casing joints shall withstand the pressures imposed during the installation and operation of a water bore. Care should be taken to ensure that the monitoring well material used in the construction has sufficient chemical resistance to the ground and potential contaminant conditions. Collapse resistance of casing and pipes should be carefully reviewed before making casing selection. Alternative well casing and screen materials include polypropylene, steel, stainless steel, fibreglass, and Teflon. The availability, cost and ease of use of these materials should be evaluated against the project objectives at the proposal stage and during well installation. In addition, the selected casing material and the overall diameter should be adequate to ensure that they will fulfil the scope of work and potential future objectives.

It is important to ensure sufficient internal diameter to allow monitoring or pumping equipment to be installed in the well, and certain chemical analyses may be affected by certain well casing materials. Casing centraliser should be used for deeper wells in order to ensure plumbness and straightness of the casing into the well bore. A correct casing installation will ensure a homogeneous annulus area for the gravel installation and create a much better filter packaging around the screens.

5.4.2 Screens

Depending on the selected casing, well screens can normally range from 50.8 mm (2 inches) and 10.6 mm (4 inches) ID, Class 18, threaded, flush jointed uPVC pipe with machine cut slots from 0.1 mm to 2.0 mm width. Bore screens should be provided with secured uPVC bottom plugs. No solvents, cements, or adhesive tapes should be used to connect sections of bore screens. However, these restrictions may not apply where organic compounds are not of concern or/and where savings in cost of materials may be significant (such as deep monitoring bores). In the normal operations, well screen are factory machine-slotted. However, where it is necessary to manufacture well screen from well casing on site, slots should be cut using a clean hack-saw, they should be cut at an angle to the length of the pipe and off-set on opposite sides of the pipe.

In the deeper application, it is a good practice placing at least a 1.0 m to 3.0 m blind casing section (Zero Slot Sump). This section helps in capturing and trapping all the formation water in-suspension materials (fines) allowing for a bore longer life and cleaner sample collection.

5.4.3 Gravel Pack and Fine Sand

Gravel pack material (primary gravel pack) should be of an appropriate size range so that no significant loss of gravel pack material should occur during development (less than 10 percent loss) due to passage through the well screen slots. Screen aperture and sand diameter should be carefully selected depending on the target formation expected lithology. For most applications, a 3-4 mm washed, well rounded, well sorted quartzose sand is used with the standard 0.5 – 1.0 mm slotted screens. However, where significant clay and/or silt are present finer gravel pack may be required to prevent clogging the well. In order to obtain a functional gravel package, it is a good industry practice for the annulus to be at least four times greater than the size of the gravel (e.g. a 6 mm gravel annulus space should be at least 24 mm larger on each side). Filter socks should not be utilised without consulting the Project Manager, as they may adsorb certain contaminants and reduce the overall bore permeability by attracting and maintaining the very fine material. Placement of the gravel pack must be achieved with the use of a tremie line placed at the top of the screen zone. Gravel/sand must be poured gently and slowly through the tremie to avoid bridging conditions. Clean water pumping can help the gravel travelling in the tremie. Very fine sand (secondary gravel pack, also referred to as “blinding” sand) such as pool filter sand (0.5-2.0 mm)
should be placed on top of the gravel pack. This minimises the potential for the cement/bentonite slurry to seep into the gravel pack in situations where the sealing material (bentonite pellets or granules) has not fully hydrated.

5.4.4 Bentonite Seal

A low permeability clay (bentonite) seal should be installed above the gravel pack material to minimise the ingress of water from either an overlying water-bearing unit or surface water into the well. The seal should be formed from pure bentonite pellets/chips or from a slurry made with pure bentonite and potable water. Bentonite pellet/chip size should be selected to avoid bridging the annular space above the intended seal depth. Correct placement of a bentonite seal through a long water column, will require the use of a tremie pipe landed in the annulus and placed on top of the gravel packing zone to avoid up-hole bridging. When using a tremie pipe for either pellets or slurry, it is essential that backfilling is undertaken from the bottom-up, to minimise the potential for bridging. Most of the modern bentonite chips products are swelling retarded, for an easier and safer placement in position.

Bentonite pellets/chips placed above the water table should be hydrated after placement with potable water to ensure an adequate seal (after confirming with the PM that the addition of potable water does not compromise sampling objectives (an alternative the PM may consider is use of extracted bore water).

On sites with significant thicknesses of hydrocarbon product, be aware that bentonite pellets do not swell in hydrocarbons, and pre-wetting pellets or using a bentonite slurry may be more appropriate.

5.4.5 Protective Casing

The protective casing (also called lockable toby or well cover) is made of square steel or round steel piping with a lockable cap. The size of the protective casing will depend upon the size of the bore casing and/or of the monitoring equipment that will be installed in the well. For most applications, this is a standard, commercially available item. Dependent on the purpose of the well, it may be necessary to construct a manhole/inspection chamber around the well.
Figure 1  Groundwater Monitoring Bore (Non flowing)
6.0 Fieldwork Instruction

(Print this section for use in the field)

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

Drill cuttings from borings advanced below the hand-cleared zone that are still in fill should be examined to identify the depth of the fill/in-situ contact. The possibility of unknown deeper or unmarked services should be considered when advancing borings in fill. Indicators of fill include:

- Concrete rubble, blocks, brick fragments;
- Domestic refuse (which may also result in the presence of combustible and/or toxic hazards);
- Oil, bitumen;
- Wood pieces, wood shavings, sawdust;
- Iron fillings, nails, drums, steel bars and wire;
- Bottles, broken glass;
- Rubber, old tyres;
- Imported granular backfill materials (sand, gravel, scoria); and
- Reworked site soils (as evidenced by disrupted soil structure and/or mixed material).

See Sections 5.0 and 6.0 of this document for logging and sampling procedures.

6.1 Typical Monitoring Well Installation

The following detailed field procedures are presented for a single cased well assuming drilling is conducted utilising hollow stem augers and for multiple stage wells assuming drilling is conducted utilising rotary drilling.

For all drilling, a bore log must be completed which describes the geological material encountered and indicates the depth from which samples have been taken. It is recommended that samples, whether required for collection or not, should be taken at 1-metre intervals and at each change in the formation. Every formation encountered (soil or rock) must be thoughtfully described as per below guidelines. Bore log forms are provided in Figures 5-1 and 5-2, with an example completed form in Figure 5-3. Geological logging should be undertaken in accordance with:

- AECOM Field Logging Reference Report;
- AECOM Soil and Rock Logging Chart
  - Standard Practice for Classification of Soils, ASTM D 2487 - 06

For deeper well, or for complex geological scenarios, geophysical logs should be conducted in order to confirm formation changes depths, along with permeability characteristics. This information, together with an accurate drill log, can help to place the screen more precisely within the targeted formation.

Typical monitoring well procedures are as follows:

6.1.1 Stage 1: Borehole Stabilisation and Casing Installation

After the borehole has been advanced to the targeted depth, the hole will be thoroughly cleaned to remove any slough or drill cuttings that may inhibit the well installation. Ensure that wiper trip will be conducted in order to clear-up any possible tight spot. If hollow stem techniques are being used, the centre bit and drill rod will be removed from the centre of the auger casing. If solid stem or rotary or percussive techniques (without temporary casing) are used, the augers or drill bit and rods are removed from the hole. If temporary casing is used to support the hole, this will remain in place and will be removed as filter pack and seal is placed around the in-situ well pipe. The total depth of the completed boring, hence his stability, should be measured with a weighted tape (+/- 2 cm).
6.1.2 Stage 2: Assembly of the Well Screens and Casing

a. Handling and Preparation

The well screens, bottom plug, and casing will be steam or high-pressure water cleaned (if appropriate for the selected material using clean water from a source of known chemistry unless these materials are factory sealed in plastic). For the casing installation, personnel will wear a clean pair of cotton or latex (or equivalent) gloves while handling the assembly.

When total drilled depth confirmed ensure that a Casing Tally is completed. Drift the casing to guarantee the inside diameter and clear-up possible obstructions (cylinder or pipe -often called a rabbit- of known outside diameter are available on the market. The drift diameter is the inside diameter (ID) that the pipe manufacturer guarantees per specifications).

Clean and inspect the casing threads. Discard any lengths found to have defects. Strap and tally the casing, measuring the exact length of each section (excluding male threads). Record all findings on a Casing Tally sheet.

Ensure casing pup joints are available on site to enable correct space-out at surface.

b. Casing Joints (Couplings)

The male threaded part of each required casing coupling should be wrapped with Teflon tape. Alternatively, O-rings of known chemistry, selected on the basis of prevailing environmental or physical conditions, may be used to ensure a tight seal of flush-joint couplings. Couplings are often tightened by hand; however, if necessary, steam or high pressure water cleaned wrenches may be utilised. Precautions should be taken to prevent damage to the threaded joints during installation.

c. Setting the Well Screens and Casing Assembly

The well screens and casing assembly will be lowered inside the hollow stern augers or temporary casing or open borehole to the predetermined depth and held in position. The casing assembly may require ballast to counteract the tendency to float in the borehole, which could compromise a straight casing installation. Buoyancy factor should be counteracted by continuously filling the casing with approved water during the casing installation.

To facilitate the introduction and withdrawal of sampling devices, a straight casing installation will be ensured by using the appropriate centralisers fastened at casing joints. The deeper the well, the greater the need for the use of centralisers. Records of centraliser’s position must be kept in the Well Construction Form.

It should be borne in mind, however, that centralisers increase the potential for backfill materials to bridge in the borehole and should therefore be used with care. To by-pass centralisers during the following gravel packing and bentonite completion phase, a tremie line of adequate dimension (min 20 mm ID) must be strapped to the casing while landed. No centralisers should be placed deeper than the tremie bottom depth.

Tremie line should be landed at least 2.0 m above the proposed bentonite top depth.

The casing top termination will extend above ground and capped temporarily to deter the entrance of foreign materials during the well completion operations.

6.1.3 Stage 3: Installation of the Gravel Pack

a. Volume of Gravel Pack

The theoretical volume of gravel pack required to fill the annular space between the well screens and borehole at the proposed depth must be computed and recorded on the well completion diagram prior to start the installation. The primary gravel pack and immediately overlying secondary gravel pack should extend to at least 0.3 m, but not more than 0.6 m, above the top of the well screens, depending on conditions.

In deep wells it is good industry practice to extend the top of the gravel at least 3.0 m above the screen to improve general permeability and to allow for settlement during development.

The final upward extension of the gravel pack may be adjusted to prevent seepage from overlying hydrologic units into the zone to be monitored.

During this phase it is very important to cross check the theoretical gravel volume against the real volume poured down-hole and the gravel elevation tagged into the annulus. Minor amount of gravel poured down annulus while the proposed depth has been reached, is a clear indication of bridging process. It is recommended, in this scenario, to pour water through the tremie to help de-bridging, and in any case to complete the gravel installation with all the pre-calculated volume.

This practice is fundamental to avoid screen partially uncovered or cemented, in case of gravel de-bridging under the bentonite/cement additional weight or later on during development.
b. Placement of Primary Gravel Pack

Placement of the well screens is preceded by placing no less than 2 percent and no more than 10 percent of the primary gravel pack into the bottom of the borehole and this volume must be accounted for in the correct positioning of the screens.

The gravel pack will be added directly between the casing pipe and the auger/temporary casing/borehole wall, and the top of the gravel pack will be measured using a weighted tape. The primary gravel pack will be placed in increments as the auger/temporary casing is raised off the bottom of the hole. The gravel material should be added slowly. Frequent depth measurements to the top of the gravel pack material should be taken to monitor the level of the gravel pack material and detect any bridging. Sufficient time should be allowed for the gravel pack material to settle through the water column (if present) within the borehole before each depth measurement. Comparison of the volume of gravel added versus the top of the gravel pack should be made on a frequent basis to check for bridging.

Care should be taken to minimise lifting the casing with the withdrawal of the augers/temporary casing. To limit borehole collapse, the auger/temporary casing is usually withdrawn until the lower most point on the temporary casing or hollow-stem auger is at least 0.6 m, but no more than 1.5 m, above the gravel pack for unconsolidated materials, or at least 1.5 m, but no more than 3.0 m, for consolidated materials. In highly unstable formations, withdrawal intervals may be much less. If necessary, the augers/temporary casing may be withdrawn in increments such that the top of the gravel pack sand remains inside of the augers/temporary casing, however the possibility of lifting the casing due to sand locking should be monitored.

Clean water may be used to aid in washing the gravel pack into place. In highly unstable formations, where a collapse may occur, the hydrostatic head inside the auger may be equilibrated by adding clean water up to the water table.

c. Settlement of the Primary Gravel Pack

The method of well pre-development by mechanical surging will be used to settle the primary gravel pack around the well screens. In this method, water is forced to flow into and out of the well screens by operating a plunger (or surge block) or bailer up and down in the casing. A pump or bailer should then be used to remove the dislodged sediments following surging. Great care must be taken in the use of a surge block, as the suction created by the movement of the surge block could cause damage or collapse of the screens. In shallow wells, at the PM’s discretion, this pre-development may not be required, provided the top of the gravel pack is placed with sufficient gravel to prevent it settling above the top of the screen.

As the primary gravel pack material settles, a weighted line will be used to measure the top of the primary gravel pack as work progresses. When the primary gravel pack has settled, if needed, more primary gravel pack material will be added to a level of 0.6 m above the top of the well screens, or as required.

d. Placement of Secondary Gravel Pack

A secondary gravel pack will be installed above the primary gravel pack to prevent the intrusion of the bentonite grout seal into the primary gravel pack. To be effective, the measured and recorded volume of secondary gravel pack material will be added to extend 0.5 m to 1 m above the primary gravel pack. The method of secondary gravel pack placement will be the same as described above for primary gravel pack placement through the hollow stem auger.

6.1.4 Stage 4: Installation of the Bentonite Seal

A bentonite pellet or granule seal will be placed in the annulus between the borehole and the casing on top of the gravel pack. This seal retards the movement of cement-based grout backfill into the primary or secondary gravel packs and may also be used on its own to minimise the potential for surface water ingress into the well. The bentonite seal will extend above the gravel pack a minimum of 0.5 m. The bentonite seal will be installed by allowing bentonite pellets to free-fall through the tremie line on the inside of the auger/temporary casing/borehole. The hollow-stem auger/temporary casing will be slowly raised as the bentonite pellets or granules fill the annulus. As the bentonite pellets seal is slowly poured into the borehole, the pellets may bridge or block the annulus, and a tamper or weighted line may be necessary to tamp pellets into place. A weighted line will be used to measure the top of the bentonite seal as work progresses. If the bentonite pellet seal is being constructed above the water level, approximately 20 litres of potable water must be poured into the annulus to ensure that the bentonite hydrate (after confirming with the PM the addition of potable water does not compromise sampling objectives). Sufficient time (2 hours) should be allowed for the bentonite pellets seal to hydrate before grouting the remaining annulus. The volume and elevation of the bentonite seal material will be measured and recorded on the well completion diagram.
In deep wells where the hydrostatic head imposed by the column of cement grout is large, a major volume of bentonite sealing (up to 2.0 m) is recommended to avoid material squeezing with cement in the gravel/screen area as a consequence.

In addition, a 0.5 m to 1 m of secondary gravel pack may be placed above the bentonite seal in the same manner as described above. This secondary gravel pack will provide a confining layer over the bentonite seal to limit the downward movement of cement-based grout backfill into the bentonite seal. The volume, elevation, and gradation of this final secondary gravel pack will also be documented on the well construction diagram.

6.1.5 Stage 5: Grouting the Annular Space

Grouting, as described below, will take place in increments as the auger flights/temporary casing are removed and grout fills in the annulus between the borehole and well casing to ground surface.

a. Volume of Grout

The theoretical volume and of grout to be mixed to backfill the remaining annular space must be calculated and recorded on the well completion diagram. A contingency volume of grout (normally 20% excess on the pre-calculated volume) should be pre-mixed on site to compensate for unexpected losses. Preferably, the grout mixture will consist in 2kg of bentonite mixed with 40 kg of cement and 55 litres of water to produce 68.5 L of grout (specific gravity of 1.42 kg/L). The grout should be smooth and not contain lumps of either bentonite or cement.

The density of the grout will be checked using a mud balance. The above mix will give a percent solids slurry of 47% using the following equation:

\[ \text{Specific Gravity} = \left( \frac{\text{Weight of Solids}}{\text{Weight of Solids} + \text{Weight of water}} \right) \times 100. \]

Table 5-1 indicates different cement and cement-bentonite mixes.

<table>
<thead>
<tr>
<th>Cement 20 kg bags</th>
<th>% Bentonite/Cement Mix</th>
<th>Mass of Bentonite (kg)</th>
<th>Volume of Water (litres)</th>
<th>Specific gravity (SG)</th>
<th>Yield per bag of cement (litres)</th>
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<tr>
<td>1</td>
<td>1</td>
<td>0.2</td>
<td>17.5</td>
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<tr>
<td>1</td>
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<tr>
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<td>3</td>
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<tr>
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<td>25</td>
<td>1.44</td>
<td>31.84</td>
<td></td>
</tr>
<tr>
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<td>5</td>
<td>1.0</td>
<td>27.5</td>
<td>1.44</td>
<td>31.84</td>
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</table>

Note: A 10% or greater bentonite mix is not recommended for normal cementing operations.

Mixing Instructions – Mixing bentonite into water first and the add cement. Add more bentonite to increase viscosity.

Bentonite mixes can be affected by the quality of the water used.

Source - The “Minimum Construction Requirements for Water Bores in Australia” (Edition 3, revised February 2012, National Uniform Drillers Licensing Committee Injection Procedures.

The grout backfill will be injected under pressure to reduce the chance of leaving voids in the grout, and to displace any liquids and drill cuttings that may remain in the annulus. Grouting will be accomplished using a pressure grouting technique through a tremie pipe. The grout will be introduced in one continuous operation until full-strength grout flows out at the ground surface without evidence of drill cuttings or fluid. In deep-well installations, the grout pump may not be able to handle the high downhole pressure, and consequently, the grouting operation will need to be interrupted to raise the tremie pipe. In any case, the pipe discharge must remain submerged in the grout mixture throughout the grouting operation to avoid air bubbles.

In order to avoid overloading the previously installed bentonite pack with the cement weight, it is a good industry practice, for deeper wells, to complete a primary 6.0 m volume single slurry plug. Once the plug set up, will be possible to proceed with the cement process at surface. The settled plug will sustains the weight of the rest of the cement column up to surface. To ensure the plug has solidified properly, grout samples will be collected and used to confirm the setting and curing of the mixture.

b. Grout Setting and Curing

The casing should not be disturbed until the grout sets and cures for a minimum of 24 hours. To ensure the grout has solidified properly, grout samples will be collected and used to confirm the setting and curing of the mixture.
After approximately 12 hours, the grout settlement in the well annulus will be checked, and if needed, additional grout will be used to backfill the remaining space to just below the ground surface. Concrete should be placed in the annulus at final grade to prevent bentonite swelling above ground level.

6.1.6 Stage 6: Completion of the Surface Installation

a. Protective Casing

The protective casing should extend about 0.5 m below ground to about 0.8 - 1 m above ground or as conditions require. The protective casing should be initially placed before final set of the grout backfill. The protective casing should be sealed and immobilised in concrete placed around the outside of the protective casing above the set grout backfill. The casing should be positioned and stabilised in a position concentric with the casing. Sufficient clearance, usually 150 mm should be maintained between the lid of the protective casing and the top of the casing to accommodate sampling equipment and, in any case, to such a level as to be easily reached from the top of the protective casing. A 6 mm diameter weep hole should be drilled in the casing 150 mm above the ground surface to permit water to drain out of the annular space. Coarse sand or pea gravel or both is placed in the annular space above the weep hole to prevent entry of insects. All materials chosen will be documented on the well completion diagram. The monitoring well identification number will be clearly visible on the inside and outside of the lid of the protective casing. A well cap to prevent ingress of surface water is needed. Capped deep wells may need a pressure relief port to avoid well collapse with water level and/or barometric pressure changes.

b. Road Box

In many circumstances it will be necessary to complete the monitoring bore at road level. In these cases a road box or flush-mounted toby box will be used fully grouted and level with the surrounding surface. Flush toby boxes should be used where a trip hazard exists. A “heavy traffic” rated toby box should be used, as the lighter aluminium grade types are likely to fail.

c. Concrete Pad

A minimum 100 mm thick, 0.5 m diameter concrete pad, sloped to provide water drainage away from the well, will be placed around the well installation. In areas where surface subsidence may occur, the concrete pad will be designed with a collar surrounding the protective casing.

d. Additional Protection

In areas where there is a high probability of damaging the well (demolition sites, high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, brightly painting the toby, etc.

Wells can be made more tamper-proof with the addition of a lockable toby box and/or lockable well cap installed by the driller. Lockable well caps of the screw-in type that have with an expanding rubber seal may still be able to be prised out of a well and refitted without removing the padlock and should be considered less secure than a lockable toby. Do not spray a lubricant on a well head to free rusted locks or hinges, as this may contaminate the well.

The level of protection should meet the damage threat posed by the location of the well and the sensitivity of the project to outside interference. If no trip hazard is likely and traffic disturbance is not a constraint, the well should always be completed above ground, especially in rural areas (e.g. paddocks), sites with extensive vegetation and gravel yards where wells are very prone to becoming lost over time.

6.2 Installation and Completion of Rotary-Drilled Wells

Not all monitoring wells are drilled and installed using auger drilling methods and specific casing and well installation techniques are used when drilling using rotary percussive, rotary drilling or rotary cored wells that extend in rock or will contain a multiple installation assembly. Other drilling techniques may and will be employed in different environments and, in particular, to depths beyond the reach of auger machines. One example follows.

Three-stage wells will be installed using the following procedure:

- The installation of a surface/conductor casing to stabilise the ground and prevent erosion by the drilling medium. The surface casing is generally placed to the top of the first competent formation (a stiff clay, for instance) and then cement grouted to the surface.

- The size of the surface casing (and therefore that of the drilled hole) depends upon the size of the drill bit used to continue the drilling below the surface casing shoe. In turn, these sizes depend upon the final construction and casing sizes.
- According to the requirements of the project, the surface and intermediate casing may be of different and various materials, such as steel, fibreglass, PVC, etc.

- Centralisers must be used to keep the casing centred in the hole to allow even gravelling and grouting of the annulus around the casing.

- According to the depth of the surface casing, grouting can be carried in this basic manner:
  
  a. With the casing resting firmly on to clay beds, fill the annular space by using a tremie pipe.

- A straight cement, if strength is required, or a cement/bentonite mix if only an effective seal is required, will be used as indicated in Table 5-1.

- The cement will be allowed to cure and will then be topped up as required. A cement sample will be collected to confirm the setting and cure of the mixture.

- The minimum curing time will be 12 hours, according to the mixture used. In some occasions, cement accelerators may be used.

- Drilling will proceed from the top of the grout plug using a pre-determined bit size based on the inside diameter of the surface casing. When drilling is completed to the next targeted depth, an intermediate casing will be lowered to the bottom of the hole and the procedures described in steps 3 through 6 will be repeated for the installation of the intermediate conductor casing.

- Drilling will continue using a pre-determined bit size based on the inside diameter of the intermediate casing. The final borehole for the well completion interval will be advanced to the total depth using an air or mud rotary technique.

The installation of two-stage wells will proceed as described above, with the exception of step 6, which involves the installation of an intermediate casing. For installation of wells that are drilled through a refuse layer, a stable borehole will be constructed through the refuse layer by installing a surface casing before advancing the borehole to the total depth (Note: when refuse is encountered during drilling in HSE plan must be reviewed to ensure it addresses the actual materials encountered on-site).

6.3 Well Development

The processes in which well development are outlined are detailed in Groundwater Well Development Q4AN(EV)-402-PR1

7.0 Troubleshooting

7.1 Impenetrable ground conditions

Lithology may prevent the drill rig from penetrating the surface. This can be mitigated through pre-drilling site inspections/analysis and then selecting a suitable drilling method. Contact the PM to determine if another drilling method would be more suitable.

8.0 Records

a. FQM – Borehole/Monitoring Bore Field Log Q4AN(EV)-101-FM1

9.0 Revision History

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<th>Revision date</th>
<th>Affected sections</th>
<th>Description of change</th>
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<td>May 2, 2016</td>
<td>All</td>
<td>Conversion to AECOM Australia Pty Ltd</td>
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1.0 Purpose and Scope

To describe the procedure for completing chain of custody (COC) documentation.

This Fieldwork Instruction (FI) describes how to complete chain of custody forms and the protocols for ordering analytical analysis.

2.0 References

a. NEPC, 2013: National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1) - Amendment of the National Environment Protection (Assessment of Site Contamination) Measure 1999

3.0 Responsibilities

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<thead>
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<th>Role</th>
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<tr>
<td>Fieldwork Staff</td>
<td>Complete COC documentation for ALL samples submitted to the laboratory;</td>
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<tr>
<td></td>
<td>Complete the COC neatly, fully and appropriately; and</td>
</tr>
<tr>
<td></td>
<td>Package in a manner to ensure it reaches the laboratory in good condition.</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Notify the laboratory beforehand to expect and assignment of samples;</td>
</tr>
<tr>
<td></td>
<td>Ensure the fieldwork staff are aware of the sampling and analysis required(e.g. by providing them with a field SAP); and</td>
</tr>
<tr>
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<td>Check COC within 24 hours of reaching the laboratory for mistakes or inaccuracies.</td>
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4.0 Equipment and Materials

4.1 Equipment

No critical equipment is required for this FI

4.2 Materials

No critical materials are required for this FI

5.0 Fieldwork Instruction

Any variations to this Fieldwork Instruction required to meet project specific objectives should be identified by the Project Manager prior to fieldworks and an amended uncontrolled instruction provided to fieldwork staff. Variations made in the field by fieldwork staff should be documented in the site notes and communicated to the Project Manager.

5.1 Background

Chain of custody records are used to ensure that legal requirements for continuity are met and that any problems or discrepancies may be traced backwards from the analytical results to sampling. All parties in the chain (sampler, dispatcher, courier and laboratory) should complete the COC documentation so that it gains the status of a valid record of sample transfer to the laboratory.

It is necessary to complete COC forms for the laboratory so that the analyst is provided with relevant sampling information, including the parameters to be analysed and a record of the actual storage period prior to analysis.

A COC form needs to be completed and must be sent with the all samples. If analytical requirements are unknown a COC still needs to be completed which lists all samples and places them on hold.

The COC must be provided in our reports to be reviewed by the regulators and clients and therefore must be neatly and comprehensively completed. Poorly or untidily completed forms can give an impression that fieldwork may not have been completed to a satisfactorily standard.
5.2 Completing the Chain of Custody Form

The COC must include the following information:

- Project name and number;
- Laboratory details;
- Name(s) of sampler(s) and contact details;
- Sample type (or ‘matrix’);
- Sample identification reference (in accordance with AECOM standard procedures);
- Date and time of collection;
- Number and type of containers;
- Required analyses;
- Preservatives;
- Signatures documenting change of sample custody; and
- Known impacted samples, odour etc. (this will save time later if dilution of the samples is required.

Other information that may be required is as follows

- Quotation reference from the laboratory; and
- If you suspect that asbestos is present in the samples you must state this clearly on the COC.

Make sure to clearly write the AECOM analytical suite codes for any combined analyses suites (i.e. W-2 or S-3) from the relevant quote. This is important because AECOM has contract billing rates with certain laboratories and if we do not write the AECOM analytical code, AECOM will not get billed properly.

The COC should indicate the holding time for samples that are to be retained for a certain period. Alternatively the laboratory can be instructed to hold the samples in cold storage (“hold cold”) pending subsequent scheduling on analysis. NOTE: if sample analysis is not listed on the chain of custody, scheduling must be undertaken so that analysis can be undertaken within the analytical holding time.

Do not state which samples are for QA/QC purposes in the comments box (e.g. duplicates, rinstate etc.)

If schedule permits, it is advisable to fill out the COC electronically in Excel to alleviate any handwriting translation errors that may occur.

Check the COC carefully prior to sending to the laboratory as mistakes can be costly.

Have another individual double check your COC, verify the sample numbers, analyses, PM, and add their signature to the COC in addition to your signature.

5.3 Packing the Chain of Custody Form

Include a copy of the COC inside the esky (in a sealed plastic bag) and keep a copy in the project central file.

The cooler box containing the samples will be sealed with tape and secured with a signed custody seal and other relevant stickers (e.g. Fragile). The custody seal will provide an indication of whether the cooler was opened by unauthorized personnel. The counter signed COC from the lab should state whether the Custody seal was intact upon receipt of samples.

All COC forms are to be counter signed by the testing laboratory and emailed back to AECOM, to advise that all samples have been received and are not damaged.
6.0 Troubleshooting

The following troubleshooting guide has been prepared for some common problems encountered while completing a COC form.

I do not want my samples to be analysed, do I still need to send a COC?

1. Yes - A COC must accompany all samples, so that there is record of which samples are being sent, a record of the custody and assurance of sample integrity.

2. Record ‘HOLD’ on the COC to indicate that you wish the samples to remain on HOLD for the time being. Remember to schedule in analysis before holding times expires or otherwise inform the laboratory of the required actions (long term storage or disposal).

I can’t find the laboratory analysis reference codes or other analysis suite:

Laboratory quotes including suites and pricing should be located on your local server (soon to be available on Australia wide national Sharepoint). If you are unable to locate the most up to date version contact the laboratory and ask them to send you another copy.

7.0 Records

a. FQM – Chain of Custody Form Q4AN(EV)-007-FM1

8.0 Revision History

<table>
<thead>
<tr>
<th>Revision date</th>
<th>Affected sections</th>
<th>Description of change</th>
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<tbody>
<tr>
<td>May 2, 2016</td>
<td>All</td>
<td>Conversion to AECOM Australia Pty Ltd.</td>
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</table>
Appendix D

Field Forms
## Site Contamination Analysis – Ground Water Sampling

### WELL PURGING

<table>
<thead>
<tr>
<th>Purge Volume Calculation</th>
<th>Purge Method</th>
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<tbody>
<tr>
<td>((\text{TD} - \text{WL}) \times \frac{\text{D}}{2} \times 0.00314) = \text{Calculated Purge Volume (L)})</td>
<td>Bladder Pump, Peristaltic Pump, Foot-valve, Passive Diffusion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field Parameter Measurements</th>
<th>Time</th>
<th>Volume Purged (L)</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>Cond (µS/cm)</th>
<th>pH</th>
<th>Redox (mV)</th>
<th>Temp (°C)</th>
<th>SWL (mBTOC)</th>
<th>Flow rate (L/min)</th>
<th>Notes</th>
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**Observations during purging (well condition, turbidity, colour, odour, sheen):**

**Discharge water disposal:**
- Container
- Sanitary sewer
- Storm sewer
- Surface
- Other

### WELL SAMPLING

**Sampling Method:**
- Same as Purge method

**Sample Distribution:**
- Sample Series:
  - Sample No.
  - Vol/Cont.
  - Analysis
  - Preservatives
  - Lab
  - Comments

**Quality Control Samples:**
- Duplicate Samples
  - Original No
  - Duplicate No
- Blank Samples
  - Type
  - Sample No
- Other Samples
  - Type
  - Sample No
Photoionization Detector (Hire Unit)

Job Number/Name:

Frequency: Daily on Use or Twice Daily

<table>
<thead>
<tr>
<th>PID Serial Number</th>
<th>Date/Time</th>
<th>Fresh Air Cal.</th>
<th>Span Gas concentration (e.g. 101 ppm Isobutylene)</th>
<th>Span Gas Cal.</th>
<th>Name (print)</th>
<th>Signature</th>
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<th>Sample ID</th>
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<td>Sample ID</td>
<td>Duplicate Sample</td>
<td>Date</td>
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Serial Number: .................................................................

Frequency: After Each day in the field

<table>
<thead>
<tr>
<th>Job Number</th>
<th>Date</th>
<th>pH 4</th>
<th>pH 7</th>
<th>Temp</th>
<th>Conductivity (8000µS/cm)</th>
<th>Redox Potential (Reading)</th>
<th>Dissolved Oxygen</th>
<th>Name (print)</th>
<th>Signature</th>
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# Site Contamination Analysis Water Level Data Sheet

**Project Name:**

**Project Number:**

**Recorded by:**

**Date:**

**Instrument Model:**

**Weather conditions:**

<table>
<thead>
<tr>
<th>Well ID</th>
<th>Actual Time</th>
<th>Depth to product</th>
<th>DTW - 1st Reading</th>
<th>DTW - 2nd Reading</th>
<th>DTW - 3rd Reading</th>
<th>Well Depth</th>
<th>Well condition</th>
<th>Comments</th>
</tr>
</thead>
</table>

Notes: Measurements in m bTOC (meters below top of casing)  
DTW = Depth to Water
Serial Number: ____________________
Frequency: Daily on Use

<table>
<thead>
<tr>
<th>Job Number</th>
<th>Date</th>
<th>pH 4</th>
<th>pH 7</th>
<th>Conductivity (2767μS/cm)</th>
<th>Name (print)</th>
<th>Signature</th>
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