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Liddell and Bayswater Power Stations

Stage 2 PFAS Investigation – Part 1

AECOM

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Stage 2 PFAS Investigation

Liddell and Bayswater Power Stations

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Client: AGL Macquarie Pty Ltd and The Crown in right of NSW, acting through Treasury

AGL Macquarie ABN: 18 167 859 494

Prepared by

AECOM Australia Pty Ltd
17 Warabrook Boulevard, Warabrook NSW 2304, PO Box 73, Hunter Region MC NSW 2310, Australia
T +61 2 4911 4900 F +61 2 4911 4999 www.aecom.com
ABN 20 093 846 925

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SITE CONTAMINATION SPECIALIST
No.SC40094
CEnvP
2019

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Table of Contents

List of Figures

List of Tables

Glossary

Glossary	
AFFF	Aqueous Film Forming Foam
AGL Macquarie	AGL Macquarie Pty Limited
ALS	Australian Laboratory Services Pty Ltd
AHD	Australian Height Datum
AMG	Australian Map Grid
APECS	Additional Pre-Existing Contamination Study
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)
BoM	Bureau of Meteorology
CEC	Cation Exchange Capacity
COC	Chain of Custody
CoPCs	Contaminants of Potential Concern
CSM	Conceptual Site Model
DSI	Detailed Site Investigation
DQIs	Data Quality Indicators
DQOs	Data Quality Objectives
EC	Electrical Conductivity
ECC	Environmental Clearance Certificate
EMP	Environmental Management Plan
EPL	Environment Protection Licence
ERA	Ecological Risk Assessment
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HRSTS	Hunter River Salinity Trading Scheme
IBC	Intermediate Bulk Container
IL	Investigation Level
LDPE	Low Density Polyethylene
LOR	Limit of Reporting
mAHD	Meters Above Horizontal Datum
mbgl	Meters below ground surface
mbtoc	Meters below top of casing
NATA	National Association of Testing Authorities
NDD	Non-Destructive Digging
NEPC	National Environment Protection Council
NSW	New South Wales
OCP	Organochlorine Pesticides

Glossary	
OPP	Organophosphorus Pesticides
PAH	Polycyclic Aromatic Hydrocarbons
PFAS	per- and poly-fluoroalkyl substances
PFHxS	Perfluorohexane Sulfonic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
POP	Persistent Organic Pollutant
QA/QC	Quality Assurance / Quality Control
RPD	Relative Percent Difference
Study Area	SA
SAQP	Sampling and Analysis Quality Plan
SOP	Standard Operating Procedure
SWL	Standing Water Level
TOC	Total Organic Carbon
TDS	Total Dissolved Solids
TRH	Total Recoverable Hydrocarbons
TWP	Trade Waste Plant
USEPA	United States Environmental Protection Agency
USCS	Unified Soil Classification System
VOC	Volatile Organic Compounds
SVOC	Semi Volatile Organic Compounds

Executive Summary

AGL Macquarie Pty Limited (AGL Macquarie) and The Crown in right of NSW, acting through Treasury (The Principals) engaged AECOM Australia Pty Ltd (AECOM) to complete a Stage 2 Per and Poly-Fluoroalkyl Substances (PFAS) Investigation at Liddell Power Station (LPS) and Bayswater Power Station (BPS), together referred to as the 'Sites'. The Sites' Lot/DP boundaries, Environment Protection Licence (EPL Licence boundaries) and surrounding land, which form the Study Area (SA), are presented on **Figures F1**, **F2a** and **F2b** in **Appendix A**.

AGL Macquarie acquired the Sites on 2 September 2014 and carried out two baseline studies [(ERM (2014a) and ERM (2014b)] which, amongst other items, identified the presence of PFAS in a targeted number of locations. In response, an Additional Pre-Existing Contamination Study (APECS) was completed for the Sites in 2017 by Environmental Strategies Pty Ltd (now Arcadis Australia Pacific Pty Ltd) [ES (2017)]. The APECS identified locations across the Sites where Aqueous Film Forming Foams (AFFF) had historically been used for fire training exercises. The investigation confirmed the presence of PFAS at a number of these locations which were termed 'Areas of Identified Contamination' (AIC).

In response to these findings, the NSW Environment Protection Authority (EPA) issued letters to each power station, dated 8 September 2017, requesting that additional investigation be undertaken in areas where AFFF was used and stored to further assess the nature and extent of PFAS in environmental media.

Objectives

Principals Objective

To address the EPA's request, the Principals have the following objectives:

- To refine the existing PFAS conceptual site model (CSM) and better define the potential risk posed to sensitive off-site human health and ecological receptors.
- Make recommendations for additional investigations, if required.

Project Objective

The specific project objective is to build on the existing PFAS data set obtained during the ERM (2014a), ERM (2015b) and ES (2017) investigations by obtaining additional soil, sediment, leachate, surface water and groundwater at the existing AICs and at additional locations at the Sites.

Scope of Works

To complete the project objectives, AECOM undertook soil, groundwater, sediment and surface water PFAS assessment activities across the Study Area. The Stage 2 Investigation was undertaken over two mobilisations, with the first phase of works completed in December 2018, and the second phase of works completed in May 2019.

Conclusions

The following conclusions are made based on the data collected during the investigation as assessed against the Principals' and project objectives detailed above.

The objectives have been met by revising the CSMs, specifically based on:

- Lateral and vertical soil sampling in the AICs and surrounding areas has demonstrated that PFAS concentrations are generally less than the laboratory limits of reporting (LORs) and/or investigation levels (ILs). Where ILs are exceeded in 3 of 274 soil samples, nearby sediment and surface water results were all less than the LOR and or ILs, indicating no complete exposure linkage.
- Sampling of groundwater in the AICs and surrounding areas indicated that while PFAS has migrated to groundwater at concentrations exceeding ILs in 21 of 74 monitoring well locations,

nearby downgradient sediment and surface water results were all less than the LOR and/or ILs, indicating no complete exposure linkage. Whilst the full vertical and lateral extent of PFAS impacts may not have been fully defined at each AIC (which was not the purpose of this investigation), the refined CSMs, based on the data obtained, infer that PFAS does not appear to be impacting off-site receptors and has been assessed relative to the downgradient receptors.

- Sampling from nearby drainage lines, receiving waters and sediments has demonstrated that PFAS has not migrated from the AICs at concentrations greater than the ILs, indicating no complete exposure linkage.
- Investigation of potential off-site migration of impacts at EPL discharge points, specifically EPL8, has demonstrated that PFAS concentrations are less than the laboratory LORs at all locations, indicating no complete exposure linkage with surface water receptors.

While there is no evidence of a complete exposure linkage between the impacts reported in groundwater down gradient of AIC 17 and potential down gradient receptors, further investigation would be necessary to fully delineate the reported concentrations.

1.0 Introduction

1.1 Preamble

AGL Macquarie Pty Limited (AGL Macquarie) and The Crown in right of NSW, acting through Treasury (The Principals) engaged AECOM Australia Pty Ltd (AECOM) to complete a Stage 2 Per and Poly-Fluoroalkyl Substances (PFAS) Investigation at Liddell Power Station (LPS) and Bayswater Power Station (BPS), together referred to as the 'Sites'. The Sites' Lot/DP boundaries, Environment Protection Licence (EPL Licence boundaries) and surrounding land, which form the Study Area (SA), are presented on **Figures F1**, **F2a** and **F2b** in **Appendix A**.

1.2 Background

LPS and BPS are two active coal-powered thermal power stations, operated by AGL Macquarie, and located approximately 100 km northwest of Newcastle, in New South Wales (NSW).

AGL Macquarie acquired the Sites on 2 September 2014. As part of the acquisition, two baseline studies [(ERM (2014a) and ERM (2014b)] were carried out which identified the presence of PFAS in a targeted number of locations.

In response, an Additional Pre-Existing Contamination Study (APECS) was completed for the Sites in 2017 by Environmental Strategies Pty Ltd (now Arcadis Australia Pacific Pty Ltd) [ES (2017)]. The APECS identified locations across the Sites where Aqueous Film Forming Foams (AFFF) had historically been used for fire training exercises. The investigation confirmed the presence of PFAS at a number of these locations, which were termed 'Areas of Identified Contamination' (AIC).

In response to these findings, the NSW Environment Protection Authority (EPA) issued letters to each power station, dated 8 September 2017, requesting that additional investigation be undertaken in areas where AFFF was used and stored and that the following should be undertaken:

- Lateral and vertical soil sampling.
- Testing soils for leachate obtained using the Australian Standard Leaching Procedure (ASLP) for PFAS.
- Sampling of groundwater.
- Sampling from nearby drainage lines, receiving waters and sediments.
- Chemical analysis of the above samples for PFAS.
- Identification of sensitive receptors on off-site locations that may have been impacted by migration of PFAS from one of both of the BPS and LPS.
- Investigate potential off-site migration of impacts at EPL discharge points, specifically EPL8.
- Construction of a Conceptual Site Model.
- Recommendations for any further investigation, if required.

The letters are provided in **Appendix B**.

1.3 Objectives of the Stage 2 PFAS Investigation

1.3.1 Principals Objective

To address the EPA's request, the Principals have engaged AECOM to carry out this Stage 2 PFAS Investigation with the following objectives:

- To refine the existing PFAS conceptual site model (CSM) and better define the potential risk posed to sensitive off-site human health and ecological receptors.
- Make recommendations for additional investigations, if required.

1.3.2 Project Objective

The specific project objective is to build on the existing PFAS data set obtained during the ERM (2014a), ERM (2015b) and ES (2017) investigations by obtaining additional soil, sediment, leachate, surface water and groundwater at the existing AICs and at additional locations at the Sites.

1.4 Scope of Works

A summary of the scope of work performed in the Stage 2 PFAS Investigation is provided below. The field program was carried out in two mobilisations, 13 November 2018 to 20 December 2018; and 6 February 2019 and 15 April 2019. All work was conducted in general accordance with the Sampling and Analysis Quality Plan (SAQP) (AECOM, 2018). Deviations from the SAQP are detailed in **Section 8.0**.

1.4.1 Soil and groundwater sampling:

- Underground service clearance at all intrusive sampling locations;
- Non-Destructive Digging (NDD) and/or hand augering at all intrusive sampling locations;
- Mechanical drilling using a Sonic Drill Rig at locations designated for deep (> 1.5 m below ground level) soil bores and/or groundwater monitoring well installation.
- Lithological logging of the soil and/or rock profile encountered at each intrusive sampling location;
- Installation of 25 new groundwater monitoring wells;
- Collection and analysis of 276 soil samples from 117 soil bores;
- Collection of groundwater samples from 49 existing monitoring wells and from 25 newly installed wells.

1.4.2 Surface Water and Sediment Sampling

- Collection of co-located surface water and sediment samples; 83 surface water samples from 48 locations, and collection of 55 sediment samples from 41 co-located sampling locations;
- Collection of field measured surface water geochemical parameters;
- Recording of GPS coordinates for all surface water and sediment sampling locations.
- Characterisation and disposal of waste soil and groundwater by a licenced waste contractor.

1.4.3 Laboratory Analysis

- Laboratory analysis of selected soil, groundwater, surface water, and sediment samples for the full suite of PFAS compounds.
- Analysis of 29 primary soil and sediment samples for PFAS concentrations using demineralized water to replicate pH neutral conditions. These samples were collected from the upper unsaturated soil profile. These soil data were compared with groundwater PFAS guidelines to assist the understanding of the potential for an on-going secondary source of PFAS impacts from migration from soil to groundwater.

1.4.4 Waste Disposal

- Collection of all soil, water and sediment waste into bunded 200 L drums located on pallets, in designated areas of the site.
- Collection and disposal of these drums by a licensed waste contractor.

2.0 Data Quality Objectives

The amended National Environment Protection (Assessment of Site Contamination) Measure (ASC 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 ASC NEPM and the NSW EPA Guidelines for the NSW Site Auditor Scheme (3rd edition),, 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 1 The seven steps in defining DQOs

Step	Data Quality Objective Step
1	***State the problem*** – Define the problem that necessitates the study; identify the planning team, examine budget, schedule.
2	***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.
3	***Identify information inputs*** – Identify data and information needed to answer study questions.
4	***Define the boundaries of the study*** – Specify the target population and characteristics of interest, define spatial and temporal limits, scale of inference.
5	***Develop the analytic approach*** – Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings.
6	***Specify performance or acceptance criteria*** – Develop performance criteria for new data being collected or acceptable criteria for existing data being considered for use.
7	***Develop the plan for obtaining data*** – Select the resource-effective sampling and analysis plan that meets the performance criteria.

The approach adopted relative to the seven steps presented above is detailed in the SAQP (AECOM, 2018) and summarised below.

2.1 Step 1 – State the Problem

Detections of PFAS concentrations have been reported in soil, groundwater, surface water and sediments in and around areas of historic use of AFFF (designated as AICs) at the Sites.

PFAS impacts have the potential to migrate off-Site from these AICs via groundwater, sediment and surface water where it may interact with surface water receptors (Lake Liddell, Bayswater Creek and Hunter River) and subsequently pose a potential risk to off-Site receptors.

The problem is:

- PFAS presence has previously been confirmed on-Site in groundwater, soil, surface water and sediment, its nature and extent is not fully understood, and the potential risks to off-Site receptors is currently not fully understood; and
- The potential for migration of PFAS from AICs into groundwater and subsequently into surface waters of Lake Liddell, Bayswater Creek and onto the Hunter River is not fully understood; and

- The exposure link between PFAS in the environment and human and ecological receptors is unknown.

2.2 Step 2 – Identify the Goal of the Study

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

The primary questions to be addressed include:

- What is the extent of on-Site PFAS impacts in the groundwater, surface water, and/or sediment in association with historic sources of AFFF at the Site?
- Does migration of impacts pose a risk to on and / or off-Site receptors?
- How do PFAS concentrations inform the understanding of the nature and extent of PFAS impact?
- What are the potential human and ecological risks?

The data collected to answer these questions are intended to subsequently be used in refining the CSM and informing future on and off-Site investigation works, if deemed necessary.

The Principals 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 data valid and sufficient to undertake a human health and ecological risk assessment, if required?
1. Are the laboratory Limits of Reporting (LORs) appropriate for the objectives of the investigation?
2. Are concentrations of PFAS present within the boundaries of the investigation (see Step 4) above greater than laboratory LORs for PFAS?
3. Has the extent of the PFAS (as evidenced from presence in multiple sample media) been defined?
4. Is the investigation approach scientifically suitable and defensible?

2.3 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 investigations results by others (see **Section 3.1**) and other data collected across the Study Area. 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 outlined in **Section 7.0 Approach and Methodology**;
- Results of analysis of samples to be collected as proposed in **Section 7.0 Approach and Methodology.**

2.4 Step 4 – Define the Boundaries of the Study

The spatial boundaries are:

- Lateral: on-Site areas are defined by the EPL associated with each of the Sites. Within each Site are specific AICs in which impacts requiring further investigation have been identified. Off-Site areas include the down gradient / downstream locations which could be affected by contaminant migration, and are shown on figures in **Appendix A**. The lateral extent is defined as the SA.
- Vertical:
  - Soil samples were collected from boreholes designated as "shallow", with a maximum depth of 1.5 m below ground level (mbgl) at approximately 0.5 mbgl and 1.5 mbgl, or on refusal. Soil samples were collected from boreholes >1.5 mbgl, designated as "deep", at depths of 0.5 mbgl, 1.0 mbgl, 1.5 mbgl, 2.0 mbgl and then approximately at every 1.0 mbgl, until reaching the final target depth.
  - Groundwater samples have been collected from monitoring wells installed at various depths with the purpose of assessing the vertical extent of PFAS compounds. Sampling depths varied spatially as follows: samples were collected from the centre of the screened interval in 49 groundwater locations; the remaining 24 groundwater locations had two samples collected at depths representative of the top and bottom of the screened interval, (circa 2.5 m and 0.5 m from the well base).
  - Surface water samples were collected, where permissible by the environmental/access conditions at a point near shore and just below surface level.
  - Sediment samples were co-located with surface water samples and collected between 0.1 and 0.15 mbgl.

Temporal boundaries are limited to the fieldwork timeframes across two mobilisations: the first mobilisation occurred between November and December 2018, the second mobilisation occurred between January and May 2019. Historical data may be considered in assessing temporal trends in contaminant concentrations.

The final location of boreholes was dependent on a number of factors, including: the presence of adequate flat, firm ground to place a drill rig safely, proximity to traffic and incorporation of new data.

2.5 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 investigation levels (ILs) 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 ILs in the samples applicable to a specific pathway, then it will be considered that there is no evidence of a complete source-pathway-receptor linkage and, therefore, inclusion of that pathway in the assessment of risk assessment will not be required.

The decision on the acceptance of the analytical data was 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
- **Comparability**: The confidence (expressed qualitatively) that data may be considered to be equivalent for each sampling and analytical event..

2.5.1 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
- The RPDs were assessed as acceptable if less than or equal to 30% as per the ASC NEPM Schedule B3. Where the results show greater than 30% difference, a review of the cause was 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%
  - Heterogeneous materials are encountered and adequately documented.

2.5.2 Accuracy (Bias)

The closeness of the reported data to the "true" value was 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
- Laboratory control samples.

2.5.3 Representativeness

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

- Sample locations were designed to provide representative samples of the locations being sampled (refer to sample rationale provided in **Section 8.1**
- 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 appropriateness of collection methodologies, as well as handling, storage and preservation techniques were assessed to ensure/confirm there was minimal opportunity for sample interference or degradation.
- Blank samples were 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

2.5.4 Completeness

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

- Whether data have generated in accordance with the SAQP, to enable valid and defensible 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; and
- Whether the Data Quality Indicators have been met.

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.

2.5.5 Comparability

Issues of comparability between historic data sets were reduced through adherence to SOPs and regulator endorsed or made guidelines and standards for each data gathering activity.

In addition, the data was collected by experienced AECOM field staff, and all laboratory analysis conducted by National Association of Testing Authorities (NATA) accredited in all laboratory programs for soil, sediment and surface/groundwater analysis.

2.6 Step 6 – Specify Performance or Acceptance Criteria

Specific limits for this investigation 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 collected data. This includes 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 outlined minimum numbers of samples proposed to be collected from each media. As such, limitations in the data due to aspects of the SAQP which were not able to be implemented **Section 8.1**
    - Proposed surface water sample locations which were dry at the time of sampling
    - Proposed soil samples not collected due to refusal during drilling.
- Limitations in ability to acquire useful and representative information from the data 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 were implemented:
    - Field staff followed 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.
    - Laboratory assurance that a standard procedure is followed when preparing samples for analysis and undertaking analysis.
    - Laboratories reported quality assurance/ quality control data which were compared with the DQIs established for the project.

2.7 Step 7 – Optimise the Design for Obtaining Data

Optimisation of the data collection process was achieved by:

- Working closely with the analytical laboratories and sampling equipment suppliers to ensure that appropriate procedures and processes were developed and implemented prior to and during the field work, ensuring that sample handling, and transport to and processing by the analytical laboratories is appropriate.
- Sampling was conducted according to set SOPs for the type of sampling being conducted (e.g. groundwater monitoring well sampling). SOPs are presented in the SAQP (AECOM, 2018).

2.8 Assessment of Data Quality

The quality of data collected as part of the sampling has been assessed as detailed in **Section 2.7**. The 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 2**.

Table 2 Acceptance Criteria for Data Quality Indicators for Sample Analysis

Data Quality Indicators	Acceptance Criteria
Water, Sediment and Soil Samples	
Rinsate (where sampling equipment is reused)	Less than the laboratory LOR.
Field duplicates/Inter-lab duplicates	The RPDs will be assessed as acceptable if less than or equal to 30% as per the ASC 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: • 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.
Laboratory duplicates	RPDs less than: • 20% for high level laboratory duplicates (i.e. >20 x LOR); and • 50% for medium level laboratory duplicates (i.e. 10 to 20 x LOR).
Matrix spikes	Recoveries between 70-130% of the theoretical recovery or as nominated in the laboratory's QC report, based on their historical database.
Method blanks	Less than the laboratory LOR.
Laboratory control samples	Recoveries between laboratories specified range for each particular analyte / analytical suite.

3.0 Sites and Study Area Identification

3.1 Sites Identification

LPS and BPS are coal-powered thermal power stations with electrical output capacities of 2,000 and 2,640 megawatts, respectively. The Sites are located adjacent to each other between Singleton and Muswellbrook in the Upper Hunter Valley of NSW, approximately 100 km northwest of Newcastle. Both BPS and LPS are operated by AGL Macquarie, one of Australia's major electricity generators, and are described in **Table 3** Figure 1 in Appendix A shows an overview of the study area.

Table 3 Sites Description

Site	Description
LPS & Lake Liddell	LPS is located 15 km south east of Muswellbrook and occupies total area of approximately 1500 hectares. The operating area of the Site is surrounded to the north, east and south by Lake Liddell, and New England Highway is located west of the Site. Beyond the highway are the Liddell Ash Dam and associated coal loading operations. Lake Liddell was constructed in 1971 for the purpose of providing water cooling and storage for LPS operations, and subsequently started servicing BPS from its commission in1985. The operational area of LPS occupies approximately 700 hectares and includes coal stockpiles and conveyors, electricity generator units and transmission infrastructure, bulk fuel transfer and storage facilities, waste water treatment facilities, plant maintenance workshops and administration offices. The balance of the Site comprises AGL Macquarie-owned buffer land, which incorporates farming areas and surrounding coal mines. An aerial view of the LPS is shown in **Figure 2a** in **Appendix A**. LPS' operational areas are zoned 'SP2: Infrastructure' in the Muswellbrook Local Environmental Plan (LEP) 2009 (LEP, 2009), while the surrounding buffer areas are zoned as 'RU1: Primary Production'. The north western shore of Lake Liddell, which was publicly accessible, is zoned 'RE1: Public Recreation'. Lake Liddell itself is permanently closed to public access due to the detection of the harmful amoeba *Naegleria fowleri*, a naturally occurring organism which has not been introduced to the environment by Sites' activities[1].
BPS	BPS is located 3 km south west of LPS on the western side of the New England Highway and has a total area of approximately 8300 hectares. The operating area of the Site is surrounded by the Bayswater Liddell Freshwater Dam to the west, the Bayswater Ash Dam to the east, and predominantly bush- and grassland to the north and south. The operational area of BPS occupies approximately 300 hectares and includes coal stockpiles and conveyors, electricity generator units and transmission infrastructure, water cooling towers, bulk fuel transfer and storage facilities, waste water treatment facilities, plant maintenance workshops and administration offices. A location map of the BPS is shown in **Figure F2b** in **Appendix A**. Similarly to LPS, the non-operational areas of the site comprise of buffer land that incorporates farming and coal mining operations. The Site's operational areas are zoned 'SP2: Infrastructure' in the LEP (2009) while the surrounding buffer areas are zoned as 'RU1: Primary Production'.

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[1] https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2016/march/update-on-lake-liddell-closure

3.2 Study Area Identification

The Study Area (SA) is defined as the area within the EPL boundaries of the Liddell (EPL 2122) and Bayswater (EPL 779) Power Stations. In addition to the operational areas and buffer land of each Site, the SA encompasses some area surrounding the Hunter River, including discharge point EPL 8 which is within the Hunter River Salinity Trading Scheme (HRSTS) catchment. The features of the SA are described in **Table 4** below and shown within the EPL boundaries in **Figure 1**, **Appendix A**.

Table 4 Study Area Features

Aspect	Details
AICs	Within the SA are specific AICs in which impacts identified in the Stage 1 Investigation (ES, 2018), requiring further investigation have been identified. The boundaries of the five AICs across the SA are shown in the LPS **Figure 2a** and BPS **Figure 2b** (**Appendix A)**, and described below. LPS • Northern Peninsula (AIC NP): a low lying grassed peninsula of approximately 8 ha, to the north of LPS, on the shores of Lake Liddell. It is located immediately west of the Lake Liddell process water intake. Firefighting training was conducted on the southern side of the NP. • AICs 93, 94, 95 and 96 (AIC 93-96): these four AICs are located adjacent to each other and have been investigated as one area. AIC 93 contains decommissioned fuel tanks E & F, AIC 94 includes the chemical drain outlet from the Water Treatment Plant (WTP) and AIC 95 has interceptor pits capturing discharge from LPS prior to entering Lake Liddell. PFAS-containing AFFF was used during firefighting training activities conducted across the grassed area and in the tank farm. BPS • AIC 11W: a grassed, level area of ~ 0.8 ha (**Figure 7**). Firefighting training activities using AFFF were conducted across the grassed area; several fire hydrants are also present in the area. • AIC17: the area includes transformers and infrastructure on concrete hardstand at the southern end of the plant; it also comprises a 'clean' and 'contaminated' stormwater system moving surface water runoff into the EPL discharge point and the contaminated water system, respectively. Firefighting activities with AFFF were carried out on infrastructure in this area. • AICs 51 and 52 (AIC 51-52): two AICs investigated / reported as one area. Specifically, AIC 51 comprises of a Diesel Tank Overflow Pond, an unlined settling pond catching surface runoff from the diesel AST bunds within AIC 52. Pond over flows into a dry gully and into the Ash Dam. AIC 52 is the BPS tank farm with a concrete hardstand and is fitted with extensive fire suppression system throughout the tank farm. Firefighting activities and testing using AFFF are known to have occurred around the diesel tanks, and testing of the AFFF deluge system was conducted regularly at AIC 52.
Study Area Outside AICs	The areas outside the AICs include those areas down gradient / downstream of the AICs which could be affected by contamination migration and subsequently pose a potential risk to off-Site receptors. The investigation works outside the AICs are comprised of the following, grouped by general area: LPS • Skimmer Dam • Seepage to Drayton Levee • V-Notch Weir Seepage • Tinkers Creek

Aspect	Details
	• EPL Discharge Point #12 • EPL Discharge Point #13 BPS • Tinkers Creek: downgradient of AIC 11W and AIC 17 • Coal Pad Settling Pond • EPL Discharge Point #7 • Discharge to Tinkers Creek • EPL Discharge Point # 8 • Seepage from AIC 51-52: downgradient of AIC 51-52 • Ash Dam Seepage Collection • Pikes Gully • Bayswater Creek Hunter River • Bayswater Creek near BPS Ash Dam: downgradient of AIC5152 • Plashett Reservoir near dam • Bayswater Creek near the Hunter River: downgradient of AIC11W and AIC17 • Hunter River at the abstraction/discharge point • Hunter River downstream • Hunter River upstream

4.0 Previous Investigations

The following summary provides the PFAS related scope of work and results from the previous investigation conducted at LPS and BPS.

4.1 ERM, 2013a – Liddell Power Station Preliminary Site Assessment

ERM was commissioned to provide advice in relation to potential soil and groundwater contamination which may be relevant to the sale of certain electricity generation assets owned and operated by Macquarie Generation. The Preliminary Site Assessment (PSA) identified 22 Areas of Environmental Concern (AECs), with one relating to PFAS, and proposed a Stage 2 intrusive works programme including PFOS and PFOA sampling of nine soil bores and 17 groundwater monitoring wells of maintenance stores, workshops, foam generator and lay-down areas.

4.2 ERM, 2013b – Bayswater Power Station Preliminary Site Assessment

ERM was commissioned to provide advice in relation to potential soil and groundwater contamination which may be relevant to the sale of certain electricity generation assets owned and operated by Macquarie Generation. The PSA identified 25 AECs with one relating to PFAS, and proposed a potential Stage 2 intrusive works programme including PFOS and PFOA sampling of seven soil bores and six groundwater monitoring wells in the in the Transformer Area.

4.3 ERM, 2014a – Liddell Power Station Stage 2 ESA

ERM was commissioned to undertake a Stage 2 Environmental Site Assessment (ESA) at LPS, which included the investigation of 22 AECs, with one related to PFAS, primarily via sampling and analysis of soil and groundwater. A total of 25 soil investigation bores, of which 14 were completed as groundwater monitoring wells, were installed within this AEC. The ESA identified the presence of PFAS in groundwater samples from five monitoring wells surrounding the area containing the former and current maintenance workshops, foam generator and an unofficial laydown yard. Acceptance criteria were not adopted for comparison with these samples, however the ESA concluded overall that no contamination issues required material management or remediation providing the Site continues to operate as a power station.

4.4 ERM, 2014b - Bayswater Power Station Stage 2 ESA

ERM was commissioned to undertake a Stage 2 ESA at BPS, which included the investigation of 25 AECs, with one related to PFAS, primarily via sampling and analysis of soil and groundwater. A total of 13 soil investigation bores, six of which were completed as groundwater monitoring wells, were advanced within this AEC to assess potential impacts to soil and groundwater. PFOS was analysed for soil and groundwater within the transformer area. The report lists one groundwater sample above LOR within this area (BL_MW05 - 0.12 µg/L). The supplied report did not have analytical tables attached to cross check other locations.

Generally the report concluded identified soil and groundwater impacts are unlikely to represent a risk to human health and/or the environment based on the current and continued use of the Site as a power station.

4.5 Environmental Strategies, 2018a - Liddell Power Station APECS

Sixty three AECs were investigated at the LPS Site which included the excavation of 19 test pits, advancement of 123 soil bores (46 of which were converted to groundwater monitoring wells), and environmental sampling of soil, groundwater, surface water and sediment. An additional, targeted investigation was also completed for selected AECs and a number of additional AECs. PFAS were detected at the following locations:

- AEC 86: Demineralisation plant located immediately south of the AEC 106 (Site transformers);
- AEC 93: Old fuel tanks located in the south eastern portion of the operational Site area;

- AEC 94: Chemical drain outlet from the Water Treatment Plant, located east of AEC 96 on the edge of Lake Liddell;
- AEC 95: Interceptor pits located adjacent to AEC 94;
- AEC 96: Fuel Tanks located in the south eastern portion of the operational Site area;
- AEC 96: Fuel Tanks located in the south eastern portion of the operational Site area;
- AEC 106: Transformers and foam generators used for fire suppression located adjacent to the substation;
- Northern Peninsula: Historic fire-fighting training area located north of the substation; and
- Between AECs 101 and 106: The area comprising central LPS operations.

PFAS were detected in groundwater samples from monitoring wells within AECs 86, 93, 94, 95, 96 and at two locations not designated AECs (the Northern Peninsula and between AECs 101 and 106).

PFAS as PFOS was detected above acceptance criteria for ecological protection in 13 of 49 groundwater samples collect from AECs 93, 95 and 96. Eight of these samples also exceeded acceptance criteria for the protection of human health.

PFAS as PFOA was detected above acceptance criteria for human health in one groundwater sample collected within AEC 95.

PFAS concentrations above the laboratory limit of reporting (LOR) were detected in the majority of soil samples collected from AECs 95 and 96. No soil samples exceeded adopted acceptance criteria for PFAS.

4.6 Environmental Strategies, 2018b - Bayswater Power Station APECS

Environmental Strategies investigated 74 AECs across the BPS Site. This included the advancement of 159 soil bores (95 of which were converted to groundwater monitoring wells), excavation of 26 test pits, and environmental sampling of soil, groundwater, surface water and sediment. An additional, targeted investigation was also completed for selected AECs and a number of additional AECs. PFAS were detected at the following locations:

- AEC 11W: A fire-fighting training area in the north east portion of the operational area of the Site, located between the contaminated water pond (AEC 11) and treated water pond (AEC 12);
- AEC 17: The area between the southernmost cooling towers where Site transformers are located; and
- AECs 51 and 52: Diesel tank storage area and associated overflow pond located south of the operational Site area.

PFAS were detected in two shallow soil samples within AEC 11W, one sediment sample collected within AEC 51 and in groundwater samples collected from AEC 17, AEC 51 and AEC 52. No PFAS concentrations exceeded the adopted acceptance criteria.

4.7 ERM Environmental Strategies, 2018c – Lake Liddell APECS

Twenty eight (28) sediment samples and 26 surface water samples were collected within the general Lake Liddell area. Thirty six surface water samples were also collected from locations potentially discharging into Lake Liddell, and additional 6 sediment and 8 surface water samples were collected from discharge points sourced from the BPS. Two sediment and surface water samples were also collected between Lake Liddell and the Northern Peninsula.

PFAS as PFOS was detected in one sediment sample collected from a location adjacent to the Northern Peninsula. This sample did not exceed the adopted acceptance criteria for PFAS.

PFAS as PFOS was detected in a surface water sample from adjacent to the Northern Peninsula at a concentration equal to the adopted acceptance criteria.

5.0 Environmental Setting

5.1 Topography

LPS is located in a natural depression at an elevation of approximately 140 m Australian Height Datum (mAHD). The power station area is relatively flat, gradually sloping up to the north and west, and gently sloping down to Lake Liddell to the east. The BPS is also located in a natural depression at an elevation of approximate 190 mAHD. The power station area is relatively flat, gradually increasing in elevation to the south and west, and gently sloping down towards the north and east.

5.2 Climate

The SA is located in a region with a temperate climate. The closest open weather station on the Bureau of Meteorology (BoM) website that provides climate data is St Heliers (station 61374) located approximately 25 km northeast of the SA. The mean annual rainfall at this station is 618.3 millimetres, based on data between 1993 and 2018, with monthly totals being relatively higher in late spring, summer and early autumn months Mean monthly rainfall is shown below in **Table 5**.

The regional area has a relatively high mean maximum temperature in summer (31.4 C in January) and cool mean minimum temperatures in winter (4.7 C in July) based on data between 1953 and 2018.

Evaporation data are not available at this meteorological station; however, the Climatic Atlas of Australia – Evaporation (BoM 2001) indicates that the annual average potential evaporation is around 1300 millimetres for the region.

Table 5 Mean monthly rainfall at St Heliers (61374)

	January	February	March	April	May	June	July	August	September	October	November	December
Mean monthly rainfall (mm) (61374)	60.0	62.2	59.3	37.1	42.5	51.9	37.1	40.3	44.2	44.9	74.3	64.0

5.3 Geology and Hydrogeology

5.3.1 Regional Geology

The Sites are underlain by the late Permian Wittingham Coal Measures, consisting of marine sediments of sandstone and siltstone overlain by coal seams, siltstone, lithic sandstone, shale and conglomerate (Geological Survey of NSW, 2003). The Hunter Coalfield Regional Geology 1:100 000 Geological Map (Department of Mineral Resources, 1993) further indicates that Quaternary age alluvial sediments comprising silt, sand and gravel, are associated with Bayswater Creek and the Hunter River.

5.3.2 Regional Hydrogeology

The Site is located within the northern part of the Sydney Basin which is characterised by Permian and Triassic aged sedimentary rocks with overlying localized Quaternary alluvial deposits. The regional hydrogeological units within the sediments are predominately fresh water with some marine, terrestrial and coal deposits. Yields are generally low in the sedimentary units, increased by faulting and fractures (Commonwealth of Australia, 2018). Water quality in the marine sequences and coal measures is generally saline and thought to have an influence on the overall water quality of the

Hunter River (Kellett et al., 1989). The alluvial deposits are composed of clays, silts, sands and gravels with variable permeability. The Hunter River alluvial aquifer is part of the Hunter Valley Alluvium aquifer which is an important groundwater management unit (GMU) in the region.

Groundwater recharge in the sedimentary unit is estimated at less than 2% of annual rainfall, increasing in areas of increased permeability (Commonwealth of Australia, 2018). In addition the alluvial aquifers receive recharge from adjacent river flow, increasing during flood events. Groundwater discharge forms river baseflow throughout Hunter River alluvial aquifer.

The SA is underlain by the Permian sedimentary unit with some alluvial units in the surrounding creeks and rivers.

5.3.3 Site Geology

LPS and the northerly adjacent areas of Lake Liddell are shown on the Muswellbrook 1:25 000 Geological Sheet 9033-11-N (NSW Department of Mineral Resources) as being underlain by Permian Age Mulbring siltstone comprised of dark grey shale and siltstone.

A cross section running northeast-southwest, between where LPS and BPS are now located, was produced by the Electricity Commission of NSW (1961) during geotechnical investigations, prior to construction of LPS and the damming of Lake Liddell. The cross-section indicates the local area is generally comprised of weathered sandstones and siltstones overlain by natural clayey sand/sandy clay.

ERM (2014a) provided a generalised description of the local geology describing disturbed areas at both LPS and BPS as fill or reworked natural weathered soils and rock overlying bedrock. To the east of LPS it was noted that variable types of fill material from across the Site, such as virgin excavated natural material, coal fines, ash dredged, material from the grit trap and general rubbish, were used to extend the shoreline. Undisturbed areas were described as comprising shallow native soils and alluvial deposits overlying sandstone and siltstone bedrock. A summary of the lithology for LPS and BPS is provided in **Table 6** and **Table 7**.

Table 6 General description of the LPS lithology (ERM, 2014a)

Lithology	Description	General Depth (mbgl[1])
Hard stand (operational areas)	Concrete or bitumen.	0.0 – 0.4
FILL	Reworked natural material comprised of silty clay, clay and/or gravel, brown or brown with orange or grey mottling.	less than 2.5
Silty CLAY	Orange-brown with grey mottling and light brown with grey mottling, moist with weathered shale or siltstone gravel inclusions.	0.5 – 1.0
Bedrock	Siltstone, shale or sandstone bedrock, brown grading to grey with depth, generally dry and fine grained.	1.0 - 20

Table 7 General description of the BPS lithology (ERM, 2014a)

Lithology	Description	General Depth (mbgl[1])
Hard stand (operational areas)	Concrete	0.0 – 0.2
FILL	Reworked silty clay, clay and/or gravel, brown or brown with orange or grey mottling, dry to moist non-plastic, no odours or staining.	less than 5 (3.5 mbgl within main operational areas)
Silty CLAY	Orange-brown with grey mottling and light brown with grey mottling, moist, shale or siltstone gravel inclusions (completely weathered).	0.5 – 1.0
Bedrock	Siltstone, shale or sandstone bedrock, brown	1.0 - 30

Lithology	Description	General Depth (mbgl[1])
	becoming grey with depth, generally dry and fine grained.	

5.4 Surface Water

There are a number of surface water bodies at LPS and BPS, some of these form part of the on-Site water process systems, which provide cooling and process water to the power stations.

Clean stormwater from the southern section of the operational area of BPS reports to the Environmental Protection Licence (EPL) discharge point #1. A section of the stormwater drain system at the western end of the operational area of BPS reports through a drain to the coal pad settling basin along with all stormwater from the northern section of the station, around the garage. Water from all the contaminated stormwater drains reports to the contaminated water system, into the treatment system and onto the coal settling basin.

The coal settling basin reports to Tinkers Creek through EPL discharge point. Water entering the drainage channel, which surrounds the coal pad, reports to the settling pond to the northwest of the coal pad and spills via a weir into the EPL discharge point and onto Tinkers Creek. Tinkers Creek collects water from several EPL discharge points on-Site before draining into Lake Liddell.

LPS predominantly discharges clean water directly into Lake Liddell.

Water from Lake Liddell is used throughout LPS and BPS as process water and combined with ash to create a slurry that can be deposited into the Ash Dam. AGL have advised that both the Lake Liddell and Ash Dam walls have a seepage collection system for seepage occurring through the dam walls towards Bayswater Creek and Drayton Levee respectively.

5.5 Historical AFFF Use Review

A review of the available historical information (ERM, 2014a and 2014b; ES, 2018) indicated that AFFF formulations have historically been used within the SA for firefighting training and firefighting purposes.

The SA was designed based on the water flow paths (local and regional) as well as preliminary results for PFAS concentrations in soil, groundwater, surface water and sediment from previous investigations giving consideration to areas where fire retardants may have been stored or used.

5.5.1 Liddell Power Station

A foam generator used for firefighting suppression is located at Liddell Power Station, however, there is limited information on historical use, and quantities of release (if any) relating to firefighting activities and training. It should be noted that the specific foam formulations contained within the foam generator are unknown. An investigation completed by ERM in 2013 (ERM, 2014) indicated the presence of PFAS in the subsurface within the vicinity of the former and current maintenance workshops, foam generator and unofficial laydown areas.

5.5.2 Bayswater Power Station

During 1986 a failure of the 2A Generator Transformer at BPS resulted in a fire which was reported to have been supressed by PFOS or PFOA containing firefighting foam (ERM, 2014). An environmental site assessment completed in 2013 (ERM, 2014) indicated the presence of PFAS in the subsurface within the transformer area and the area referred to as Transgrid switchyard.

A subsequent investigation of PFAS in soil sediment and groundwater at BPS identified PFAS in soils, within the fire training area (AIC 11W), within groundwater and sediments in the vicinity of the diesel tank farm (AIC 51-52) which is likely attributed to firefighting activities and testing of the fire suppression system pre-dating September 2014 (ES, 2018).

6.0 Preliminary Conceptual Site Models

A preliminary CSM for both LPS and BPS was developed, prior to conducting the Stage 2 PFAS Investigation site works, based on the outcome of a desktop review of the available data collected and described in **Sections 3.0** to **5.0**. The preliminary CSMs are presented graphically in figures **Figure 3** – LPS Preliminary CSM; and **Figure 4** – BPS Preliminary CSM.

6.1 Contaminants of Concern

This investigation focuses on PFAS so the primary Contaminants of Potential Concern (COPC) are considered to primarily including (but not limited to) PFOS, PFOA and Perfluorohexane Sulfonic Acid (PFHxS).

6.2 LPS Preliminary CSM

An evaluation of the potential Source-Pathway-Receptor (SPR) exposure scenarios is provided for each AIC at LPS in **Table 8** and **Table 9.**

Table 8 AICs 93-96 Fuel tanks, firefighting training area: Sources > Pathways > Receptors

AICs 93-96: S > P > R	Description
Potential Sources	**Source Activity** • The source is AFFF containing PFAS used during firefighting training activities conducted across the grassed area and firefighting activities conducted in the tank farm. **Reported PFAS concentrations from previous investigations** • AIC 95 - Groundwater ▪ PFOA (2.9 – 3.7 µg/L) ▪ PFOS (5.9 – 52 µg/L). - Soil ▪ PFOS (>LOR (AIC 95 and 96)) ▪ 6:2 Fluorotelomer Sulphate (FTS) (>LOR (AIC 96)). **AIC Description** • This area is composed of four AICs which are to be treated as one area • AIC 93 is defined as old fuel tanks E & F • AIC 94 chemical drain outlet from the Water Treatment Plant (WTP) • AIC 95 interceptor pits capturing discharge from LPS prior to entering Lake Liddell. Pits have been noted as being emptied periodically but have been known to overflow when blocked • AIC 96 fuel tanks. Surface water is contained within the bunding of the AIC flowing into a drain and onto and oil and grit trap prior to entering Lake Liddell.
Potential Pathways	• Drainage system from the tank farm to interceptor • Surface water runoff, assumed to be in a general easterly/south easterly direction towards Lake Liddell • Sediments travelling in drains and runoff • Groundwater infiltration and migration, assumed to be in a general easterly/south easterly direction towards Lake Liddell.

AICs 93-96: S > P > R	Description
Potential Receptors	• Intrusive maintenance workers (typically defined by those workers who are on site infrequently, but who have a high potential for exposure when on site e.g. excavation workers) • Commercial maintenance workers (typically defined by those workers who are on site frequently, but who have a low potential for exposure when on site e.g. office employee) • Potential unauthorised recreational use of Lake Liddell[2] • Groundwater • Surface water receptors • Biota Lake Liddell • Bayswater Creek and onto the Hunter River.

Table 9 Northern Peninsula: Sources > Pathways > Receptors

Northern Peninsula: S > P > R	Description

Potential Source	**Source Activity**
	• The source of impacts is AFFF firefighting training activities conducted across the grassed area in the southern portion of the NP.
	Reported PFAS concentrations from previous investigations
	• Groundwater
	  - PFOS + PFHxS (0.067 – 0.116 µg/L)
	  - 6:2 FTS (<0.01 – 0.012 µg/L).
	• Soil
	  - PFOS (0.00166 – 0.608 µg/L)
	  - PFOA (0.00067 – 0.0079 µg/L)
	  - 6:2 FTS (0.00069 – 0.001 µg/L)
	  - PFPeS (0.00088 – 0.008 µg/L)
	  - PFHpS (0.00052 – 0.0054 µg/L)
	  - PFNA (0.00061 – 0.0071 µg/L)
	  - 8:2 FTS (<0.0005 – 0.0046 µg/L)
	  - PFDS (0.00064 – 0.0031 µg/L)
	  - PFPeA (0.00064 – 0.0031 µg/L).
	• Sediment
	  - PFOS (0.00012 mg/kg)
	• Surface Water
	  - PFOS (0.13 µg/L)
	AIC Description
	• The Northern Peninsula is a low lying grassed peninsula of approximately 8 ha, on the shore of Lake Liddell, to the north of the LPS
	• The Northern Peninsula is immediately west of the Lake Liddell process water intake
	• The topography slopes gently towards the lake with a wide riparian zone of grassy vegetation
	• The area immediately to the south of the NP is a plateau elevated approximately 40 m, which rises very steeply from the NP. There was no reported firefighting training on this plateau. A contingency location has been placed in this area, installation of which will be subject to the results of PFAS analysis from the well located immediately to the north

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[2] it is noted that Lake Liddell has been closed to all recreational uses and is signposted accordingly (refer Table 3, Section 3.1). While AGL Macquarie is not aware of any unauthorised recreational use occurring, AECOM considers that the possibility remains that there may potentially be some illegal recreational use.

Northern Peninsula: S > P > R	Description
Potential Pathways	Groundwater infiltration and migration is assumed to be in a northerly, easterly and westerly direction towards Lake Liddell Surface water runoff, assumed to be in northerly, easterly and north westerly direction towards Lake Liddell Sediment runoff
Potential Receptors	Intrusive maintenance workers Commercial maintenance workers Potential unauthorised recreational use of Lake Liddell Groundwater Surface water receptors Biota in Lake Liddell Seepage into Bayswater Creek and onto the Hunter River.

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:

- Surface water receptors: Lake Liddell and a possible seepage link to Bayswater Creek which continues onto the Hunter River; and
- Recreational users of downgradient surface water bodies.

6.3 BPS Preliminary CSM

An evaluation of the potential Source-Pathway-Receptor (SPR) exposure scenarios is provided for each AIC at BPS in **Table 10** to **Table 12**.

Table 10 AIC 11W – Fire Fighting Training Area: Sources > Pathways > Receptors

AIC 11W: S > P > R	Description
Potential Source	**Source Activity** • Firefighting training activities using AFFF conducted across the grassed area. **Historic Impacts** • Groundwater - PFOS and PFOA <LOR. • Soil (~0:1 m) - PFOS 0.01 - 0.01 mg/kg - PFOA 0.02 mg/kg. **AIC Description** • Grassed, level area of approximately 0.8 ha • Several fire hydrants noted within the area • Surface water runoff appears likely to enter the adjacent Contaminated Water Holding Pond and then onto the oil/water separator.
Potential Pathways	Drainage system into the settling pond and ultimately into Lake Liddell via Tinkers Creek Sediments found in drains and surface water bodies Groundwater infiltration and migration, assumed to be in northerly direction based on topography.
Potential Receptors	Intrusive maintenance workers Commercial maintenance workers Potential unauthorised recreational use of Lake Liddell Groundwater Surface water receptors Tinkers Creek

AIC 11W: S > P > R	Description
	- Lake Liddell - Seepage into Bayswater Creek and onto the Hunter River.

Table 11 AICs 51 and 52 - Diesel Tank Overflow Pond and Tank Farm: Sources > Pathways > Receptors

AICs 51 and 52: S > P > R	Description

Potential Sources	**Activity**
	- Firefighting activities and testing conducted around the diesel tanks using AFFF
	- Testing of AFFF deluge system at AIC 52 is known to have occurred during regular required testing.
	Historic Impacts
	- Groundwater
	  - PFOA (0.012 – 0.11 µg/L)
	  - PFHpA (0.019 – 0.16 µg/L)
	  - PFNA (<0.01 – 0.11 µg/L)
	  - PFHxA (0.06 – 0.092 µg/L)
	  - PFPeA (0.045 – 0.11 µg/L)
	  - 8:2 FTS (0.11 µg/L (AIC 51 only)).
	- Sediment
	  - 8:2 FTS (<0.0005 – 0.0014 µg/kg (AIC 51 only)).
	AIC Description
	- AIC 51 is Diesel Tank Overflow Pond, an unlined settling pond catching surface runoff from the diesel AST bunds within AIC 52. Pond over flows into a dry gully and into the Ash Dam
	- AIC 52 is the BPS tank farm with a concrete hardstand. Fitted with extensive fire suppression system throughout the tank farm.

Potential Pathways	- Groundwater infiltration and migration assumed to be in an easterly or westerly direction based on topography - Drainage system into the settling pond - Surface water discharge from the settling pond via an unnamed gully into the Ash Dam, and surface water run-off in an easterly direction - Sediments found in gully capturing overflow.
Potential Receptors	- Intrusive maintenance workers - Commercial maintenance workers - Groundwater - Surface water receptor - Unnamed gully - Seepage into Bayswater Creek and onto the Hunter River - Potential unauthorised recreational use of Lake Liddell

Table 12 AIC 17 - Transformers: Sources > Pathways > Receptors

AIC 17: S > P > R	Description
Potential Source	**Source Activity** • Firefighting activities carried out on infrastructure in this area using AFFF. **Historic Impacts** • Groundwater - PFOS (<0.01 – 0.12 µg/L). **Soil** • PFAS >LOR • FTS >LOR. **AIC Description** • Transformers and infrastructure on concrete hardstand at the southern end of the plant • Area has a 'clean' and 'dirty' stormwater system moving surface water runoff into the EPL discharge point and contaminated water system respectively.
Potential Pathways	• Existing drainage system into the EPL discharge point and contaminated water system • Sediments found in drains and surface water bodies • Groundwater infiltration and migration assumed to be in a general northerly direction based on topography.
Potential Receptors	• Intrusive maintenance workers • Commercial maintenance workers • Potential unauthorised recreational use of Lake Liddell • Groundwater • Surface water receptors • Tinkers Creek • Lake Liddell • Seepage into Bayswater Creek and onto the Hunter River.

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:

- Surface water receptors: Lake Liddell and a possible seepage link to Bayswater Creek which continues into the Hunter River; and
- Recreational users of downstream surface water bodies.

6.4 Entire Study Area Preliminary CSM

In addition to the individual Preliminary CSMs for the AICs at LPS and BPS, an Entire Study Area Preliminary CSM which includes the entire Study Area and downstream areas outside the AICs has also been developed, to account for the wider environmental setting. The Entire Study Area Preliminary CSM is described in **Table 13.**

Table 13 Entire Study Area CSM, including BPS and LPS

BPS and LPS: S > P > C	Description
Potential Sources	**Primary Source** • AFFF used historically in firefighting training and firefighting activities. **Secondary Sources** • Impacted soil • Impacted sediments • Impacted process waste including ash.
Potential Pathways	• Groundwater infiltration and migration • Surface water runoff • Sediment runoff • Surface water bodies • Transfer of water across both Sites and Lake Liddell through the Process Water System • Seepage through Lake Liddell and Drayton Levee dam walls.
Potential Receptors	• Intrusive maintenance workers • Commercial maintenance workers • Potential unauthorised recreational use of Lake Liddell • Groundwater • Surface water receptors • Lake Liddell • Seepage into Bayswater Creek and onto the Hunter River.

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:

- Surface water receptors: Lake Liddell and a possible seepage link to Bayswater Creek which continues into the Hunter River; and
- Recreational users of downstream surface water bodies.

Whilst information provided by AGL Macquarie indicates there are proposed works to capture the seepage from the Lake Liddell Dam wall at the Hunter River Salinity Trading Scheme (HRSTS) discharge point, this exposure pathway remains potentially complete and requires assessment.

7.0 Adopted Assessment Criteria

7.1.1 Overview

Selection and use of soil, sediment, leachate, surface water and groundwater assessment criteria were considered in the context of the Preliminary CSM (**Section 6.0**) to ensure appropriate evaluation of potential risks to human health and the environment. The adopted PFAS assessment criteria are selected from existing published criteria which are considered to be conservative, and are referred to as Tier 1 assessment criteria.

7.1.2 PFAS Assessment Criteria

At the date this report, there were three nationally adopted guidance documents on the assessment of potential impacts from PFAS. The documents, which contain both human health and environmental assessment criteria, are detailed as follows:

- Heads of EPAs Australia and New Zealand (HEPA), 2018. PFAS National Environmental Management Plan, January 2018 (PFAS NEMP [HEPA, 2018)].
- Department of Health, 2017. Health Based Guidance Values for PFAS for use in site investigations in Australia. April 2017 (DoH, 2017).
- FSANZ, 2017. Perfluorinated chemicals in food. Food Standards Australia New Zealand and associated supporting documents.

The PFAS NEMP (HEPA, 2018) was released by HEPA in collaboration with the Australian Government Department of the Environment and Energy (DoEE) to "*achieve a clear, effective coherent and nationally consistent approach to the environmental regulation of PFAS*". This document presents a number of environmental guideline values including guideline values for:

- Drinking water – Health based (consistent values with DoH, 2017)
- Recreational water – Health based (consistent values with DoH, 2017)
- Fresh water – aquatic ecosystems
- Soil – Human health screening values
- Soil – Interim values for ecological exposure
- Sediment – Human health screening values
- Sediment – Interim values for ecological exposure

In March 2019, HEPA released the *PFAS NEMP Version 2.0 Consultation Draft* report which includes updates to soil criteria, new guidance on the reuse of soil, initial guidance on management of PFAS in wastewater and new on-site storage and containment guidance for PFAS-containing products and materials. Since HEPA (2019) is a '*consultation draft*', the criteria presented in HEPA (2018) is adopted for this study. A summary of the PFAS criteria considered in this report is presented in **Table 14**.

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Table 14 Summary of PFAS Assessment Criteria

Media	Pathway	Compound	Criteria	Comment/Reference
Human Receptors				
Water	Drinking water – groundwater	PFOS + PFHxS	0.07 µg/L	• 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), (2011) 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*'. • *All groundwater results were compared to these criteria*
		PFOA	0.56 µg/L	
	Potential unauthorised recreational use of Lake Liddell[3] – surface water	PFOS + PFHxS	0.7 µg/L	• 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. • As with the drinking water values, the DoH utilised the tolerable daily intake (TDI) for PFOS and PFOA from FSANZ (2017) and 'the methodology described in Chapter 6.3.3 of the NHMRC of the ADWG (2011) 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. • *All surface water results were compared to these criteria*
		PFOA	5.6 µg/L	

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[3] it is noted that Lake Liddell has been closed to all recreational uses and is signposted accordingly (refer Table 3, Section 3.1). While AGL Macquarie is not aware of any unauthorised recreational use occurring, AECOM considers that the possibility remains that there may potentially be some illegal recreational use.

Media	Pathway	Compound	Criteria	Comment/Reference
Soil and sediment	Industrial / commercial maintenance and intrusive workers	PFOS + PFHxS	20 mg/kg	• The values presented in the PFAS NEMP (2018) are 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 -D assumptions. • *All soil and sediment results will be compared to these criteria.*
		PFOA	50 mg/kg	
Ecological Receptors				
Water	Freshwater	PFOS	0.13 µg/L	• The PFAS NEMP (HEPA, 2018) presents criteria for both freshwater and marine systems for four levels of species protection (99%, 95%, 90% and 80%). Lake Liddell is a reservoir primarily and continually used for cooling water in both LPS and BPS. It is permanently closed to public access, including recreational fishing, due to the detection of the harmful amoeba *Naegleria fowleri*, a naturally occurring organism. For these reasons the Lake Liddell receiving environment is considered conservatively to be a highly disturbed system (ANZG, 2018) and adoption of the 95% species protection to be conservative. The HEPA, 2018 for 95% species protection in slightly to moderately disturbed systems will be adopted for indicative purposes to assess the potential significance of any exceedances. Should surface water concentrations indicate a potential risk to sensitive receptors, consideration will be given to assessment of the data against the 99% species protection criteria. However it is noted that the 99% species protection criteria for PFOS are two orders of magnitude less than the laboratory LOR. As such any detection greater than the laboratory LOR is considered to exceed the 99% species protection criteria for PFOS. AECOM understands that the interim PFOS 99% trigger value is currently being revised in association with CSIRO, and that a less conservative criterion is likely to result based on current ecotoxicity
		PFOA	220 µg/L	

Media	Pathway	Compound	Criteria	Comment/Reference
				testing results (e.g. Vogs et al, 2019) and updated statistical interpretation methodology recommended in ANZG (2018). Revised draft aquatic ecosystem protection criteria were presented in Batley et al (2018), application of revised methodologies for default guideline value derivations: PFOS in freshwater, at the Society of Environmental Toxicology and Chemistry (SETAC) North America scientific conference in November 2018. Batley et al (2018) reported a draft revised 99% species protection criterion of 0.051 µg/L for PFOS, based on a reassessment of the data used to derive the HEPA (2018) criterion to account for modality in the species sensitivity distribution. AECOM understands that this criterion is currently subject to further review to include data from recently published scientific research. • *All fresh surface water locations and any groundwater locations identified as discharging to fresh surface waters.*

Media	Pathway	Compound	Criteria	Comment/Reference
Soil and sediment	Ecological indirect exposure	PFOS	0.14 mg/kg	• The PFAS NEMP (HEPA, 2018) presents criteria for both direct and indirect exposure of ecological receptors to soil. As the Sites are likely to have secondary consumers (e.g. insectivorous birds and mammals), criteria considering indirect exposure are deemed relevant. The PFAS NEMP (HEPA, 2019) presents a single interim indirect criterion for 'all land uses' for PFOS only (previously classified as 'residential' in HEPA (2018)). This criterion is based on dietary exposure of a secondary consumer as the most sensitive exposure pathway assessed. A single direct exposure interim soil criterion is provided for public open space land uses for PFOA and PFOS. • Interim values listed in the PFAS NEMP (2018) are based the Canadian Federal Environmental Quality Guidelines (2017) for coarse soil in a Commercial and Industrial land use area, and represents the concentration in soil that is expected to protect against potential impacts on freshwater aquatic life from PFOS originating in soil that may enter the groundwater and subsequently discharge to a surface water body (applicable under any land use category, where a surface water body, sustaining aquatic life, is present within 10 km of the site). • *All soil and sediment data (dry only) will be initially screened against the indirect criterion. If the indirect criterion is exceeded, the soil concentrations collected from public open space will also be compared to the direct soil criterion to screen for potential risk to soil organisms.*

8.0 Approach and Methodology

8.1 Sampling Rationale

8.1.1 SAQP

AECOM's approach to deliver the Stage 2 PFAS investigation was comprised of methodologies described in the SAQP (AECOM, 2018) and reviewed and agreed by the Principals.

8.1.2 Sample Collection Rationale

Proposed sample locations and rationale behind the selection of the proposed sample locations are summarised in the SAQP and in **Table 15** to **Table 18** below.

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Table 15 LPS Sample Locations and Rationale for Location Selection

Matrix	Number of Locations	Number of Samples	Rationale	SAQP Conformance
[illegible]				
Soil	• 24 locations	• 52 samples (Total) • 19 Deep PFAS • 27 Shallow PFAS • 6 PFAS and ASLP (shallow)	• Grid sampling system to assess the lateral and vertical extent and concentration/potential mass of PFAS in soils within the vadose zone. • Assess potential leachability.	Variation to the SAQP occurred due to refusal on consolidated material in some of the proposed soil bore locations.
Groundwater	• 5 new wells • 1 existing well	• 9 PFAS samples collected	• Assess the lateral and vertical extent and concentration of PFAS in groundwater. • Identify potential migration pathways.	Refusal on consolidated material was encountered at four of the proposed soil bore locations which were unable to be converted to groundwater monitoring wells and as such were not sampled. Three of the four existing monitoring wells were dry and therefore not sampled.
Sediment / Surface Water	6 lake surface water sample locations • 4 lake edge sediment locations	• 12 PFAS (SW) and 8 PFAS (sediment) • 2 PFAS and ASLP (sediment)	• Assess locations reporting historical PFAS presence. • Assess lake adjacent to AIC. • No receiving drains to assess.	Four additional lake samples were collected. Sediment samples scheduled for ASLP analysis was not completed due to laboratory error disposing of samples.
[illegible]				
Soil	• 30 locations	• 34 Deep PFAS • 33 Shallow PFAS • 4 Shallow PFAS and ASLP	• Grid sampling system to assess the lateral and vertical extent and concentration/potential mass of PFAS in soils within the vadose zone. • Assess potential leachability • Asses potential pre-cursors in the source area	One deep location not completed due to access and sub-service infrastructure location. Refusal on consolidated material prevented the advancement of two soil bore locations.

Matrix	Number of Locations	Number of Samples	Rationale	SAQP Conformance
Groundwater	• 5 new wells • 17 existing wells	• 36 PFAS	• Assess the lateral and vertical extent and concentration of PFAS in groundwater. • Identify potential migration pathways.	Refusal on consolidated material was encountered at one of the proposed soil bore locations which was unable to be converted to a groundwater monitoring well and as such as not sampled.
Sediment / Surface Water	• 2 drainage water • 3 surface water • 6 sediment	• 20 PFAS • 2 ASLP and PFAS	• Assess locations reporting historical PFAS presence. • Assess lake adjacent to AICs. • Assess receiving drains.	Sediment samples scheduled for ASLP analysis was not completed due to laboratory error disposing of select samples.

Table 16 BPS Sample Locations and Rationale for Location Selection

Matrix	Number of Locations	Number of Samples	Rationale	SAQP Conformance
[illegible]				
Soil	• 30 locations • 7 deep • 25 shallow	• 71 PFAS • 4 ASLP and PFAS	• Grid sampling system to assess the lateral and vertical extent and concentration/potential mass of PFAS in soils within the vadose zone. • Assess potential leachability. • Assess potential pre-cursors in the source area.	• Refusal on consolidated material prevented the advancement of two soil bore locations. • Samples scheduled for ASLP analysis was not completed at three locations due to laboratory error disposing of select samples.
Groundwater	• 7 new wells • 13 existing well	• 27 PFAS	• Assess the lateral and vertical extent and concentration of PFAS in groundwater. • Identify potential migration pathways.	• Scope met

Matrix	Number of Locations	Number of Samples	Rationale	SAQP Conformance
Sediment / Surface Water	• 2 surface water • 2 sediment	• 10 PFAS • 2 PFAS ASLP and PFAS	• Assess locations reporting historical PFAS presence. • Assess ponds adjacent to AIC. • Assess receiving drains.	• Additional surface water samples collected where depth of water was equal to or greater than 0.5 metres below surface. •
Soil	• 11 locations • 3 deep • 8 shallow	• 21 PFAS	• Grid sampling system to assess the lateral and vertical extent and concentration/potential mass of PFAS in soils within the vadose zone. • Assess potential leachability • Asses potential pre-cursors in the source area	• Samples scheduled for ASLP analysis was not completed at select locations due to laboratory error disposing of select samples.
Groundwater	• 1 new wells • 13 existing well	• 18 PFAS	• Assess the lateral and vertical extent and concentration of PFAS in groundwater. • Identify potential migration pathways.	• Scope met
Sediment / Surface Water	• 6 surface water • 5 sediment	• 11 PFAS	• Assess locations reporting historical PFAS presence. • Assess receiving drains.	• Scope met with the exception of 1 proposed sediment sample location where no sediment was present to collect for analysis.
Soil	• 13 deep • 8 shallow	• 44 PFAS • 5 ASLP and PFAS	• Grid sampling system to assess the lateral and vertical extent and concentration/potential mass of PFAS in soils within the vadose zone. • Assess potential leachability • Asses potential pre-cursors in	• Refusal on consolidated material prevented the advancement of soil bore locations. • ASLP analysis was not completed at one location do to nil sediment available for sample collection.

Matrix	Number of Locations	Number of Samples	Rationale	SAQP Conformance
			the source area	
Groundwater	- 6 new wells - 4 existing wells	- 15 PFAS	- Assess the lateral and vertical extent and concentration of PFAS in groundwater. - Identify potential migration pathways.	- Refusal on consolidated material prevented the advancement of soil bore locations. - Insufficient well volume prevented the analysis of PFAS in both shallow and deep in well water column at some groundwater monitoring locations.
Sediment / Surface Water	- 4 drainage water - 5 drainage sediment	- 11 PFAS - 2 PFAS ASLP and PFAS	- Assess locations reporting historical PFAS presence. - Assess receiving drains. - Assess settling pond adjacent to the AIC.	- Additional PFAS samples were collected from two drainage water locations, and three drainage sediment locations.

Table 17 Locations outside AICs sample locations and rationale for location selection

Matrix	Number of Locations	Number of Primary Samples	Rationale	SAQP Conformance
Sediment / Surface Water	- 3 lake locations	- 6 PFAS	- Assessment of pathways and potential for off-site migration. - EPL Discharge Point #12 – Oil/Grit Trap Outlet - EPL Discharge Point #13 - Cooling Water Outlet and Lake Liddell - Background location away from potential discharge points	- Some sediment samples were not collected in conjunction to water samples where sediment was absent (eg. concrete lining or gravels), or due to inaccessibility of sediments.

[illegible]				
Sediment / Surface Water	- 2 creek locations	- 4 PFAS	- Assess Tinkers Creek for presence of PFAS.	- Scope met
[illegible]				
Sediment / Surface Water	- 1 creek location	- 2 PFAS	- Assess seepage system for presence of PFAS.	- No sediment samples collected due to structure of discharge point.
[illegible]				
Sediment / Surface Water	- 1 dam location	- 2 PFAS	- Assess dam for presence of PFAS.	- Scope met
[illegible]				
Sediment / Surface Water	- 1 creek location	- 2 PFAS	- Assess potential for off-Site migration of PFAS.	- Scope met
[illegible]				
[illegible]				
Sediment / Surface Water	- 2 creek locations	- 4 PFAS	- Assess Tinkers Creek for presence of PFAS. - EPL Discharge Point #7 – BPS discharge to Tinkers Creek	- Scope met
[illegible]				
Sediment / Surface Water	- 4 drainage locations	- 8 PFAS	- Assess drainage around the basin for presence of PFAS	- Some sediment samples were not collected in conjunction to water samples where sediment was absent (eg. concrete lined structure), or due to inaccessibility of sediments.
[illegible]				
Sediment / Surface Water	- 1 lake location	- 2 PFAS	- EPL Discharge Point #8 – BPS discharge from Lake Liddell into Saltwater Creek	- No sediment samples collected due to structure of discharge point.

Sediment / Surface Water	• 1 dam location	• 2 PFAS	• Assess ash dam seepage collection for presence of PFAS	• Scope met
Sediment / Surface Water	• 1 creek location	• 2 PFAS	• Assess Pikes Gully for presence of PFAS	• Scope met
Sediment / Surface Water	• 1 dam location	• 2 PFAS	• Assess Pikes Gulley for presence of PFAS	• Bayswater creek dry during site mobilisation - no surface water sample collected.
Sediment / Surface Water	• 1 dam location	• 2 PFAS	• Assess Plashett Reservoir for presence of PFAS	• Scope met
Sediment / Surface Water	• 1 dam location	• 2 PFAS	• Assess Pikes Gully for presence of PFAS	• No sediment samples collected due to rocky subsurface.

Table 18 Hunter River Sample Locations and Rationale for Location Selection.

Matrix	Number of Locations	Number of Primary Samples	Rationale	SAQP Conformance
[illegible]				
Sediment / Surface Water	• 1 river location	• 2 PFAS	• Assess background PFAS concentrations in river water upstream from power stations.	• Scope met
[illegible]				
Sediment / Surface Water	• 1 river location	• 2 PFAS	• Assess background PFAS concentrations in river water upstream from power stations.	• Scope met
[illegible]				
Sediment / Surface Water	• 1 river location	• 2 PFAS	• Assess PFAS concentrations in river water downstream from power stations for comparison with upstream samples.	• Scope met

8.2 Sampling Methodology

The sampling methodologies are summarised in the following sections.

8.2.1 Soil

Table 19 Soil Investigation Methodologies

Activity	Details
Service clearance	In accordance with AGL Macquarie requirements and AECOM's internal Service Identification and Clearance (SIC) procedure, borehole locations were selected based on the Preliminary CSM and in consultation with: • utility plans obtained through the Dial-Before-You-Dig service. • private service plans provided by AGL Macquarie. • AGL Macquarie Safety officer Maps of the selected borehole locations were provided to AGL Macquarie for review and approval and an AGL Macquarie safety officer attended locations to confirm final approval. Each proposed borehole location was also checked for underground services by an independently engaged Telstra accredited service locator, using electromagnetic-detection and/or Ground Penetrating Radar. Due to AGL Macquarie resourcing restrictions locations in and around the transformer area were attended by AGL Macquarie staff after clearance and required four mobilisations by AECOM and the service locator prior to final AGL Macquarie approval. Borehole locations were cleared using NDD, which included the use of a hand auger and/or a pressurised water sprayer and vacuum truck. Where possible, borehole locations were cleared to a target depth of 1.5 mbgl, with a hole diameter greater than or equal to 130 % of the final drill hole diameter. At 48 locations, encountered ground conditions were such that both hand auger and vac truck methods had to be abandoned before the target depth of 1.5 mbgl was reached. Under these circumstances, an alternate location was attempted, and if similar conditions found, locations where marked as refused and completed at the maximum depth accessible by hand auger and/or a pressurised water sprayer and vacuum truck. For deep locations a third attempt was made and if refusal was still met an alternate location attempted.

Activity	Details
Drilling method to retrieve soil samples and/or advance hole for monitoring well installation	Where conditions allowed, boreholes designated 'shallow' were advanced by either hand auger and vac truck method to a target depth of 1.5 mbgl. Shallow boreholes reached a maximum depth of 1.95 mbgl (LPS_AICNP_SB123). At 48 locations, encountered ground conditions were such that both hand auger and vac truck methods had to be abandoned before the target depth of 1.5 mbgl was reached. In this instance an alternate location was tried and if similar conditions where found the location was marked as refused and completed at the maximum accessible depth after, collecting a final depth sample. Boreholes designated 'deep' were drilled to target depths (typically 6m) using a Geoprobe Sonic drill rig. Due to encountered drilling and lithological conditions and deeper than expected groundwater occurrence, a second mobilisation was necessary to complete the scope of works. Sonic drilling proceeded to a maximum depth of 15 mbgl at AIC NP during the first mobilisation. In review of the work completed during first mobilisation, the Principals requested the scope be amended to exclude drilling deeper than six mbgl when completing groundwater monitoring locations. This decision was informed by locations in the Northern Peninsula where groundwater was found to be at depths >7 meters below ground level (mbgl), likely due to drought conditions in the Upper Hunter. Where groundwater was not encountered within the top six metres, locations were backfilled, using soil cuttings and bentonite, without installation of a monitoring well.
Soil logging	Soil logging was in general accordance with the Unified Soil Classification System (USCS).
Soil sample collection	Soil samples were collected directly from the hand auger or from the sonic drill sleeve by gloved hand, or in some instances with the aid of a hand trowel and placed into laboratory-provided 250 mL plastic soil containers with minimal headspace and no Teflon lid-liners.
Spoil management	Cuttings from boreholes were placed into 205 L soil drums for subsequent disposal by AGL Macquarie. Waste transport certificates are provided in **Appendix D**.
Borehole coordinates	Borehole coordinates were obtained using a Garmin handheld GPS unit with a stated accuracy of ≤ 10 m. Monitoring well locations, ground level elevations, and Top of Casing (TOC) elevations were recorded by an independently engaged surveyor using RTK GPS with a stated accuracy of 0.01 m.

8.2.2 Groundwater

Table 20 Groundwater Investigation Methodologies

Activity	Details
Monitoring well installation	Monitoring wells were constructed from machine-threaded 50 mm inside diameter well casing made of Class 18 uPVC. The base section of each monitoring well comprised a capped, screened section pre-slotted to 0.5 mm. The length of the screened section was typically 3.0-6.0 m and was threaded into a section of blank uPVC which extended to above ground surface. Filter pack sand material was added to the annulus space around the uPVC from the base of the borehole to approximately 0.5 m above the screened section. Filter pack sand was covered by a minimum 0.5 m thickness of hydrated bentonite pellets, followed by cement/grout to surface. Monitoring wells were finished with flush fitting 'gatic' lids or with steel monument covers. Well construction details are contained in borehole logs provided in **Appendix E**. Monitoring well IDs are presented in **Table T5** in **Appendix B**.
Well development	New monitoring wells were developed using dedicated HDPE tubing with either a Foot-Valve or a down-well submersible pump attached. Where a pump was used, this was decontaminated between each event by flushing with Liquinox® followed by a final rinse with water. Monitoring wells were purged until the well went dry or groundwater parameter stabilisation was achieved. At locations where low recharge was encountered, the well was purged dry, allowed to recharge and pumped dry again. A minimum of three well volumes were targeted for removal at each location. Development water was transferred directly into bunded 200 L drums for collection by a licenced waste contractor. Waste transport certificates are provided in **Appendix D**.
Water level gauging	Standing water level (SWL) and depth to base were measured in targeted existing monitoring wells and all newly installed monitoring wells using an electronic water/oil interface meter. An initial gauging round was undertaken between 19 and 29 November 2018, prior to the installation of new monitoring wells, for the purposes of producing groundwater contour maps and to gain an understanding of the depth to water to aid in the drilling program. Wells were also gauged individually before sampling to monitor stabilization of depth to water during groundwater sampling. A comprehensive gauging round of 73 monitoring wells was completed on 14 and 15 March 2019, following the installation of all new monitoring wells for the purposes of producing groundwater contour maps. The gauging data are presented in **Table T1** in **Appendix B**; Groundwater Contour Maps are presented in **Figures 5 – 9** in **Appendix A**.

Activity	Details
Well purging and geochemical parameters	Following development, the wells were allowed to stabilise for a minimum of seven days. Monitoring wells were then purged using low flow sampling equipment with new HDPE tubing at each location. Geochemical parameters (temperature, electrical conductivity, redox, dissolved oxygen and pH) were measured by a calibrated water quality meter (WQM) through a flow cell during purging, and SWLs were measured with an oil/water interface probe. Where possible, purging continued until the geochemical parameters stabilised to within 10% for three successive readings. Where SWL and/or geochemical parameters would not stabilise, the well was purged dry with a PFAS free disposable bailer and left to recharge. The recharged well was sampled at a later date (typically 24-48 hours following purging). Wells with insufficient water column for sampling due to limited recharge following purging were not selected for multi-depth sampling. The stabilised geochemical parameters are provided in **Table T2** in **Appendix B**. Calibration records for the WQM are provided in **Appendix F**.
Purge water management	Purged groundwater was placed in labelled 205 L water drums for subsequent disposal.
Groundwater sampling from monitoring wells	Groundwater samples were collected from monitoring wells using low flow methods via peristaltic pump or bladder pump and HDPE tubing, where this was not possible the well was purged dry and sampled using a bailer after 24-48 hours of recovery. Samples were collected into laboratory supplied sample containers suitable for PFAS (e.g. no Teflon lid inserts). Selected monitoring wells were sampled at two depths to account for potential PFAS stratification. Where two depths were sampled, samples were collected at depths representing the top and bottom of the screened interval, respectively. General observations of the water quality were also recorded including colour, turbidity and odours. Sampling sheets are presented in **Appendix G**.
Survey	Newly installed monitoring wells were surveyed by a registered surveyor to obtain position information and ground surface/top of casing elevations. Survey results are provided in **Appendix H** and on borelogs in Appendix DE.

8.2.3 Surface Water

Table 21 Surface Water Investigation Methodologies

Activity	Details
Surface water sample collection	Surface water samples were collected from dams, ponds, discharge points, creeks, and the Hunter River. Where possible, two samples were collected at each location - one near shore and one below the surface around 1 m offshore. Where conditions permitted (shallow water body and easy access via the banks), shallow samples were collected directly into sample containers by gloved hands. Offshore samples were collected using a telescopic sampling pole to retrieve water from the midpoint of the water column. The sampling pole was decontaminated between each sampling location using Liquinox®.
Stormwater Drain sample collection	Water samples were collected directly into sample containers from selected drains comprising the sites' stormwater network using a telescopic sampling pole to retrieve water from the centre of the drain. The sampling pole was decontaminated between each sampling location using Liquinox®.
Geochemical parameters	A calibrated WQM was used to measure geochemical parameters by lowering the probes into the surface water and recording the stabilised readings, which indicated. General observations of the surface water quality and flow were recorded (refer to **T3** in **Appendix B**). The WQM was decontaminated between each sampling location using Liquinox®

8.2.4 Sediment Sampling

Table 22 Sediment Investigation Methodologies

Activity	Details
Sediment sample collection	Sediment samples were collected at dams, ponds, discharge points, creeks, and the Hunter River. Sediment samples were co-located with near shore surface water samples. Samples were collected between 0.1 and 0.15 mbgl, directly into sample containers by a gloved hand, or by using a hand trowel to retrieve the sample from the centre mass of soil/sediment. The trowel was decontaminated using Liquinox® between each sampling location.
Sample logging	Sample logging was in general accordance with the USCS.

8.2.5 Sample Quality Control

Table 23 Sample Quality Control

Activity	Details
Sample storage	Samples were placed into laboratory prepared containers, iced, and transported as soon as reasonably practicable to the primary and secondary laboratories under chain of custody documentation.
Decontamination	To minimise the potential for field cross-contamination, a new pair of disposable gloves were used to collect each sample. **Soil boreholes**: The drill stems and hand auger were rinsed in a two stage procedure ('dirty' then 'clean' bucket of mains water) between each soil sampling location. When a hand trowel or utensil was used to assist in the collection of soil samples from the hand auger and sonic drill casing, this was brushed, decontaminated using Liquinox® and rinsed with PFAS-free water between each sample and drill location. **Groundwater (low flow sampling)**: The interface probe and WQM were decontaminated in a solution of laboratory supplied deionised water and Liquinox® followed by a second rinse with deionised water. New sampling tubing was used at each well to reduce the risk of cross contamination. **Surface water**: Decontamination of the sampling pole was undertaken by spraying the solution of Liquinox®, followed by a double rinse with laboratory supplied deionised water. **Sediment samples**: Decontamination of the hand trowel, if used, was undertaken by scrubbing, spraying the solution of Liquinox®, and then using a double rinse with laboratory supplied deionised water.
Field QA/QC sample frequency	Refer to **Section 9.0**

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8.3 Laboratory Analysis

The analytical laboratories, in accordance with the SAQP, included:

- ALS Environmental (ALS) of Smithfield, NSW: used as the primary laboratory for soil, sediment, groundwater, surface water and ASLP analyses. ALS utilised methods certified by NATA.
- Symbio Laboratories (Symbio) of Lane Cove West, NSW: used as the secondary laboratory for soil, sediment, groundwater and surface water analyses and utilised methods certified by NATA.

The full PFAS suite available through the NATA accredited laboratories was chosen for analysis. A summary of the laboratory analysis suites for PFAS and water chemistry, together with their respective analytical techniques/methods and LORs, are presented in **Table 24** and **Table 25** for water and solid media respectively. **Table 26** provides an overview of details pertaining to the primary laboratory, such as analysis suite codes, samples container types and analyte holding times.

Laboratory reports and COC documentation are presented in **Appendix I.**

Table 24 Sample Analysis Suites and Methods for Groundwater and Surface Water

Sample Type	Parameter	Method Reference	Limit of Reporting*
Primary, Duplicate, Inter-lab Duplicate	PFAS Full Suite (28 analytes): 4:2 Fluorotelomer sulfonic Acid (4:2 FTS) 6:2 Fluorotelomer sulfonic Acid (6:2 FTS) 8:2 Fluorotelomer sulfonic Acid (8:2 FTS) 10:2 Fluorotelomer sulfonic Acid (10:2 FTS) N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA) N-Ethyl perfluorooctane sulphonamide (EtFOSA) N-Ethyl perfluorooctane sulphonamide (EtFOSE) N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA) N-Methyl perfluorooctane sulphonamide (Me-FOSA) N-Methyl perfluorooctane sulphonamide (MeFOSE) Perfluorobutane sulfonic acid (PFBS) Perfluorobutanoic acid (PFBA) Perfluorodecane sulfonic acid (PFDS) Perfluorodecanoic acid (PFDA) Perfluorododecanoic acid (PFDoDA) Perfluoroheptane sulfonic acid (PFHpS) Perfluoroheptanoic acid (PFHpA) Perfluorohexane sulfonic acid (PFHxS) Perfluorohexanoic acid (PFHxA) Perfluorononanoic acid (PFNA) Perfluorooctane sulfonic acid (PFOS) Perfluorooctane sulphonamide (FOSA) Perfluorooctanoic acid (PFOA) Perfluoropentane sulfonic acid (PFPeS) Perfluoropentanoic acid (PFPeA) Perfluorotetradecanoic acid (PFTeDA) Perfluorotridecanoic acid (PFTrDA) Perfluoroundecanoic acid (PFUnDA)	LC/MS-MS	0.01 - 0.1 µg/L
Rinsate	PFAS Short Suite: 4:2 Fluorotelomer sulfonic Acid (4:2 FTS) 6:2 Fluorotelomer sulfonic Acid (6:2 FTS) 8:2 Fluorotelomer sulfonic Acid (8:2 FTS) 10:2 Fluorotelomer sulfonic Acid (10:2 FTS) Perfluorobutane sulfonic acid (PFBS) Perfluorobutanoic acid (PFBA) Perfluoroheptanoic acid (PFHpA) Perfluorohexane sulfonic acid (PFHxS).	LC/MS-MS	0.01 - 0.1 µg/L

Sample Type	Parameter	Method Reference	Limit of Reporting*
	Perfluorohexanoic acid (PFHxA) Perfluorooctane sulfonic acid (PFOS) Perfluorooctanoic acid (PFOA) Perfluoropentanoic acid (PFPeA)		

Notes

**Limit of Reporting for Australian Laboratory Services (ALS)*
LC/MS-MS = Liquid chromatography–mass spectrometry
ICP = inductively coupled plasma,
AES = Atomic Emission Spectrometer
MS = Mass Spectrometer

Table 25 Sample Analysis Suites and Methods for Soil and Sediment

Sample Type	Parameter	Technique/Method Reference	Limit of Reporting*
Primary, Duplicate, Inter-lab Duplicate	PFAS Full Suite	LC/MS-MS	0.0002-0.001 mg/kg

Notes

**Limit of Reporting for Australian Laboratory Services (ALS)*
LC/MS-MS = Liquid chromatography–mass spectrometry

Table 26 ALS Sample Containers, Sample Volumes and Sample Holding Times

Sample Type	Analysis Suite	Media	Container Type (Preservation)	Holding Time
Primary, Duplicate, Inter-lab Duplicate	PFAS Full Suite: EP231X	Water	60 or 125 mL plastic bottle (nil preservation) (grey labelled)	6 months
Rinsate	PFAS Short Suite: EP231	Water	60 or 125 mL plastic bottle (nil preservation) (grey labelled)	6 months
Primary, Duplicate, Inter-lab Duplicate	PFAS Full Suite: EP231X	Solid	250 mL HDPE soil jar (nil preservation) (grey labelled)	6 months

9.0 Quality Assurance and Quality Control

The QA/QC program implemented for the investigation was completed in accordance with the seven-step DQO process, as described in **Section 2.0**.

9.1 PFAS Analysis and Data Interpretation Considerations

Due to the ubiquity of PFAS used in a variety of everyday products and the potential for cross contamination during sampling activities, the sampling methodologies implemented during the sampling program where based on the recommended practices identified in HEPA (2018), the AECOM Field Quality Manual (AECOM, 2017) and the AECOM PFAS Sampling Guide (AECOM, 2018).

The following points provide an overview of some of the items that have been considered in validating analytical results and interpreting the results of environmental testing.

- Accurate analytical techniques for identifying and quantifying PFAS are relatively new. The USEPA standard method was published in 2009 and Australian NATA certified commercial analysis services also became available in 2009.
- Analytical proficiency in Australia is continuing to improve, with limits of detection lowering and the range of detectable PFAS increasing. The use of laboratory standard reference materials has also been improved to better address issues including the quantitation of linear and branched PFAS compounds. As a consequence, some differences in analysis results can be expected when sample locations are retested using more recent analytical techniques or where samples are split (for quality control purposes) between different laboratories. These issues are considered in the data quality assurance and data validation processes that have been used in the investigation (refer to **Table 2** in **Section 2.8**).
- Differences in sampling methods – Over the course of the investigation, groundwater has been sampled by peristaltic pump and grab samples where the rate of recharge or volume of water in the well was not sufficient for peristaltic sampling. These different methods could introduce additional PFAS concentration variability between locations or from the same locations over time.
- Low screening concentrations - At part-per-billion (ppb) and part-per-million (ppm) concentrations, very minor changes on environmental conditions can lead to seemingly large relative differences in PFAS results between adjoining sample locations or in repeat sampling events. However, the actual concentration differences may only be very small in terms of absolute concentrations.
- Fluctuation of results and long-term trends at individual testing locations - It will take repeated sampling of individual monitoring wells or surface water sampling locations over time (potentially years) to develop an understanding of the range of typical variations in concentration and longer term trends (if any).
- Different analytical methods for different media - PFAS have been detected as being present in almost all media tested within the SA including soil, sediment, surface water and groundwater. It is noted that different media (soil/sediments, waters, etc.) all have different sample preparation and analysis processes.
- Background concentrations and cross contamination - The widespread use of PFAS in industrial processes and products (including manufacture of water and grease resistant coatings, metal plating, paints, cement additives, food packaging and numerous other applications [USEPA, 2017]) over decades and its resistance to breakdown in the environment, means PFAS are being detected throughout the environment and in human blood serum from sources other than AFFF usage.

9.2 Summary of Data Validation

The data validation procedure employed in the assessment of the field and laboratory QA/QC data indicated that the reported analytical results are representative of the sample locations and that the overall quality of the analytical data produced is acceptably reliable for the purpose of the Stage 2 PFAS Investigation. The following is a summary of the non-conformances from the 25 data validation certificates.

Data validation certificates for each laboratory batch are attached in **Appendix J.** Laboratory Quality Control Certificates are attached in **Appendix I.**

9.2.1 Rinsate Blanks

A total of 60 rinsate blanks were taken throughout the sampling program. Rinsate blank concentrations were below the LOR for all samples and all analytes, with the exception of one sample. Because all other samples reported concentrations below the LOR, the decontamination methods are assessed as acceptable and the potential for cross contamination via sampling methods is considered unlikely.

9.2.2 Recommended Holding Times

A total of 587 samples were collected throughout the sampling program. Samples were extracted and analysed within recommended holding times, with the exception of 14 water samples for pH analysis. These samples were analysed between one and four days overdue.

As these samples were analysed marginally outside recommended holding times for pH, there is the potential for this parameter to have changed overtime and not be truly representative of field conditions. pH interpretation in this report has been based on pH measurements taken in-situ for this reason.

9.2.3 Frequency of Laboratory Quality Control

Of the 587 samples collected, the primary laboratory reported a sufficient frequency of quality control samples to assess whether the results have been reported to an acceptable accuracy and precision. There were four samples with an exception to this, none of these analytes where chemicals of concern from the PFAS suite, including:

- One sample with less than the required frequency reported for laboratory duplicates for Sulfate as $SO4^{2-}$ and two samples with less than the required frequency reported for laboratory duplicates for Moisture Content (); and
- One sample with less than the required frequency reported for matrix spikes for Sulfate as $SO4^{2-}$.

Since all other frequency of laboratory QCs were run satisfactorily, it is unlikely that there are data integrity issues.

9.2.4 Surrogate Spikes

Surrogate Spike (SS) recoveries were within control limits for all samples, for both laboratories. There were four SS recovery exceptions, including:

- One SS recovery for PFNA, from AECOM sample LPS_GW_QC120, less than lower data quality objective (58.0%) [control limits 60-120%].
- SS recovery for PFOS, for AECOM sample BPS_AIC11W_SD521, less than lower data quality objective (40.5%) [control limits 60-120%] and SS recovery for 13C8-PFOA, for AECOM sample BPS_AIC11W_SD521, less than lower data quality objective (27.0%) [control limits 60-120%]
- SS recovery for PFNA, from AECOM sample BPS_WG_QC205, greater than upper data quality objective (130%) [control limits 60-120%]. The potential exists for PFNA in sample BPS_WG_QC205 to be slightly over reported, however results were below the LOR.

The potential exists for PFNA in sample LPS_GW_QC120, and PFOS and PFOA in sample BPS_AIC11W_SD521 to be slightly under reported. However, the exceedances were marginal and all other SS recoveries were within control limits. It is considered unlikely that there are data integrity issues. ALS also stated that the low SS recoveries for BPS_AIC11W_SD521 were due to matrix interferences.

9.2.5 Sample Temperature and Preservation

All 587 samples were received chilled on ice at the laboratory. Eleven of the laboratory batches were received with a temperature slightly below the recommended range (4°C±2°C). It is likely that the technicians at the laboratory sample receipt scanned the ice within the esky and not the actual sample temperature. Considering the samples were on ice, it is likely that they were a suitable temperature. Seven of the laboratory batches were received with a temperature slightly above the recommended range (4°C±2°C). However, the temperature is not considered to compromise data integrity as PFAS are non-volatile.

9.2.6 Matrix Spikes

Matrix Spikes (MS) were conducted by ALS on anonymous samples for Perfluorinated Compounds. The majority of MS recoveries were within control limits, with the exception of 13 samples. These non-conformances were due to the background level being greater than or equal to 4 x the spike level. Matrix spike non-conformances were related to PFOS (five samples), PFHxS (two samples), Sulfate as SO4 (four samples) or Chloride (one sample).

The final MS recovery exception was less than the lower data quality objective due to matrix interference. This was confirmed by laboratory quality control samples. This non-determination does not reflect method bias and does not affect data interpretation. The accuracy of the data can be assessed as acceptable based on method blanks, laboratory control samples and surrogate spike recoveries (which were reported at or above the required frequencies and within control limits).

9.2.7 Field Duplicate RPDs

A total of 53 field duplicates were collected during the sampling program. Field duplicate samples were analysed as listed, with their matching primary sample. Duplicate RPDs were within control limits, where calculated, with the following exceptions:

- Ten soil bore or sediment samples with RPD exceedances. Exceedances likely due to sample heterogeneity, as a conservative measure the highest concentrations will be used for reporting purposes.
- Three water grab samples with RPD exceedances. These exceedances were marginal. As a conservative measure the highest results will be used for reporting purposes.

9.2.8 Field Triplicate RPDs

A total of 53 field triplicates were collected during the sampling program. Field triplicate samples were analysed as listed, with their matching primary sample. Triplicate RPDs were within control limits, where calculated, with the following exceptions:

- Nine soil bore or sediment samples with RPD exceedances. Exceedances likely due to sample heterogeneity, as a conservative measure the highest concentrations will be used for reporting purposes.
- Six water grab or groundwater samples with RPD exceedances. These exceedances were marginal. As a conservative measure the highest results will be used for reporting purposes.

All other field duplicate and field triplicate RPD's were within control limits, where calculated. Therefore, these non-conformances are not considered to compromise data integrity.

9.2.9 Other:

As stated by ALS: several LORs were raised due to high sample moisture content.

As stated by ALS: Analysis EP231X - particular samples required dilution due to sample matrix (High conductivity). The corresponding LOR values have been adjusted accordingly for EP231X analysis.

10.0 Results

10.1 Rainfall

Rainfall data collated from St Heliers (station 61374), the BoM weather station with the most recent rainfall data and in closest proximity to the SA (and considered valid for LPS and BPS) indicates the following statistics:

- A total of 62.5 mm of rain was recorded in November 2018, the month preceding the December 2018 fieldwork mobilisation; this was slightly below the long term November mean of 74.3 mm;
- In February 2019, the month preceding the March 2019 fieldwork mobilisation, a total of 31.9 mm of rain was recorded, almost half the long term February mean of 62.8 mm; and
- For the year preceding the December 2018 mobilisation, the cumulative annual rainfall recorded was 357.3 mm, significantly below the annual average of 618.2 mm/year.

The BoM has identified a decreasing trend of total rainfall in the region of the site of approximately 10 mm per decade since 1970, which is supported by long-term averages and actual rainfall by month.

A summary of the lowest, average and highest monthly rainfall recorded by St Heliers weather station is presented in **Table 27**. Daily and monthly rainfall during the November / December sampling period is presented in **Table 28** below and presented graphically in **Figure** 1.

Table 27 Summary of St Hiliers monthly rainfall records

Month	Average Monthly Rainfall in mm	Lowest Monthly Rainfall in mm (year)	Highest Monthly Rainfall in mm (year)
BoM Muswellbrook (St. Heliers) weather station - number 61[illegible]			
January	60	5.2 (2018)	137.5 (2013)
February	62.2	4.4 (2016)	205.3 (1997)
March	59.3	6.6 (1998)	172.4 (2017)
April	37.1	0 (2002)	151.3 (2015)
May	42.5	0 (2006)	152.1 (1998)
June	51.9	8.4 (2001)	158 (2011)
July	37.1	0 (2018)	129.5 (1998)
August	40.3	1.6 (2009)	108 (1998)
September	44.2	3.5 (2003)	101.2 (1996)
October	44.9	0.2 (2006)	85.7 (1993)
November	74.3	10.2 (1997)	217.8 (2013)
December	64	19.4 (2005)	148.7 (1992)

It is noted that according to the above climate data, September and October 2018, immediately preceding the investigation, exhibited the lowest rainfall for those months in recording history. The below graph represents average vs actual monthly rainfall recorded at St Heliers leading up to the works.

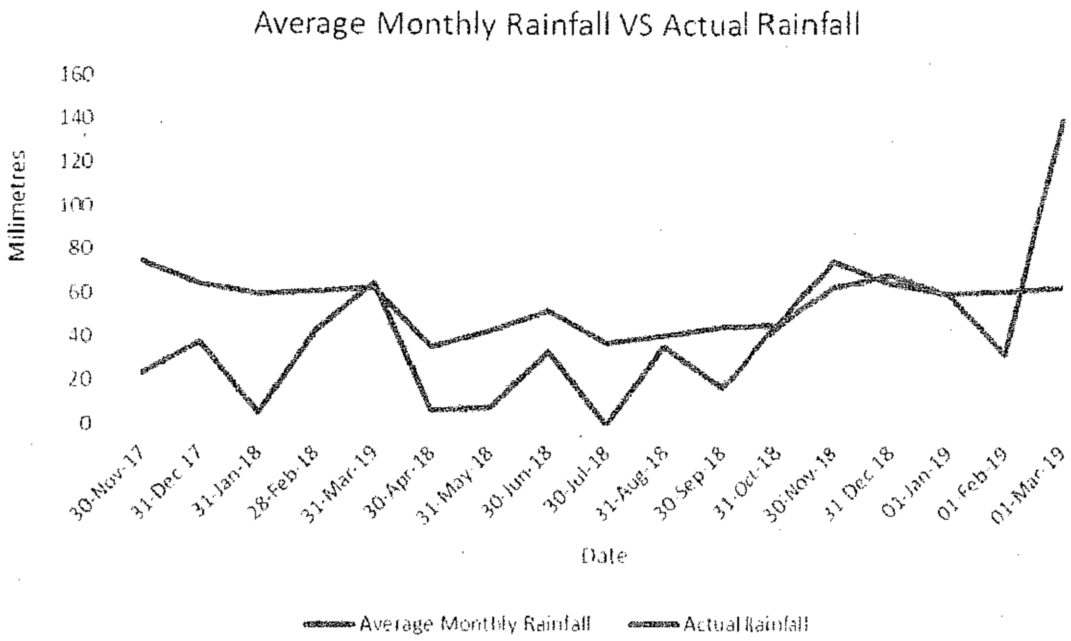

Figure 1 **Average vs actual rainfall at St Heliers weather station from November 2017 to the March 2019 investigation**

Data from the St Heliers station (61374) for the period preceding sampling for both Stage 2 PFAS Investigation and the previous investigations are summarised in **Table 28**below, and provided in **Appendix K.**

Table 28 **Rainfall conditions during fieldwork**

Period	Monthly Rainfall Total (mm)	Average Monthly Rainfall (mm)	Highest Daily Rainfall Total (mm)
May 15 - Sept 15			
May 15	66.8	42.5	20
June 15	45	51.9	17.2
July 15	31.8	37.1	12.4
August 15	65	40.3	6.8
Sept 15	19.6	44.2	8.6
[illegible]			
October 18	44.7	44.9	16
November 18	62.5	74.3	25.5
December 18	68.3	64	10
January 19	59.1	60	30
February 19	31.9	60.7	0.3
March 19	139.4	62.8	10

Notes: Average monthly rainfall derived from data from 1969 to 2019.

It is noted that in August 2015, most of the rainfall total for the month (65 mm) was from an accumulated 3-day period.

A summary of the rainfall data is provided as follows:

- Monthly rainfall during the previous ESA was generally consistent with monthly averages, excepting the last month of the fieldwork, September 2015, which saw a total monthly rainfall of 19.6 mm, significantly below the average of 44.2 mm.
- Monthly rainfall during the 12 month period prior to this investigation was between 0 mm for July 2018 and 139.4 mm in March 2019,generally significantly lower than the average, apart from March 2019 which recorded rainfall over double the mean (refer **Table 5** in **Section 5.2** above).
- Monthly rainfall was consistent with the average during the October 2018 fieldwork period generally consistent with the monthly average for November and December 2018 and significantly below average during the first two months of 2019.
- Rainfall recorded during the final month of fieldwork (March 2019) was the highest recorded over the fieldwork period (139.4 mm), and exceeded the March monthly average. The highest daily rainfall total recorded during the fieldworks program occurred on 29 November 2018.

10.2 LPS AICs

10.2.1 Geology

Geological conditions observed at LPS are detailed in the borelogs presented in **Appendix E** and are summarised below. Representative photographs are provided in **Appendix L**.

10.2.1.1 AIC NP

Grey to dark grey, firm to stiff silty clay and claystone with trace sand was intercepted in soil bores within AIC Northern Peninsula at depths between 9.2 mbgl (LPS_AICNP_SB105) and 9.9 mbgl (LPS_AICNP_SB105). This material was encountered only in the deeper soil bores and was proven to extend at least 15.0 mbgl in soil bore LPS_AICNP_SB129. The grey colouring is distinct from overlying soils and is generally consistent with the dark-grey shales, siltstones, claystones and fine grained sandstones of the Permian-aged Mulbring Siltstone mapped in the area (Summerhayes, 1983; Glen & Beckett, 1993).

Overlying the Mulbring Siltstone were friable clayey silts and silty clays, typically containing fine to medium sand and fine to coarse, angular to rounded gravels. Soil colours were variable and included brown, orange, orangish brown, yellow, yellowish brown, light grey and red. These materials extended to the surface and are interpreted as variably weathered Mulbring Siltstone material.

10.2.1.2 AIC 93-96

Underlying this AIC between surface level in some areas to >6 mbgl stiff, friable clayey silts and silty clays, typically containing fine to medium sand and fine to coarse, angular to rounded gravels. Soil colours were variable and included brown, orange, orangish brown, yellow, yellowish brown, light grey and red. These materials extended to the surface or the extent of the natural material and are interpreted as variably weathered Mulbring Siltstone material.

Overlying this formation in some areas of AIC 93-96 is fill or reworked natural weathered soils generally comprised of gravel with brown or brown with orange or grey mottling silts and clays and some sand. The gravel and cobbles was found to be angular to subrounded ranging in size up to 250 mm.

10.2.1.3 Summary of LPS Geological Conditions

Table 29 Summary of subsurface conditions at the LPS AICs

Description	Depth Encountered (mbgl)	
	AIC NP	AIC 93-96
Fill and reworked natural weathered soils generally comprised of gravel with brown or brown with orange or grey mottling silts and clays and some sand	NE	<1.2
Friable clayey silts and silty clays, typically containing fine to medium sand and fine to coarse, angular to rounded gravels.	0 – 1.2	0 – 7.0
Grey to dark grey, firm to stiff silty clay and claystone with trace sand.	>9.2	NE

Notes
NE = Not Encountered

10.2.2 Hydrogeology

Hydrogeological conditions encountered are described in the following sections. Seepage velocity calculations are presented in Appendix M.

10.2.2.1 AIC NP

Hydrogeology at the AIC NP is summarised below:

- SWLs ranged from 4.17 metres below top of casing (mbtoc) (LPS_AICNP_MW122) to 9.41 mbtoc (LPS_AICNP_MW129).
- A review of the BOM Groundwater Dependent Ecosystems Atlas (8 May 2019) showed no Groundwater Dependent Ecosystems (GDEs) in or adjacent to AIC-NP.
- Two existing monitoring wells were reported as dry when gauged (L_P_ESMW01 and L_P_ESMW02).
- Based on the SWL and the survey data, the inferred potentiometric contours infer that groundwater generally follows surface topography with a shallow gradient north-east towards Lake Liddell.
- The average horizontal hydraulic gradient was calculated to be between 0.0019 and 0.12 (average of 0.0026) for the predominant flow direction.
- The hydraulic conductivity was estimated using literature values representative of the clayey silt aquifer unit encountered and estimated to be within the range of 8.6 x 10^{-3} m/day to 8.6 x 10^{-6} m/day (Fetter, 1988).
- The average linear groundwater velocity[4] can be estimated to range from (8.6 x 10^{-6} m/day × 0.0019 / 0.2 ×365 days/year) **0.00003 m/year** to (8.6 x 10^{-3} m/day × 0.12 / 0.10 ×365 days/year) **0.38 m/year**, based on effective porosity assumed to range between 0.1 and 0.2[5].

10.2.2.2 AIC 93–96

Hydrogeology at AIC 93-96 is summarised below:

- Groundwater levels were measured in 17 existing monitoring wells and five newly installed monitoring wells at AIC 93-96 on 14 March 2019.
- SWLs ranged from 1.96 mbtoc (LH_MW01) to 5.37 mbtoc (LPS_AIC9396_MW128).
- A review of the BOM Groundwater Dependent Ecosystems Atlas (8 May 2019) showed no Groundwater Dependent Ecosystems (GDEs) in or adjacent to AIC 93-96.
- Based on the SWL and the survey data, the inferred potentiometric contours indicate that groundwater generally follows surface topography, flowing generally east towards Lake Liddell.

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[4] Groundwater velocity calculated using Darcy's Law
[5] Based on published literature values (Freeze, A. and Cherry, J., 1979)

- The horizontal hydraulic gradient was estimated to be between 0.013 and 0.04 for the predominant flow direction.
- The hydraulic conductivity was estimated using literature values representative of the clayey silt aquifer unit encountered and estimated to be within the range of 8.6 x 10^{-3} m/day to 8.6 x 10^{-6} m/day (Fetter, 1988).
- The average linear groundwater velocity[3] can be estimated to range from (8.6 x 10^{-6} m/day × 0.013 m/m / 0.2 ×365 days/year) **0.0002 m/year** to (8.6 x 10^{-3} m/day × 0.04 / 0.10 ×365 days/year) **0.13 m/year**, based on effective porosity assumed to range between 0.1 and 0.2[4].

10.2.2.3 Summary of LPS Hydrogeological Conditions

Table 30 Summary of LPS hydrogeological conditions

Monitoring Well ID	AIC NP	AIC 93 - 96
Standing Water Level (mbgl)	4.17 to 9.41	1.96 to 5.37
Groundwater Elevation (mAHD)	123.92 to 127.22	127.15 to 132.37
Inferred Flow Direction	NE	E
Hydraulic Gradient (k)	0.019 to 0.12	0.013 to 0.04
Hydraulic Conductivity (m/year)	0.00003 to 0.38	0.0002 to 0.13

10.2.3 Groundwater Geochemical Parameters

The groundwater geochemical parameters measured in the field are presented in **Table T2** and summarised in **Table 31**. The groundwater sampling locations are shown in **Figures 36** to **40** in **Appendix A**. The stabilised geochemical parameter measurements at each AIC are summarised in the following sections.

10.2.3.1 AIC NP

- pH: measurements were between 3.54 (L_P_ESMW04) and 6.53 (LPS_AICNP_MW112) indicating acidic to near-neutral groundwater conditions.
- EC: measurements ranged between 14610 µS/cm (LPS_AICNP_MW112) and 18060 µS/cm (LPS_AICNP_MW129) indicating brackish groundwater conditions.
- Dissolved oxygen: measurements ranged between 0.15 mg/L (LPS_AICNP_MW114) and 2.61 mg/L (LPS_AICNP_MW105) indicating that groundwater ranges from anaerobic to moderately oxygenated conditions.
- Temperature: measurements ranged between 21.3 °C and 23.3 °C. Both extremes were recorded in the same monitoring well (LPS_AICNP_MW114) at different depths.
- Redox: measurements ranged between -158 mV (LPS_AICNP_MW112) and 405.3 mV (L_P_ESMW04) indicating a range of conditions, from mildly reducing to oxidising.

10.2.3.2 AIC 93–96

- pH: measurements were between 3.09 (L_93_ESMW01) and 7.71 (LH_MW01) indicating acidic to slightly alkaline groundwater conditions.
- EC: measurements ranged between 1518 µS/cm (LH_MW01) and 91100 µS/cm (LPS_AIC9396_MW128) indicating brackish to highly saline groundwater conditions.
- Dissolved oxygen: measurements ranged between 0.19 mg/L (LO_MW13) and 3.33 mg/L (LE_MW08) indicating that groundwater ranges from anaerobic to moderately oxygenated conditions.
- Temperature: measurements ranged between 20.6 °C (LE_MW07) and 28.1 °C (LPS_AIC9396_MW106).

- Redox: measurements ranged between -152 mV (LPS_AIC9396_MW125) and 435.8 mV (L_93_ESMW01), indicating a range of conditions, from mildly reducing to oxidising.

10.2.3.3 Summary of Geochemical Parameters

Table 31 Summary of groundwater geochemical parameters at LPS

Parameter	AIC NP		AIC 93-96	
	Minimum	Maximum	Minimum	Maximum
pH	3.54	6.53	3.09	7.71
EC (µS/cm)	14,610	18,060	1,518	91,100
Dissolved Oxygen (mg/L)	0.15	2.61	0.19	3.33
Temperature (°C)	21.3	23.3	20.6	28.1
Redox (ORP) (mV)	-158	405.3	-152	435.8

10.2.4 Sediment Observations

Sediment observations are discussed in the following sections.

10.2.4.1 AIC NP

Conditions observed during sediment sampling around AIC Northern Peninsula are summarised in **Table 32** below. Sediment sampling locations are shown in **Figure 49** to **Figure 56** in **Appendix A**. Analytical results are presented in **Section 10.2.6**.

Table 32 Summary of sediment observations in the vicinity of AIC Northern Peninsula

Location	Sample Name	Observations
Lake Liddell – E Boundary of AIC NP	LPS_AIC_NP_SD537_0.1	Sediment sampled from the edge of Lake Liddell on the eastern boundary of AIC Northern Peninsula comprised brown, soft to firm, moderate plasticity gravelly clay with some fine to coarse sand. Gravel was fine to coarse and angular to sub-rounded. No staining or odours were noted.
EPL Discharge Point 13	LPS_ SD526	Sediment sampled from EPL 13 was a brown/black sandy clay with some gravel. Sand was fine to medium grained; gravel was fine to coarse grained, subangular to surrounded. An organic odour was noted.
Lake Liddell – NE Boundary of AIC NP	LPS_AIC_NP_SD527	Sediment collected at the edge of Lake Liddell on the north-eastern boundary of AIC Northern Peninsula was grey gravelly sand with high organic content and shells. Gravel was fine to medium and angular to sub-rounded. Sand was fine to coarse. No odours were noted.
Lake Liddell – NW Boundary of AIC NP	LPS_AIC_NP_SD528	Surface sediment (0-0.05 mbgl) from the edge of Lake Liddell on the north-western boundary of AIC Northern Peninsula comprised grey gravelly sand with high organic content and shells. Gravel was fine to medium and angular to sub-rounded. Sand was fine to coarse. No odours were noted. Sediment below the surface (0.05-0.15 mbgl) became grey, high plasticity clay with minor gravel.

Location	Sample Name	Observations
Lake Liddell – W Boundary of AIC NP	LPS_AIC_NP_SD529	Sediment collected at the edge of Lake Liddell on the western boundary of AIC Northern Peninsula was soft, low plasticity dark brown sandy clay with some organic content and shells. Sand was fine. An organic odour was noted.

10.2.4.2 AIC 93-96

Table 33 Summary of sediment observations in the vicinity of AIC 93-96

Location	Sample Name	Observations
Pond Adjacent to Lake Liddell	LPS_AIC95_ SD523	Sediment sampled from the pond adjacent to Lake Liddell on the eastern boundary of AIC 93-96 comprised black to brown sandy gravel with some clay and organic material. Gravel was fine to medium and angular. Sand was fine to medium. A hydrocarbon odour was noted.
Lake Liddell – E Boundary of AIC 93-96	LPS_AIC93_SD524	Sediment collected from a body of water at the edge of Lake Liddell on the eastern boundary of AIC 93-96 was brown to black moderate plasticity clay with trace sand and a high organic component. No odours were noted.
Lake Liddell – E Boundary of AIC 93-96	LPS_AIC94_SD525	Sediment collected near the edge of Lake Liddell on the eastern boundary of AIC 93-96 was brown mottled black and orange fine to coarse moist sand with trace gravel and suspected coal fines. Gravel was medium and angular. No odours were noted.
Lake Liddell – E Boundary of AIC 93-96	LPS_AIC9396_SD560_0.0	Sediment from the edge of Lake Liddell on the eastern boundary of AIC 93-96 comprised loosely packed, sandy gravel with some cobbles, shells, silt and suspected coal fines. Gravel was fine to coarse and angular to sub-rounded. Sand was fine to coarse and angular to sub-rounded. No odours were noted.
Creek near Lake Liddell - E Boundary of AIC 93-96	LPS_AIC9396_SD561_0.0	Sediment from a creek bed near the eastern boundary of AIC 93-96 was soft, black, grey and orange low plasticity clay with trace fine to coarse sand and coal fines. No odours were noted.

10.2.5 Surface Water Observations

10.2.5.1 AIC NP

Surface water samples were collected at AIC NP on its north, east and west sides, situated with the aim of identifying potential impacts from the general area of estimated groundwater discharge on each side of the peninsula . Observations noted during surface water sampling around the perimeter of AIC NP are summarised in **Table 34** below. Photographs of sample locations are presented in **Appendix L**. The surface water sampling locations tabulated below are illustrated in **Figure 41** to **Figure 48** in **Appendix A**.

Table 34 Summary of surface water observations associated with AIC Northern Peninsula

Location	Sample Names	Observations
Lake Liddell – SE Boundary of AIC NP	LPS_AIC_NP_WG538_0.0 LPS_AIC_NP_WG538_0.5	On 7 December 2018, water samples were collected at the lake edge on the south-eastern boundary of AIC Northern Peninsula. The sampling location comprised the base of a steep, engineered rocky embankment positioned 2-3 m below the ground surface with sparse vegetation present on the upper slopes. Water was odourless, colourless and clear with small brown suspended solids. A fish was observed swimming in the vicinity of the sampling location and aquatic grass-like vegetation was noted approximately 1 m offshore.
Lake Liddell – SE Boundary of AIC NPEPL Discharge Point 13	LPS_ WG526_0.0 LPS_ WG526_0.5	Water samples were collected at EPL Discharge Point 13 on the edge of Lake Liddell. The sampling location comprised the base of a wide concrete culvert, approximately 6 m wide and 2 m deep which discharges into Lake Liddell. . Water was fast flowing and turbulent. odourless, colourless and clear with low turbidity.
Lake Liddell – E Boundary of AIC NP	LPS_AIC_NP_WG537_0.0 LPS_AIC_NP_WG537_0.5	On 7 December 2018, water samples were collected at the lake edge on the eastern boundary of AIC Northern Peninsula. The samples were collected where the gradient of the engineered rocky embankment becomes shallow and meets the shoreline. Vegetation in the immediate area was sparse, however dead reeds approximately 2 m up gradient from the shoreline were suggestive lake water levels have been higher in recent times. Water was odourless, colourless and clear with small brown suspended solids. Fish and aquatic grass-like vegetation were observed near the sampling location, and small accumulations of foam were noted on the lake surface clinging to partially submerged rocks.
Lake Liddell – NE Boundary of AIC NP	LPS_AIC_NP_WG527_0.0 LPS_AIC_NP_WG527_0.5	On 27 November 2018, water samples were collected near the lake edge on the north-eastern boundary of AIC Northern Peninsula. The samples were collected amongst dense reed vegetation within an approximately 0.2 m deep, 5 m wide marsh area separating the lake edge and the water line. A 10-15 m wide band of dead reeds were observed upgradient of the marsh area, indicative of historically higher water levels. The water had a salty/mineral odour, was colourless to slightly brown and slightly turbid. Small to medium sized fish were observed in the vicinity of the sampling location, and sedge vegetation was also noted amongst the reeds.
Lake Liddell – NW Boundary of AIC NP	LPS_AIC_NP_WG528_0.0 LPS_AIC_NP_WG528_0.5	On 26 November 2018, water samples were collected at the lake edge on the north-western boundary of AIC Northern Peninsula. The sampling location was positioned on the shoreline adjacent to a dry band of dead reeds and sedges extending from the lake edge 10s of metres inland. The water was colourless and clear, non-turbid and odourless and contained small pieces of suspended vegetation. Fish were observed in the vicinity of the sampling location.

Location	Sample Names	Observations
Lake Liddell –W Boundary of AIC NP	LPS_AIC_NP_WG529_0.0 LPS_AIC_NP_WG529_0.5	On 27 November 2018, water samples were collected from both the lake edge and surface water ponded near the western boundary of AIC Northern Peninsula. The ponded water was approximately 2 m x 3 m and located in a clearing of dense vegetation a few metres from the lake edge. The ponded water had an organic odour, was slightly brown, slightly turbid and contained suspended particulates. Water from the lake was slightly brown, moderately turbid and contained suspended particulates and minor dead vegetation floating on the surface. A fish was noted near the lake edge, and reed vegetation was dense in the surrounding area.

10.2.5.2 AIC 93–96

Surface water associated with AIC 93-96 comprised samples from the edge of Lake Liddell bounding AIC 93-96 on its east side, and a sample from a pond which discharges to Lake Liddell. Sample locations were identified downgradient of areas of potential surface water drainage and groundwater discharge. Observations noted during surface water sampling associated with AIC 93-96 are summarised in **Table 35** below, and photographs of sample locations presented in **Appendix L** . The surface water sampling locations tabulated below are illustrated in **Figure 62** in **Appendix A**.

Table 35 Summary of surface water observations associated with AIC 93-96

Location	Sample Names	Observations
Pond Adjacent to Lake Liddell	LPS_AIC95_WG523_0.0 LPS_AIC95_WG523_0.5	On 27 November 2018, water samples were collected from a pond which discharges into Lake Liddell near the eastern side of AIC 93-96. Reeds and algae were noted within the pond, and mature trees and grass vegetation were present around its banks. Water was grey to green, moderately turbid and contained pieces of organic particulate matter. A slight sheen was also noted on the pond's surface. Birds were observed in the surrounding area.
Lake Liddell – E Boundary of AIC 93-96	LPS_AIC93_WG524	On 27 November 2018, a water sample was collected from a small body of water close to the lake edge near the south eastern corner of AIC 93-96. Vegetation in the immediate area was dense, and included reeds and mature trees. Water was moderately turbid, with a slight brown to black colouration and contained pieces of organic particulate matter. Macroinvertebrates were observed in the vicinity of the sampling location, and birds were also noted in the area.
Lake Liddell – E Boundary of AIC 93-96	LPS_AIC9396_WG560_0.0	On 21 March 2019, a water sample was collected from the edge of Lake Liddell near the eastern boundary of AIC 93-96. Vegetation in the immediate area was minimal, however reeds were noted close-by. Water was odourless, colourless and transparent, with black particulates suspended in solution. Animal prints were indicative of Kangaroos frequenting the area.

Location	Sample Names	Observations
Creek near Lake Liddell - E Boundary of AIC 93-96	LPS_AIC9396_WG561_0.0	On 21 March 2019, a water sample was collected from a creek draining into Lake Liddell near the south eastern corner of AIC 93-96. Sparse reed vegetation and Kangaroo prints were noted in the vicinity, and the water was odourless, colourless and transparent.

10.2.6 Surface Water Geochemical Parameters

10.2.6.1 AIC NP

Geochemical parameters were measured prior to taking surface water samples associated with the Northern Peninsula AIC, a summary of measurements are presented in **Table 36** below and detailed in **Table T3** in **Appendix B**. Surface water sampling locations are shown in **Figure 41** to **Figure 48** in **Appendix A**. Analytical results are presented in **Table 52**. Stabilised geochemical parameter measurements were:

- pH: measurements were between 7.51 and 8.26 indicating neutral to slightly alkaline conditions.
- Electrical conductivity: measurements ranged between 2598 µS/cm and 3289 µS/cm and indicate brackish water.
- Dissolved oxygen: measurements exceeded theoretical maximum solubility limits (8.03 mg/L; USGS, 2016) in three of the four samples. Dissolved oxygen measured in the fourth sample was 1.01 mg/L and indicating anaerobic conditions.
- Temperature: measurements ranged from 23.7 °C to 32.7 °C.
- Redox Potential: measurements ranged between -136.9 mV and 59.9 mV and indicate mildly reducing conditions.

10.2.6.2 AIC 93-96

Geochemical parameters were measured prior to taking surface water samples associated with the Northern Peninsula AIC, a summary of measurements are presented in **Table 36** below and detailed in **Table T3** in **Appendix B**. Surface water sampling locations are shown in **Figures 61** in **Appendix A**. Analytical results are presented in **Section 10.2.6**. Stabilised geochemical parameter measurements were:

- pH: measurements were between 7.56 and 8.07 indicating neutral conditions.
- Electrical conductivity: measurements ranged between 367 µS/cm and 2466 µS/cm, inferring fresh to slightly brackish water.
- Dissolved oxygen: measurements were in the anaerobic range, between 4.06 mg/L and 5.55 mg/L.
- Temperature: measurements ranged from 20.5°C to 29.4 °C.
- Redox Potential: measurements were between 64.0 mV and 139.8 mV indicating neutral conditions.

10.2.6.3 Summary of LPS Surface Water Conditions

Table 36 Summary of surface water geochemical parameters at LPS

Parameter	AIC NP		AIC 93-96	
	Minimum	Maximum	Minimum	Maximum
pH	7.51	8.26	7.56	8.07
EC (µS/cm)	2598	3289	367	2466
Dissolved Oxygen (mg/L)	1.01	12.3[1]	4.06	5.55
Temperature (°C)	23.7	32.7	20.5	29.4
Redox (ORP) (mV)	-136.9	59.9	64.0	139.8

Note: [1] The theoretical maximum value of oxygen solubility, considering the water temperature and specific conductance conditions observed in the field is estimated to be 8.03 mg/L (USGS, 2016). Any value measured above this value has been considered to be erroneous.

10.2.7 Soil Analytical Results

Analytical results are presented in the following sections, summarised by matrix followed by AIC.

PFAS analytical results are summarised in **Table 37** and **Table 38** below, and are presented in **Table T4**, **Appendix B,** and in **Figures 11, 16, 21, 26,** and **31**, in **Appendix A**.

10.2.7.1 AIC NP

- PFOS concentrations were above the LOR in 16 locations; of these, 1 location exceeded the adopted ILs with a maximum concentration of 0.9 mg/kg reported in soil bore location LPS_AICNP_SB105.
- PFOA concentrations were above the LOR in 6 locations; none of these locations exceeded the ILs.
- PFOS and PFHxS concentrations were above the LOR in 16 locations; none of these locations exceeded the ILs.

Table 37 Summary of PFAS soil analytical results at the Northern Peninsula

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
38	PFOS	< 0.0002 - 0.9	24	1
38	PFOA	< 0.0002 - 0. 0097	7	0
38	PFOS + PFHxS	< 0.0002 - 0.955	21	0

Table 38 Comparison of PFOS with soil depth at the Northern Peninsula

Depth (mbgl)	No. Locations	No. Detects	PFOS Conc. Range (mg/kg)
0.0 - 0.5	29	18	0.0002 – 0.9
0.5 – 1.5	5	2	<0.0002 – 0.0021
1.5 – 4.0	5	1	<0.0002 - 0.0005
4.0 – 6.0	6	1	<0.0002 – 0.0015
>6.0	8	1	<0.0002 - 0.0002

Table 39 Comparison of PFOA with soil depth at the Northern Peninsula

Depth (mbgl)	No. Samples	No. Detects	PFOA Conc. Range (mg/kg)
0.0 - 0.5	29	6	0.0002 – 0.0097
0.5 – 1.5	5	0	<0.0002
1.5 – 4.0	5	0	<0.0002
4.0 – 6.0	5	1	<0.0002 - 0.0002
>6.0	8	0	<0.0002

Table 40 Comparison of PFOS + PFHxS with soil depth at the Northern Peninsula

Depth (mbgl)	No. Samples	No. Detects	PFOS + PFHxS Conc. Range (mg/kg)
0.0 - 0.5	29	19	0.0002 – 0.955
0.5 – 1.5	5	2	<0.0002 – 0.003
1.5 – 4.0	5	1	<0.0002 - 0.0013
4.0 – 6.0	5	1	<0.0002 – 0.0019
>6.0	8	1	<0.0002 - 0.0009

10.2.7.2 AIC 93-96

Soil samples were obtained during the Stage 2 PFAS Investigation field program from 29 locations at the AIC 93-96.

- PFOS concentrations were above the LOR in 17 locations; of these, 2 locations exceeded the ecological ILs (EILs) with a maximum concentration of 0.341 mg/kg reported at soil bore location LPS_AIC9396_SB102.
- PFOA concentrations were above the LOR at 9 locations; none of these locations exceeded the adopted ILs.
- PFOS and PFHxS concentrations were above the LOR in 21 samples; none of these locations exceeded the adopted ILs.

Table 41 Summary of PFAS soil analytical results at the AIC 93-96

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No Samples with Concentrations >LOR	No. Samples Exceeding ILs
74	PFOS	< 0.0002 – 0.341	17	0
74	PFOA	< 0.0002 – 0.133	9	0
74	PFOS + PFHxS	< 0.0002 - 0.969	21	2

Table 42 **Comparison of PFOS with soil depth at the AIC 93-96**

Depth (mbgl)	No. Samples	No. Detects	PFOS Conc. Range (mg/kg)
0.0 - 0.5	39	13	<0.0002 – 0.341
0.5 – 1.5	9	5	<0.0002 – 0.0029
1.5 – 4.0	20	4	<0.0002 – 0.134
4.0 – 6.0	2	1	<0.0002 - 0.0002
>6.0	3	0	<0.0002

Table 43 **Comparison of PFOA with soil depth at the AIC 93-96**

Depth (mbgl)	No. Samples	No. Detects	PFOA Conc. Range (mg/kg)
0.0 - 0.5	39	8	<0.0002 - 0.133
0.5 – 1.5	9	0	<0.0002
1.5 – 4.0	20	2	<0.0002 – 0.0009
4.0 – 6.0	2	0	<0.0002
>6.0	3	0	<0.0002

Table 44 **Comparison of PFOS + PFHxS with soil depth at the AIC 93-96**

Depth (mbgl)	No. Samples	No. Detects	PFOS + PFHxS Conc. Range (mg/kg)
0.0 - 0.5	39	16	<0.0002 - 0.969
0.5 – 1.5	9	6	<0.0002 - 0.0249
1.5 – 4.0	20	4	<0.0002 - 0.139
4.0 – 6.0	2	1	<0.0002 – 0.0008
>6.0	3	1	<0.0002 - 0.0004

10.2.8 Groundwater Analytical Results

PFAS analytical results are summarised in **Table 47** and **Table 49** below, and are presented in **Table T4** (**Appendix B**) and in **Figures 11, 16, 21, 26,** and **31** (in **Appendix A**).

10.2.8.1 AIC NP

Groundwater PFAS analytical results are summarised in **Table 45** and **Table 46** below, and are presented in **Table T5,** in **Appendix B**, and in **Figure 36,** in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at two locations, both of which exceeded the adopted ILs with a maximum concentration of 0.13 µg/L reported in groundwater monitoring location LPS_AICNP_GWMW105.
- PFOA concentrations were all below the adopted ILs.
- PFOS and PFHxS concentrations were above the LOR in 2 samples; of these, 2 samples exceeded the adopted ILs with a maximum concentration of 0.35 µg/L reported in groundwater monitoring location LPS_AICNP_GWMW105.

Table 45 Summary of PFAS in groundwater at the Northern Peninsula

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
9	PFOS	<0.01 – 3.98	3	3
9	PFOA	<0.01 – 0.24	2	0
9	PFOS + PFHxS	<0.01 – 6.77	4	4

Table 46 Comparison of PFOS + PFHxS with groundwater depth at the Northern Peninsula

Wells Sampled at Dual Depths	Depth	PFOA (µg/L)	PFOS (µg/L)	PFOS + PFHxS (µg/L)
LPS_AICNP_MW114	7.5	< 0.01	< 0.01	< 0.01
	10.5	< 0.05	< 0.05	< 0.05
LPS_AICNP_MW122	6	< 0.05	< 0.05	< 0.05
	8	< 0.05	< 0.05	< 0.05
LPS_AICNP_MW129	12	**0.24**	**3.98**	**6.77**
	13.5	**0.09**	**0.83**	**1.56**

10.2.8.1.1 Comparison With Historic Results

Location L_P_ESMW04, an existing well, reported results below LOR in this and the previous monitoring event.

10.2.8.2 AIC 93-96

Groundwater PFAS analytical results are summarised in **Table 47** and **Table 48** below, and are presented in **Table T5, in Appendix B**, and in **Figure 37,** in **Appendix A**. In summary:

- PFOS concentrations were above the LOR in 11 samples; of these, 7 samples exceeded the adopted ILs, with a maximum concentration of 28.9 µg/L reported in in groundwater monitoring well LPS_AIC9396_LAW_ESMW03.
- PFOA concentrations were above the LOR in 10 samples; of these, 4 samples exceeded the adopted ILs, with a maximum concentration of 28.9 µg/L reported in in groundwater monitoring well LPS_AIC9396_LAW_95_ESMW02.
- PFOS and PFHxS concentrations were above the LOR in 12 samples; all of these 12 samples exceeded the adopted ILs with a maximum concentration of 45.8 µg/L reported in in groundwater monitoring well LPS_AIC9396_LAW_ESMW03.

Table 47 Summary of PFAS in groundwater at AIC 93-96

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
22	PFOS	<0.01 - 28.9	11	7
22	PFOA	<0.01 - 2.26	10	4
22	PFOS + PFHxS	<0.01 – 45.8	12	12

Table 48 Comparison of PFOS + PFHxS with groundwater depth at AIC 93-96

Wells Sampled at Dual Depths	Depth	PFOA (µg/L)	PFOS (µg/L)	PFOS + PFHxS (µg/L)
LPS_AIC9396_GWL_93_ESMW03	6.6	**0.08**	**0.09**	**0.21**
	8.4	< 0.05	< 0.05	< 0.05
LPS_AIC9396_GWMW110	6.0	< 0.05	< 0.05	< 0.05
	7.0	< 0.05	< 0.05	< 0.05
LPS_AIC9396_GWMW129	5.0	< 0.05	< 0.05	< 0.05
	6.0	< 0.05	< 0.05	< 0.05
LPS_AIC9396_LO_MW13	6.5	**0.02**	**0.12**	**0.38**
	8.5	**0.02**	**0.16**	**0.43**
LPS_AIC9396_LE_MW03	2.9	**0.18**	**0.69**	**1.04**
	4.8	**0.25**	**0.85**	**1.35**
LPS_AIC9396_LH_MW01	5.5	**0.03**	**0.35**	**0.45**
	7.5	**0.01**	**0.14**	**0.20**

10.2.8.2.1 Comparison With Historic Results

Thirteen existing groundwater monitoring wells at AIC 93-96 were sampled during this investigation. A comparison of results are summarised below in **Table** 49 and detailed in **Table T10**, in **Appendix B**.

Variability between the data sets can be seen at several locations; within the fire training area; LAW_95_ESMW02, reported lower results by an order of magnitude for PFOA than when first sampled in January 2015, adjacent well, LAW_95_ESMW03, reported <LOR (0.05 µg/L) in January 2016, results increasing by up to four orders of magnitude for this monitoring event. LP_MW03, LE_MW05 and L_94_ESMW01 all reported concentrations up to three orders of magnitude higher than previously reported. LE_MW07 reported results an order of magnitude lower than previously.

Two sets of data are considered insufficient to accurately assess temporal trends in concentrations. Historic results are predominantly within the range of those reported in this investigation. Where some variability exists there is no discernible trends noted between the sampling rounds. The behaviour of PFAS in the environment and the fact it is an emerging contaminant in terms of sampling and analysis techniques, may cause some inconsistency in results between events.

Table 49 AIC 93-96 groundwater historic results comparison for locations >LOR

Locations	Sample Date	PFOA	PFOS	Sum of PFOS & PFHxS
LAW_95_ESMW02	21/01/2015	**2.9**	**52**	***52***
	22/11/2018	**0.73**	***28.9***	***31.6***
LO_MW13	3/07/2015	< 0.05	< 0.05	< 0.05
	27/11/2018	**0.02**	**0.12**	**0.38**
	27/11/2018	**0.02**	***0.16***	**0.43**
L_95_ESMW04	14/01/2016	< 0.05	< 0.05	< 0.05
	21/11/2018	**0.25**	**0.06**	***1.52***
LP_MW03	14/01/2016	< 0.05	< 0.05	< 0.05
	21/11/2018	**0.08**	***0.43***	***1.25***

Locations	Sample Date	PFOA	PFOS	Sum of PFOS & PFHxS
LAW_95_ESMW03	20/01/2016	< 0.05	< 0.05	< 0.05
	27/11/2018	**2.18**	***16.8***	***45.8***
	27/11/2018	**2.15**	***16.3***	***43.3***
	27/11/2018	**2.26**	***16.8***	***45.6***
LE_MW03	6/10/2016	**0.2**	**0.78**	***1.21***
	22/11/2018	**0.18**	***0.69***	***1.04***
	22/11/2018	**0.25**	***0.85***	***1.35***
LE_MW05	6/10/2016	< 0.01	< 0.01	< 0.02
	29/11/2018	**0.06**	***0.22***	***2.14***
LE_MW07	6/10/2016	**0.054**	**0.11**	***0.97***
	29/11/2018	< 0.05	< 0.05	< 0.05
L_93_ESMW02	11/10/2016	**0.12**	**0.1**	**0.2**
	29/11/2018	**0.06**	**0.08**	**0.23**
L_93_ESMW03	11/10/2016	**0.21**	**0.22**	**0.54**
	21/11/2018	**0.08**	**0.09**	**0.21**
L_94_ESMW01	11/10/2016	**0.034**	< 0.01	**0.034**
	21/11/2018	**0.04**	**0.02**	**0.10**

10.2.9. Sediment Analytical Results

10.2.9.1 AIC NP

Sediment samples were collected during the field program from 4 locations within the AIC boundary. Samples were collected concurrently with surface water samples with the exception of location LPS_AICNP_WG538, in the east of the AIC, which had no access to sediment due to boulders along the shoreline.

Sediment PFAS analytical results are summarised in **Table 50** below, and are presented in **Table T7** (in **Appendix B**) and in **Figure 49, in Appendix A**. In summary:

- PFOS concentrations were above the LOR in 3 samples; none of these samples exceeded the adopted ILs.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were above the LOR in 3 samples; none of these samples exceeded the adopted ILs.

Table 50 Summary of PFAS in sediment at the Northern Peninsula

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
10	PFOS	<0.0002 – 0.0048	3	0
10	PFOA	<0.0002	0	0
10	PFOS + PFHxS	<0.0002 – 0.0048	3	0

10.2.9.2 AIC 93-96

Sediment samples were collected during the field program from 3 locations within the AIC boundary and 3 outside the AIC boundary.

Sediment PFAS analytical results are summarised in **Table 51** below, and are presented in **Table T7**, in **Appendix B**, and in **Figure 50,** in **Appendix A**. In summary:

- PFOS concentrations were above the LOR in 4 samples; none of these, samples exceeded the ILs.
- PFOA concentrations were above the LOR in 1 sample which did not exceed the adopted ILs.
- PFOS and PFHxS concentrations were above the LOR in 4 samples; none of these, samples exceeded the ILs.

Table 51 Summary of PFAS in sediment associated with AIC 93-96

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
6	PFOS	<0.0002 – 0.009	4	0
6	PFOA	<0.0002 – 0.0002	1	0
6	PFOS + PFHxS	<0.0002 – 0.112	4	0

10.2.10 Soil and Sediment Leachate Analytical Results

Targeted soil and sediment locations underwent additional ASLP analysis. This analysis is used to determine the potential leachability of an analyte by rainwater. A neutral ASLP test was conducted to mimic neutral rainwater and the results compared to guidelines used for the receptor, in this case the Freshwater guidelines.

10.2.10.1 AIC-NP

Seven soil locations from the Northern Peninsula were ASLP tested, including LPS_AICNP_SB105 which exceeded the ILs. Of these locations, two results exceeded the Freshwater guidelines for PFOS, and three exceeded the guideline for Sum of PFOS & PFHxS. This indicates the potential for PFAS impacted soils to act as a secondary source, with the potential for PFAS to migrate through the soil profile to underlying groundwater.

10.2.10.2 AIC 93-96

Three soil and one sediment location from AIC 93-96 were ASLP tested. Of these locations, LPS_AIC9396_SB114 exceeded the Freshwater guidelines for PFOS at two depths, 0.5 mbgl and 1.1 mbgl. The sediment sample ASLP result was below the EIL. This indicates the potential for PFAS in soils to migrate through the soil profile to underlying groundwater however the link between groundwater and sediment is inferred to be incomplete.

10.2.11 Surface Water Analytical Results

10.2.11.1 AIC-NP

10 surface water samples were collected from five locations during the Stage 2 PFAS Investigation. Prior to sampling in December 2018, 86.2 mm of rainfall was recorded for November which was within the range of the long term average of 84.9mm (refer to **Section 10.1**).

Two additional locations were sampled outside the AIC boundary between 13 November and 27 November 2017, to resolve a potential data gap around impacts at LPS_NP_MW105.

Surface water PFAS analytical results are summarised in **Table 52** below, and are presented in **Table T6,** in **Appendix B**, and in **Figure 41,** in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 52 Summary of PFAS in surface water associated with AIC Northern Peninsula

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
10	PFOS	<0.01	0	0
10	PFOA	<0.01	0	0
10	PFOS + PFHxS	<0.01	0	0

10.2.11.2 AIC 93-96

Surface water PFAS analytical results are summarised in **Table 53** below, and are presented in **Table T6,** in **Appendix B**, and in **Figure 42,** in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 53 Summary of PFAS in surface water associated with AIC 93-96

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
7	PFOS	<0.01	0	0
7	PFOA	<0.01	0	0
7	PFOS + PFHxS	<0.01	0	0

10.3 BPS AICs

10.3.1 Geology

Geological conditions observed at LPS are detailed in the borelogs presented in **Appendix E** and are summarised below. Representative photographs are provided in **Appendix L.**

10.3.1.1 AIC 11W

Lithology between surface level and >6 mbgl was comprised of soft to firm friable clayey silts and silty clays, typically containing fine to medium sand and fine to coarse, angular to subangular gravels. Soil colours were generally brown /grey with orange, light grey and red mottling and minor black staining. Composition in some areas included a gravelly clay/silt layer between 0.5 and 1.5 mbgl. Soils were moister when compared with the drier silts and clays found in other areas of the site.

Groundwater strike depths were not able to be measured accurately during drilling due to the introduction of drilling water at some soil bore locations, and. slow groundwater recovery into drilled bores. Groundwater levels were determined by allowing the drilled boreholes to recover following monitoring well installation and ranged between 1.47 mbgl (BPS_AIC11W_MW123) and 3.16 mbgl (BPS_AIC11W_MW120).

10.3.1.2 AIC 17

Three deep soil bores were drilled at AIC 17; these locations were underlain by a fine grey silty claystone which had a highly weathered zone at the top of the profile. Once through the weathered zone the claystone was found to be hard and dry.

Sub-surface lithology between surface level in some areas and >5.2 mbgl was comprised of soft clayey silts and silty clays with a medium plasticity, typically containing fine to coarse sand and fine to coarse, angular to sub angular gravels. Colours were generally brown or grey with orange, red and grey or dark brown mottling.

Overlying this formation in the vicinity of the transformer area is fill or reworked natural weathered soils generally comprised of sandy brown clays and silts with minor subrounded to subangular gravel.

Groundwater strike depths were not able to be measured accurately during drilling due to the introduction of drilling water at some soil bore locations, and encountering primarily dry soils across AIC 17. These features, combined with observations of slow groundwater recovery into drilled bores obscured the interpretation of groundwater levels during the drilling sequence. Groundwater level was determined by allowing the drilled borehole to recover following monitoring well installation and was found to be 2.55 mbTOC at the single new well installed to the south-west of the transformer area (BPS_AIC17_MW109).

10.3.1.3 AIC 51-52

Subsurface conditions observed during the advancement of 21 soil bores within AIC 51-52 are detailed in the borelogs presented in **Appendix E** and are summarised below. Representative photographs are provided in **Appendix L**.

Sub-surface lithology between surface level in some areas and >6 mbgl was comprised of soft to firm friable clayey silts and silty clays, typically containing fine to medium sand and fine to coarse, angular to rounded gravels. Soil colours were variable and included brown, orange, orangish brown, yellow, yellowish brown, light grey and red. Composition included more gravel in the lower eastern portion of this AIC, towards the Ash Dam. These materials extended to the surface, or in disturbed areas the extent of the natural material, and are interpreted as variably weathered Mulbring Siltstone material.

Overlying this formation in the vicinity of the tank farm is fill or reworked natural weathered soils generally comprised of gravel with brown or brown with orange or grey mottling silts and clays and some sand. The gravel and cobbles was found to be angular to subrounded ranging in size up to 250 mm.

Groundwater strike depths were not able to be measured accurately during drilling due to the introduction of drilling water at some soil bore locations, and encountering primarily dry soils across AIC 93-96. These features, combined with observations of slow groundwater recovery into drilled bores obscured the interpretation of groundwater levels during the drilling sequence. Groundwater levels were determined by allowing the drilled boreholes to recover following monitoring well installation and ranged from 4.19 mbgl in the south-east of the AIC (LPS_AIC9396_MW106) to 5.37 mbgl in the north-eastern portion of the AIC (LPS_AIC9396_MW128).

10.3.1.4 Summary of BPS Geological Conditions

Table 54 Summary of subsurface conditions at the LPS Study Area

Description	Depth Encountered (mbgl)		
	AIC 11W	AIC 17	AIC 51-52
Fill and reworked natural weathered soils generally comprised of gravel with brown or brown with orange or grey mottling silts and clays and some sand	NE	0 – <0.3	<1.2
Friable clayey silts and silty clays, typically containing fine to medium sand and fine to coarse, angular to rounded gravels.	0 – 6.9	0 – 5.5	0 – 6.8
Silty claystone, fine and grey with a highly weathered zone at the top of the profile.	NE	>5.2	NE

Notes

NE = Not Encountered

10.3.2 Hydrogeology

10.3.2.1 AIC 11W

Hydrogeology at AIC 11W is summarised below:

- Groundwater levels were measured in 13 existing monitoring wells and seven newly installed monitoring wells at AIC 11W on 15 March 2019.
- SWLs ranged from 0.00 mbtoc (B_08_ESMW02) to 9.96 mbtoc (BV_MW06).
- A review of the BOM Groundwater Dependent Ecosystems Atlas (8 May 2019) showed no Groundwater Dependent Ecosystems (GDEs) in or adjacent to the SA.
- Based on the SWL and the survey data, the inferred potentiometric contours infer that groundwater generally follows surface topography, flowing generally north.
- The horizontal hydraulic gradient was estimated to be between 0.023 and 0.012 for the predominant flow direction.
- The hydraulic conductivity was estimated using literature values representative of the clayey silt aquifer unit encountered and estimated to be within the range of 8.6×10^{-3} m/day to 8.6×10^{-6} m/day (Fetter, 1988).
- A nominal effective porosity value of 0.1 to 0.2 from literature values has been selected as representative for fine silts encountered across the Sites.
- The average linear groundwater velocity can be estimated using Darcy's Law to range from (8.6×10^{-6} m/day × 0.012 / 0.2 ×365 days/year) **0.00019 m/year** to (8.6×10^{-3} m/day × 0.023 / 0.10 ×365 days/year) **0.073 m/year.**

10.3.2.2 AIC 17

Hydrogeology at AIC 17 is summarised below:

- Groundwater levels were measured in the 12 existing monitoring wells and one newly installed monitoring well at AIC17 on 14 March 2019.
- SWLs ranged from 1.320 mbtoc (B_02_ESMW02) to 6.27 mbtoc (B_16_ESMW03).
- A review of the BOM Groundwater Dependent Ecosystems Atlas (8 May 2019) showed no Groundwater Dependent Ecosystems (GDEs) in or adjacent to the SA.
- Based on the SWL and the survey data, the inferred potentiometric contours indicate that groundwater generally follows surface topography, flowing towards the north-west.

- The horizontal hydraulic gradient was calculated to be between 0.005 and 0.013 for the predominant flow direction.
- The hydraulic conductivity was estimated using literature values representative of the clayey silt aquifer unit encountered and estimated to be within the range of 8.6 x 10^{-3} m/day to 8.6 x 10^{-6} m/day (Fetter, 1988).
- A nominal effective porosity value of 0.1 to 0.2 from literature values has been selected as representative for fine silts encountered across the Sites.
- The average linear groundwater velocity can be estimated using Darcy's Law to range from (8.6 x 10^{-6} m/day × 0.005 / 0.2 ×365 days/year) **0.00008 m/year** to (8.6 x 10^{-3} m/day × 0.013 / 0.10 ×365 days/year) **0.04 m/year**.

10.3.2.3 AIC 51-52

Hydrogeology at AIC 51-52 is summarised below:

- Groundwater levels were measured in five existing monitoring wells and five newly installed monitoring wells within AIC 51-52 on 15 March 2019.
- SWLs ranged from 3.64 mbtoc (BPS_AIC5152_MW106) to 19.30 mbtoc (BC_MW05).
- A review of the BOM Groundwater Dependent Ecosystems Atlas (8 May 2019) showed no Groundwater Dependent Ecosystems (GDEs) in or adjacent to the SA.
- Based on the SWL and the survey data, the inferred potentiometric contours infer that groundwater generally follows surface topography, shedding either side of the ridge the tank farm is situated on, towards the east-west and south-east.
- The horizontal hydraulic gradient was estimated to be 0.16 to the south-east and 0.068 to the south west.
- The hydraulic conductivity was estimated using literature values representative of the clayey silt aquifer unit encountered and estimated to be within the range of 8.6 x 10^{-3} m/day to 8.6 x 10^{-6} m/day (Fetter, 1988).
- A nominal effective porosity value of 0.1 to 0.2 from literature values has been selected as representative for fine silts encountered across the Sites.
- • The average linear groundwater velocity can be estimated using Darcy's Law to range from (8.6 x 10-6 m/day × 0.007 / 0.2 ×365 days/year) **0.001 m/year** to (8.6 x 10-3 m/day × 0.16 / 0.10 ×365 days/year) **0.21 m/year**.

10.3.2.4 Summary of BPS Hydrogeological Conditions

Table 55 Summary of BPS hydrogeological conditions

Monitoring Well ID	AIC11W	AIC 17	AIC 51-52
Standing Water Level (mbgl)	0.00 to 9.96	1.320 to 6.27	3.64 – 19.30
Groundwater Elevation (mAHD)	165.91 to 169.07	173.56 to 178.59	174.70 to 196.48
Inferred Flow Direction	N	NW	SW and E
Hydraulic Gradient (k)	0.01 to 0.026	0.005 to 0.013	0.07 to 0.16
Hydraulic Conductivity (m/year)	0.00016 to 0.082	0.00008 to 0.04	0.001 to 0.21

10.3.3 Groundwater Geochemical Parameters

10.3.3.1 AIC 11W

The groundwater geochemical parameters measured in the field are presented in **Table T3** in and summarised in **Table 33** below. The groundwater sampling locations are shown in **Figure 36** in **Appendix A**. Analytical results are presented in **Section 10.3.8**. The stabilised geochemical parameter measurements were:

- pH: measurements were between 3.19 (BG_MW06) and 6.68 (BPS_AIC11W_MW102) indicating acidic to near-neutral groundwater conditions.
- EC: measurements ranged between 2,393 µS/cm (BPS_AIC11W_MW129) and 26,729 µS/cm (BG_MW06) indicating brackish to saline groundwater conditions.
- Dissolved oxygen: measurements ranged between 0.20 mg/L (BPS_AIC11W_MW102) and 3.43 mg/L (B_12_ESMW02) indicating that groundwater ranges from anaerobic to moderately oxygenated conditions.
- Temperature: measurements ranged between 20.3 °C (BV_MW04) and 28.2 °C (BPS_AIC11W_MW129) .
- Redox: measurements ranged between -234.2 mV (BPS_AIC11W_MW102) and 408.2 mV (B_08_ESMW02).

10.3.3.2 AIC 17

The groundwater geochemical parameters measured in the field are presented in **Table T2** in **Appendix B** and summarised in **Table 56** below. The groundwater sampling locations are shown in **Figure 39,** in **Appendix A**. Analytical results are presented in **Section 10.3.8**. The stabilised geochemical parameter measurements were:

- pH: measurements were between 3.43 and 6.82 indicating acidic to near-neutral groundwater conditions.
- EC: measurements ranged between 2,102 µS/cm and 10,794 µS/cm indicating brackish to saline groundwater conditions.
- Dissolved oxygen: measurements ranged between 0.22 mg/L and 1.97 mg/L indicating that groundwater moderately oxygenated conditions.
- Temperature: measurements ranged between 20.4 °C and 27.8 °C consistent with ambient temperatures.
- Redox: measurements ranged between -178.0 mV and 380.6 mV indicating a range of values from mildly reducing to neutral.

10.3.3.3 AIC 51-52

The groundwater geochemical parameters measured in the field are presented in **Table T2** in **Appendix B** and summarised in **Table 56** below. The stabilised geochemical parameter measurements were:

- pH: measurements were between 6.39 and 7.48 indicating near-neutral groundwater conditions.
- EC: measurements ranged between 2,099 µS/cm and 16,744 µS/cm indicating brackish groundwater conditions.
- Dissolved oxygen: measurements ranged between 0.14 mg/L and 3.64 mg/L indicating that groundwater ranges from anaerobic to oxygenated conditions.
- Temperature: measurements ranged between 21.3 °C and 25.4 °C.
- Redox: measurements ranged between -316.1 mV and 35.9 mV.

10.3.3.4 Summary of Geochemical Parameters

Table 56 Summary of groundwater geochemical parameters at BPS

Parameter	AIC 11W		AIC 17		AIC 51-52	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
pH	3.19	6.68	3.43	6.82	6.39	7.48
EC (µS/cm)	2393	26729	2102	10794	2099	16744
Dissolved Oxygen (mg/L)	0.20	3.43	0.22	1.97	0.14	3.64
Temperature (°C)	20.3	28.2	20.4	27.8	21.3	25.4
Redox (ORP) (mV)	-234.2	408.2	-178.0	380.6	-316.1	35.9

10.3.4 Sediment Observations

Sediment observations are discussed in the following sections.

10.3.4.1 AIC 11W

Conditions observed during sediment sampling around AIC 11W are summarised in **Table 57** below. Sediment sampling locations are shown in **Figure 51** in **Appendix A**.

Table 57 Summary of sediment observations in the vicinity of AIC 11W

Location	Sample Name	Observations
AIC 11W Eastern Settling Pond	BPS_AIC11W_SD521	This coal settling pond is adjacent to the coal pad and is a wide and shallow. It has steep banks with some coal fines on the bank. The sediment sample taken at this location was black fill with high coal fine components and a hydrocarbon odour.
AIC 11W Western Settling Pond	BPS_AIC11W_SD522	This coal settling pond is adjacent to the coal pad. It is shallow and wide, approximately 60 m long, 40 m wide with mildly sloping banks. The sediment sample taken at this location was brown/black silt with low plasticity, a high organic content and organic odour. There are some sand and clay inclusions.

10.3.4.2 AIC 17

Conditions observed during sediment sampling around AIC 17 are summarised in **Table 58** below. Sediment sampling locations are shown in **Figure 52** in **Appendix A**. Analytical results are presented in **Section 10.3.6**.

Table 58 Summary of sediment observations in the vicinity of AIC 17

Location	Sample Name	Observations
Stormwater drain – east of transformers	BPS_AIC17_SD535_0.0	This location had no sediment present to sample.
Stormwater drain – south-eastern boundary of the eastern transformer area	BPS_AIC17_WG534_0.0	This sediment sample was collected from a stormwater drain pit at AIC 17 on the south eastern boundary of the eastern transformer area. The sediment was comprised of black clayey silt with a high organic component and some fine to coarse sand. A hydrocarbon sheen was noted.
Stormwater drain – south-central boundary of the eastern transformer area	BPS_AIC17_SD533_0.1	Sediment collected at this location was a grey-brown clayey gravel, fine to medium grained and angular to subrounded with some fine to coarse, well sorted sand and some organic matter such as roots.
Stormwater drain –central area of the transformer area	BPS_AIC17_SD532_0.1	Sediment collected at this location was a grey sandy clay with trace gravel, fine to coarse grained and angular to subrounded, and some organic matter such as roots.
Stormwater drain – south-central boundary of the western transformer area	BPS_AIC17_WG531_0.1	Sediment collected at this location was a gravelly sandy clay. Gravel and sand where both fine to coarse grained and generally angular. A hydrocarbon sheen was present. Rubbish and organic matter where noted in the pit.
Stormwater drain – to the west of the western transformer area	BPS_AIC17_WG530	Sediment collected at this location was comprised of a brown/grey gravelly clay with trace sand. Some metal debris was present.

10.3.4.3 AIC 51-52

Conditions observed during sediment sampling around AIC 51-52 are summarised in **Table 59** below. Sediment sampling locations are shown in **Figure 53** in **Appendix A**. Analytical results are presented in **Section 10.3.6**.

Table 59 Summary of sediment observations in the vicinity of AIC 51-52

Location	Sample Name	Observations
AIC 51-52 Settling pond	BPS_52_SD501	This settling pond is downgradient from the tank farm and is flat and shallow with a substantial hydrocarbon layer on the surface. The sediment sample taken at this location was black/dark grey sandy clay with low plasticity, high coal content and trace organic content. There was a sheen observed and an oily consistency to the sediment sample.
AIC 51-52 Settling pond	BPS_AIC5152_SD539_0.0	This settling pond is downgradient from the tank farm and is deep with steep banks either side. The sediment sample taken at this location was brown silty sand, loose and poorly sorted with high organic content and organic odour. There were rootlet and decayed vegetation inclusions in the sediment sample.
AIC 51-52 Settling pond	BPS_AIC5152_SD540_0.0	This settling pond is downgradient from the tank farm and is deep with steep banks either side. The sediment sample taken at this location was brown silty sand, loose and poorly sorted with high organic content and organic odour.
Process Water Dam East	BPS_AIC5152_SD542_0.0	This location, downgradient of the tank farm, was at a discharge outlet into the lake East of the tank farm. The sediment sample taken at this location was brown clay with trace sand, low plasticity, high organic content and organic odour. There were rootlet inclusions observed in the sediment sample.
Process Water Dam West	BPS_AIC5152_SD564	A sample was taken from the nearest accessible downgradient location to the tank farm. The sediment sample taken at this location was soft brown silt with some sand and trace gravel, low plasticity, high organic content and no odour. There were rootlet inclusions observed in the sediment sample.

10.3.5 Surface Water Observations

10.3.5.1 AIC 11W

Surface water associated with AIC 11W was confined to the settling ponds. Observations noted during surface water sampling are summarised in

Table 60 below, and photographs of sample locations presented in **Appendix L** . The surface water sampling locations tabulated below are illustrated in **Figure 63** (refer to **Appendix A**). Analytical results are presented in **Section 10.3.6**.

Table 60 Summary of surface water observations associated with AIC 11W

Location	Sample Names	Observations
AIC 11W Eastern Settling Pond	BPS_AIC11W_SD 521	This coal settling pond is adjacent to the coal pad. It is shallow and wide, approximately 50 m long, 15 m wide and 2 m deep, with a flat base. It has steep banks with some coal fines on the bank. The surface water sample taken here was clear with a slight turbidity, particulates and a hydrocarbon odour.
AIC 11W Western Settling Pond	BPS_AIC11W_SD 522	This coal settling pond is adjacent to the coal pad. It is shallow and wide, approximately 60 m long, 40 m wide and 2 m deep, with a flat base. It has mildly sloping banks with some coal fines on the bank. Surface water was sampled next to the boom, it was clear with no turbidity and an organic odour.

10.3.5.2 AIC 17

Surface water associated with AIC 17 was confined to the stormwater drainage network. Observations noted during surface water sampling at AIC 17 are summarised in **Table 61** below, and photographs of sample locations presented in **Appendix L**. The surface water sampling locations tabulated below are illustrated in **Figure 44** (refer to **Appendix A**). Analytical results are presented in **Section 10.3.6**.

Table 61 Summary of surface water observations associated with AIC 17

Location	Sample Names	Observations
Stormwater drain – east of transformers	BPS_AIC17_WG535_0.0	On 30 November 2018, water samples were collected from the eastern most stormwater drain pit at AIC 17. The sampling location comprised the base of a concrete pit ~2 m below the ground surface. The stormwater pipes entering the pit were ~300 mm on the southern side and ~400 mm on the western side of the pit. Water was odourless, colourless and clear with no turbidity; some leaves were noted.
Stormwater drain – south-eastern boundary of the eastern transformer area	BPS_AIC17_WG534_0.0	On 30 November 2018, water samples were collected from a stormwater drain pit at AIC 17 on the south eastern boundary of the eastern transformer area. The sampling location comprised the base of a concrete pit ~2 m below the ground surface. The stormwater pipes entering the pit were ~300 mm on the western side of the pit. Water was odourless and colourless with slight turbidity and some black suspended solids.
Stormwater drain – south-central boundary of the eastern transformer area	BPS_AIC17_WG533_0.0	On 30 November 2018, water samples were collected from a stormwater drain pit at AIC 17 in the central southern boundary of the eastern transformer area. The sampling location comprised the base of a concrete pit ~2 m below the ground surface. The stormwater pipes entering the pit were ~200 mm diameter on the northern side of the pit. Water was grey and turbid with suspended solids; no odour was noted.
Stormwater drain – central area of the transformer area	BPS_AIC17_WG532_0.0	On 30 November 2018, water samples were collected from a stormwater drain pit at AIC 17 in the central portion of the transformer area, in front of the administration building. The sampling location comprised the base of a concrete pit ~2 m below the ground surface. The stormwater pipes entering the pit were ~300 mm and 400 mm diameter. Water was colourless and very slightly turbid; no odour was noted.
Stormwater drain –	BPS_AIC17_WG531_0.0	On 30 November 2018, water samples were collected from a stormwater drain pit at AIC 17 in the central portion of the

Location	Sample Names	Observations
south-central boundary of the western transformer area		transformer area, in front of the administration building. The sampling location comprised the base of a concrete pit ~2 m below the ground surface. Water was colourless and very slightly turbid; with a hydrocarbon sheen. Rubbish and organic matter where noted in the pit.
Stormwater drain – to the west of the western transformer area	BPS_AIC17_WG530_0.0	On 30 November 2018, water samples were collected from a stormwater drain pit at AIC – to the west of the western transformer area. The sampling location comprised the base of a concrete pit ~2 m below the ground surface. Water had a slight brown colour and slight turbidity, the water formed a foam when poured into the sampling bottle. Some debris was noted in the pit.

10.3.5.3 AIC 51-52

Surface water associated with AIC 51-52 comprised samples from downgradient areas identified as being potential groundwater discharge areas, at the edge of the cooling water dam bounding AIC 51-52 on its western side, samples from settling ponds to the east which discharges to a culvert, which was also sampled, and onto the Ash Dam. Observations noted during surface water sampling associated with AIC 51-52 are summarised in below, and photographs of sample locations presented in **Appendix L**. The surface water sampling locations tabulated below are illustrated in **Figure 45** (refer to **Appendix A**). Analytical results are presented in **Section 10.3.6**.

Table 62 Summary of surface water observations associated with AIC 51-52

Location	Sample Names	Observations
AIC 51-52 Settling pond	BPS_5152_SD501	This settling pond is immediately east and downgradient from the tank farm and is flat and shallow with a substantial hydrocarbon layer on the surface. A surface water sample was taken here but was unable to be analysed due to the high dissolved hydrocarbon concentration. The water was found to be black with high turbidity and no odour.
AIC 51-52 Settling pond	BPS_AIC5152_WG539	This settling pond is directly south and cross gradient of the tank farm at AIC 51-52. It is The surface water sample taken here was green-grey in colour with low turbidity and no odour.
AIC 51-52 Settling pond	BPS_AIC5152_WG540	This settling pond is directly south and cross gradient of the tank farm at AIC 51-52. It is The surface water sample taken here was yellowish green in colour with low turbidity and no odour.
Process Water Dam	BPS_AIC5152_SW541	This location, downgradient of the tank farm, was inaccessible, a sample was taken at the alternate location BPS_AIC5152_SW564.
Process Water Dam	BPS_AIC5152_SW564	A sample was taken from the nearest accessible downgradient location to the tank farm. The water was clear with low turbidity and no odour.

10.3.6 Surface Water Geochemical Parameters

10.3.6.1 AIC 11W

Geochemical parameters were measured prior to taking surface water samples associated with AIC 11W. A summary of measurements are presented in **Table 63** below and detailed in **Table T3** in **Appendix B**. Surface water sampling locations are shown in **Figure 44** in **Appendix A**. Analytical results are presented in **Section 10.3.6.** Stabilised geochemical parameter measurements were:

- pH: measurements were between 7.89 and 8.14 indicating neutral conditions.
- Electrical conductivity: measurements ranged between 890 µS/cm and 1130 µS/cm.
- Dissolved oxygen measured between 5.46 mg/L and 5.91 mg/L.
- Temperature: measurements ranged from 24.8 °C to 30.4 °C.
- Redox Potential: measurements were between -44.3 mV and 130.5 mV.

10.3.6.2 AIC 17

Geochemical parameters were measured prior to taking surface water samples associated with AIC 17. A summary of measurements are presented in **Table 63** below and detailed in **Table T3** in **Appendix B**. Surface water sampling locations are shown in **Figure 45** in **Appendix A**. Analytical results are presented in **Section 10.3.6.** Stabilised geochemical parameter measurements were:

- pH measurements were between 7.55 and 8.06, indicating neutral conditions.
- Electrical conductivity measurements were between 32 µS/cm and 70.9 µS/cm inferring fresh water.
- Dissolved oxygen measured between 4.07 mg/L and 7.86 mg/L indicating aerobic conditions.
- Temperature: measurements ranged from 20.1 °C to 21.2 °C.
- Redox Potential measurements were between 35.6 mV and 104.7 mV, inferring oxidising conditions.

10.3.6.3 AIC 51-52

Geochemical parameters were measured prior to taking surface water samples associated with AIC 51-52. A summary of measurements are presented in **Table 63** below and detailed in **Table T3** in **Appendix B.** Surface water sampling locations are shown in **Figure 46** in **Appendix A.** Analytical results are presented in **Section 10.3.6** Stabilised geochemical parameter measurements were:

- pH: measurements were between 7.1 and 8.84 indicating neutral to slightly alkaline conditions.
- Electrical conductivity: measurements ranged between 541 µS/cm and 2720 µS/cm indicating fresh to slightly brackish water.
- Dissolved oxygen ranged between 0.04 mg/L. and 8.66 mg/L. This high value exceeds the theoretical maximum solubility limits (8.03 mg/L; USGS, 2016) in this one sample ().
- Temperature: measurements ranged from 16.8 °C to 26.8 °C, reflective of ambient air temperature.
- Redox Potential: measurements were between -145.2 mV and 147.0 mV. Generally samples taken from the settling ponds recorded redox measurements representative of mildly reducing environments and those taken from the dam and creek where oxidising.

10.3.6.4 Summary of BPS Surface Water Conditions

Table 63 Summary of surface water geochemical parameters at BPS

Parameter	AIC 11W		AIC 17		AIC 51-52	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
pH	7.89	8.14	7.55	8.06	7.1	8.84
EC (µS/cm)	890	1130	32	70.9	541	2720
Dissolved Oxygen (mg/L)	5.46	5.91	4.07	7.86	0.04	8.66
Temperature (°C)	24.8	30.4	20.1	21.2	16.8	26.8
Redox (ORP) (mV)	-44.3	130.5	35.6	104.7	-145.2	147

Note: [1] The theoretical maximum value of oxygen solubility, considering the water temperature and specific conductance conditions observed in the field is estimated to be 8.03 mg/L (USGS, 2016). Any value measured above this value has been considered to be erroneous.

10.3.7 Soil Analytical Results

Analytical results are presented in the following sections, summarised by AIC followed by matrix.

PFAS analytical results are summarised below, and are presented in **Table T4, Appendix B,** and in **Figures 10** to **34**, in **Appendix A.**

10.3.7.1 AIC 11W

PFAS analytical results for AIC 11W are summarised in **Table 64** to **Table 67** below, and are presented in **Table T4, Appendix B,** and in **Figures 12, 17, 22, 27** and **32**, in **Appendix A.** In summary:

- PFOS concentrations were above the LOR in 15 locations; none of these samples exceeded the adopted ILs.
- PFOA concentrations were above the LOR in 7 locations; none of these samples exceeded the adopted ILs.
- PFOS and PFHxS concentrations were above the LOR in 16 locations; none of these samples exceeded the adopted ILs.

Table 64 Summary of PFAS soil analytical results at the AIC 11W

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
74	PFOS	< 0.0002 – 0.006	17	0
74	PFOA	< 0.0002 – 0.0038	8	0
74	PFOS + PFHxS	< 0.0002 - 0.0608	20	0

Table 65 Comparison of PFOS with soil depth at the AIC 11W

Depth (mbgl)	No. Samples	No. Detects	PFOS Conc. Range (mg/kg)
0.0 - 0.5	46	15	<0.0002 – 0.006
0.5 – 1.5	21	1	<0.0002 - 0.0005
1.5 – 4.0	2	0	<0.0002
4.0 – 6.0	4	1	<0.0002 - 0.0007

Table 66 Comparison of PFOA with soil depth at the AIC 11W

Depth (mbgl)	No. Samples	No. Detects	PFOA Conc. Range (mg/kg)
0.0 - 0.5	46	8	<0.0002 – 0.0038
0.5 – 1.5	21	0	<0.0002
1.5 – 4.0	2	0	<0.0002
4.0 – 6.0	4	0	<0.0002

Table 67 Comparison of PFOS + PFHxS with soil depth at the AIC 11W

Depth (mbgl)	No. Samples	No. Detects	PFOS + PFHxS Conc. Range (mg/kg)
0.0 - 0.5	46	17	<0.0002 - 0.0608
0.5 – 1.5	21	1	<0.0002 - 0.0005
1.5 – 4.0	2	1	<0.0002 – 0.0003
4.0 – 6.0	4	1	<0.0002 - 0.0007

Comparison with historic results

Previous investigations (ES, 2017) reported results above LOR and below current ILs within the central portion of the AIC with a maximum soil concentration at B_11_ESMW03 of 0.05 mg/kg (Sum of PFOS & PFHxS). BPS_AIC11W_SB116, sampled in the current Stage 2 PFAS Investigation, is adjacent to B_11_ESMW03 and reported similar concentrations of 0.061 mg/kg (Sum of PFOS & PFHxS). Two other soil locations where sampled in the same previous investigation, B_11_ESMW02 and B_11_ESMW04, both were below LOR.

10.3.7.2 AIC 17

PFAS analytical results are summarised in **Table 68** to **Table 71** below, and are presented in **Table T4** (**Appendix B**) and in **Figures 13, 18, 23, 28** and **33** (in **Appendix** A). In summary:

- PFOS concentrations were all below the LOR.
- PFOA concentrations were all below the LOR.
- PFOS and PFHxS concentrations were all below the LOR.

Table 68 Summary of PFAS soil analytical results at the AIC 17

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
42	PFOS	< 0.0002	0	0
42	PFOA	< 0.0002	0	0
42	PFOS + PFHxS	< 0.0002	0	0

Table 69 Comparison of PFOS with soil depth at the AIC 17

Depth (mbgl)	No. Samples	No. Detects	PFOS Conc. Range (mg/kg)
0.0 - 0.5	25	0	<0.0002
0.5 – 1.5	14	0	<0.0002
1.5 – 4.0	1	0	<0.0002
4.0 – 6.0	2	0	<0.0002

Table 70 Comparison of PFOA with soil depth at the AIC 17

Depth (mbgl)	No. Samples	No. Detects	PFOA Conc. Range (mg/kg)
0.0 - 0.5	25	0	<0.0002
0.5 – 1.5	14	0	<0.0002
1.5 – 4.0	1	0	<0.0002
4.0 – 6.0	2	0	<0.0002

Table 71 Comparison of PFOS + PFHxS with soil depth at the AIC 17

Depth (mbgl)	No. Samples	No. Detects	PFOS + PFHxS Conc. Range (mg/kg)
0.0 - 0.5	25	0	<0.0002
0.5 – 1.5	14	0	<0.0002
1.5 – 4.0	1	0	<0.0002
4.0 – 6.0	2	0	<0.0002

10.3.7.2.1 Comparison with historic results

A previous investigation (ERM, 2014) sampled two locations at AIC 17, BL_SB04 and BL_MW05, these locations reported PFOS results of 0.0006 mg/kg and 0.00012 mg/kg respectively. This is within the same magnitude of results found in adjacent locations in this investigation at BPS_AIC17_SB101 (<0.0001 mg/kg) and BPS_AIC17_SB110 (<0.0002 mg/kg).

10.3.7.3 AIC 51-52

PFAS analytical results are summarised in **Table 72** to **Table 75** below, and are presented in **Table T4**, in **Appendix B**, and in **Figures 14**, **19**, **24**, **29** and **34**, in **Appendix A**. In summary:

- PFOS concentrations were above the LOR in 4 samples; of these, none of these samples exceeded the ILs.
- PFOA concentrations were above the LOR in 4 samples; of these, none of these samples exceeded the ILs.
- PFOS and PFHxS concentrations were above the LOR in 4 samples; of these, none of these samples exceeded the ILs.

Table 72 Summary of PFAS soil analytical results at the AIC 51-52

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
49	PFOS	< 0.0002 – 0.0048	1	0
49	PFOA	< 0.0002 – 0.001	3	0
49	PFOS + PFHxS	< 0.0002 - 0.0056	1	0

Table 73 Comparison of PFOS with soil depth at the AIC 51-52

Depth (mbgl)	No. Samples	No. Detects	PFOS Conc. Range (mg/kg)
0.0 - 0.5	26	1	<0.0002 – 0.0048
0.5 – 1.5	9	0	<0.0002
1.5 – 4.0	0	-	-
4.0 – 6.0	14		<0.0002 –

Table 74 Comparison of PFOA with soil depth at the AIC 51-52

Depth (mbgl)	No. Samples	No. Detects	PFOA Conc. Range (mg/kg)
0.0 - 0.5	26	2	<0.0002 – 0.001
0.5 – 1.5	9	1	<0.0002 – 0.0003
1.5 – 4.0	0	-	-
4.0 – 6.0	14	0	<0.0002

Table 75 Comparison of PFOS + PFHxS with soil depth at the AIC 51-52

Depth (mbgl)	No. Samples	No. Detects	PFOS + PFHxS Conc. Range (mg/kg)
0.0 - 0.5	26	1	<0.0002 – 0.0056
0.5 – 1.5	9	0	<0.0002
1.5 – 4.0	0	-	-
4.0 – 6.0	14	0	<0.0002

10.3.7.3.1 **Comparison with historic results**

Soil analysis has previously been conducted on shallow soil samples at AIC 51-52 to a depth of 0.2 mbgl, all results were below LOR (<0.0005 mg/kg). Noting improvements in laboratory LORs (<0.0002 mg/kg), these results are within the range of soil results in the vicinity of the tank farm during this investigation.

10.3.8 Groundwater Analytical Results

10.3.8.1 AIC 11W

Groundwater PFAS analytical results are summarised in **Table 76** and **Table 77** below, and are presented in **Table T5,** in **Appendix B**, and in **Figure 38,** in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at 3 locations; none of these samples exceeded the adopted ILs.
- PFOA concentrations were above the LOR at 3 locations; none of these samples exceeded the adopted ILs.
- PFOS and PFHxS concentrations were above the LOR at 5 locations; of these, 4 locations exceeded the adopted health ILs (HILs) for Drinking Water with a maximum concentration of 0.33 µg/L at BPS_AIC11W_12_ESMW01.

Table 76 Summary of PFAS in groundwater at AIC 11W

No. Samples Analysed	Compound	Concentration Range (µg/L)	No Samples with Concentrations >LOR	No. Samples Exceeding ILs
33	PFOS	<0.01 – 0.08	7	0
33	PFOA	<0.01 – 0.04	3	0
33	PFOS + PFHxS	<0.01 – 0.33	10	9

Table 77 Comparison of PFOS + PFHxS with groundwater depth at AIC 11W

Wells Sampled at Dual Depths	Depth	PFOA (µg/L)	PFOS (µg/L)	PFOS + PFHxS (µg/L)
BPS_A1C11W_B_11_ESMW03	5.5	< 0.05	< 0.05	< 0.05
	7.5	< 0.01	< 0.01	< 0.01
BPS_AIC11W_B_11_ESMW04	5.9	< 0.05	< 0.05	< 0.05
	7.9	< 0.05	< 0.05	< 0.05
BPS_AIC11W_12_ESMW01	2.6	< 0.01	< 0.01	**0.23**
	4.6	< 0.01	< 0.01	**0.33**
BPS_AIC11W_12_ESMW03	3.0	< 0.01	**0.04**	**0.09**
	5.0	**0.02**	**0.05**	**0.17**
BPS_AIC11W_GWMW102	3.6	**0.02**	**0.04**	**0.14**
	6.0	< 0.01	**0.02**	**0.09**
BPS_AIC11W_GWMW123	4.3	< 0.05	< 0.05	< 0.05
	6.3	< 0.05	< 0.05	< 0.05
BPS_AIC11W_GWMW129	2.0	< 0.01	< 0.01	< 0.01
	4.0	< 0.01	< 0.01	< 0.01

10.3.8.1.1 Comparison With Historic Results

Five groundwater monitoring locations in the central area of AIC 11W (B_11_ESMW01, B_11_ESMW02, B_11_ESMW04, B_11_ESMW05 and B_12_ESMW01) have previously been sampled. With the exception of B_12_ESMW01 all of these locations reported concentrations below LOR for both sampling events. B_12_ESMW01 reported concentrations an order of magnitude higher than the LOR reported in January 2016,

A summary of these results is shown below in **Table 78,** detailed historic and current groundwater results are presented for comparison in **Table T10, Appendix B**.

Table 78 AIC 11W groundwater historic results comparison for locations >LOR

Locations	Sample Date	PFOA	PFOS	Sum of PFOS & PFHxS
B_12_ESMW01	14/01/2016	< 0.05	< 0.05	< 0.05
	23/11/2018	< 0.01	< 0.01	**0.23**
	23/11/2018	< 0.01	< 0.01	**0.33**

10.3.8.2 AIC 17

Groundwater PFAS analytical results are summarised in **Table 79** and **Table 80** below, and are presented in **Table T5**, in **Appendix B** and in **Figures39,** in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at 5 locations; none of these samples exceeded the adopted ILs.
- PFOA concentrations were below the LOR at all locations.
- PFOS and PFHxS concentrations were above the LOR at 6 locations; of these, 4 locations exceeded the adopted HILs for Drinking Water with a maximum concentration of 0.13 µg/L at BPS_AIC17_16_ESMW02.

Table 79 Summary of PFAS in groundwater at AIC 17

No. Samples Analysed	Compound	Concentration Range (µg/L)	No Samples with Concentrations >LOR	No. Samples Exceeding ILs
21	PFOS	<0.01 – 0.09	7	0
21	PFOA	<0.01	0	0
21	PFOS + PFHxS	<0.01 – 0.13	9	5

Table 80 Comparison of PFOS + PFHxS with groundwater depth at AIC 17

Wells Sampled at Dual Depths	Depth	PFOA (µg/L)	PFOS (µg/L)	PFOS + PFHxS (µg/L)
BPS_AIC17_16_ESMW02	7.2	< 0.01	**0.09**	**0.13**
	9.2	< 0.01	**0.08**	**0.12**
BPS_AIC17_16_ESMW03	7.8	< 0.01	**0.05**	**0.08**
	9.8	< 0.01	**0.08**	**0.10**
BPS_AIC17_BL_MW05	4.7	< 0.01	**0.05**	**0.09**
	6.7	< 0.05	< 0.05	< 0.05
BPS_AIC17_GWBL_MW01	3.5	< 0.01	< 0.01	< 0.01
	5.5	< 0.01	< 0.01	< 0.01
BPS_AIC17_GWBL_MW02	6.8	< 0.01	< 0.01	< 0.01
	8.8	< 0.01	< 0.01	< 0.01
BPS_AIC17_GWMW109	3.5	< 0.01	< 0.01	< 0.01
	4.8	< 0.01	< 0.01	**0.02**

10.3.8.2.1 Comparison with historic results

Two groundwater monitoring locations have previously been analysed for PFOS at AIC 17; B_17_ESMW01, which reported results below LOR and B_17_ESMW02. B_17_ESMW02 previously reported a concentration or 0.017 µg/L (Sum of PFOS & PFHxS) which is within the same magnitude of the results reported for this monitoring event of 0.01 µg/L.

A summary of these results is shown below in **Table 81**, detailed historic and current groundwater results are presented for comparison in **Table T10, Appendix B.**

Table 81 AIC17 groundwater historic results comparison for locations >LOR

Locations	Sample Date	PFOA	PFOS	Sum of PFOS & PFHxS
B_17_ESMW02	14/01/2016	< 0.01	**0.017**	**0.017**
	29/11/2018	< 0.01	**0.01**	**0.01**

10.3.8.3 AIC 51-52

Groundwater PFAS analytical results are summarised in **Table 82** and **Table 83** below, and are presented in **Table T5**, in **Appendix B**, and in **Figure 40**, in **Appendix A**. In summary:

- PFOS concentrations were above the LOR in 3 samples; none of these samples exceeded the adopted ILs.
- PFOA concentrations were above the LOR in 5 samples; of these, none exceeded the adopted ILs.
- PFOS and PFHxS concentrations were above the LOR in 4 samples; of these, 2 samples exceeded the Drinking Water guidelines with a maximum concentration of 0.1 µg/L at BPS_AIC5152_GWMW120.

Table 82 Summary of PFAS in groundwater at AIC 51-52

No. Samples Analysed	Compound	Concentration Range, µg/L (location)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
18	PFOS	<0.01 – 0.02	3	0
18	PFOA	<0.01 – 0.45	5	0
18	PFOS + PFHxS	<0.01 – 0.1	4	2

Table 83 Comparison of PFOS + PFHxS with groundwater depth at AIC 51-52

Wells Sampled at Dual Depths	Depth	PFOA (µg/L)	PFOS (µg/L)	PFOS + PFHxS (µg/L)
BPS_AIC5152_GWMW106	4.5	< 0.01	< 0.01	< 0.01
	5.5	< 0.01	< 0.01	< 0.01
	6.5	**0.02**	< 0.01	**0.09**
BPS_AIC5152_GWMW119	5.5	< 0.01	**0.02**	**0.04**
	6.2	< 0.01	< 0.01	< 0.01

10.3.8.3.1 Comparison with historic results

Five groundwater monitoring locations were previously sampled (ES, 2017) at AIC 51-52. Three of these locations have been sampled in the current investigation. A comparison shows that results are slightly higher at B_51_ESMW01 and B_52_ESMW04 but remain within the same range of magnitude.

A summary of these results is shown below in **Table 84**, detailed historic and current groundwater results are presented for comparison in **Table T10, Appendix B.**

Table 84 AIC 51-52 groundwater historic results comparison for locations >LOR

Locations	Sample Date	PFOA	PFOS	Sum of PFOS & PFHxS
B_52_ESMW01	5/10/2016	**0.012**	< 0.01	< 0.01
	4/12/2018	**0.45**	< 0.01	< 0.01
B_52_ESMW02	5/10/2016	**0.017**	< 0.01	< 0.01
	6/12/2018	< 0.01	< 0.01	< 0.01
	6/12/2018	< 0.01	< 0.01	< 0.01
	6/12/2018	**0.01**	< 0.01	< 0.05
B_52_ESMW04	14/10/2016	**0.021**	< 0.01	< 0.01
	10/12/2018	**0.06**	< 0.05	< 0.05

10.3.9 Sediment Analytical Results

10.3.9.1 AIC 11W

Sediment PFAS analytical results are summarised in **Table 85** below, and are presented in **Table T7**, in **Appendix B**, and in **Figure 51**, in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at one location; no samples exceeded the adopted ILs.
- PFOA concentrations were all below the LOR.
- PFOS and PFHxS concentrations were above the LOR at one location; no sample exceeded the adopted ILs.

Table 85 Summary of PFAS in sediment within AIC 11W

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
4	PFOS	<0.0002 – 0.0573	3	0
4	PFOA	<0.0002 - <0.0005	0	0
4	PFOS + PFHxS	<0.0002 – 0.0599	3	0

10.3.9.2 AIC 17

Sediment PFAS analytical results are summarised in and **Table 86** below, and are presented in **Table T7**, in **Appendix B**, and in **Figures 49** to **56**, in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at one location; no samples exceeded the adopted ILs.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were above the LOR at one location; no samples exceeded the adopted ILs.

Table 86 Summary of PFAS in sediment within AIC 17

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
7	PFOS	<0.0002 – 0.0002	1	0
7	PFOA	<0.0002	0	0
7	PFOS + PFHxS	<0.0002 – 0.0002	1	0

10.3.9.3 AIC 51-52

Sediment PFAS analytical results are summarised in **Table 87** below, and are presented in **Table T11**, in **Appendix B**, and in **Figures 49** to **56**, in **Appendix A**. In summary:

- PFOS concentrations were all above the LOR in 4 locations; none of these samples exceeded the ILs.
- PFOA concentrations were all below the LOR.
- PFOS and PFHxS concentrations were above the LOR in in 4 locations; none of these samples exceeded the ILs.

Table 87 Summary of PFAS in sediment associated with AIC 51-52

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
7	PFOS	<0.0002 – 0.0055	4	0
7	PFOA	<0.0002 - <0.0005	0	0
7	PFOS + PFHxS	<0.0002 – 0.0055	4	0

10.3.10 Soil and Sediment Leachate Analytical Results

10.3.10.1 AIC 11W

Three soil locations and one sediment location from AIC 11W were ASLP tested. Of these locations, one soil results exceeded the Freshwater guidelines for PFOS and two exceeded for Sum of PFOS & PFHxS. This indicates the potential for PFAS impacted soils to act as a secondary source, with the potential for PFAS to migrate through the soil profile and potentially leach impacts to underlying groundwater. The sediment location reported results under the adopted IL inferring sediments at this location are not acting as a secondary source of impact.

10.3.10.2 AIC 51-52

Five soil locations and two sediment location from AIC 51-52 were ASLP tested. None of these locations reported results exceeding the Freshwater guidelines. This indicates soils and sediments at these locations are not acting as a secondary source.

10.3.11 Surface Water Analytical Results

10.3.11.1 AIC 11W

Surface water PFAS analytical results are summarised in **Table 88** below, and are presented in **Table T10**, in **Appendix B**, and in **Figures 41** to **48**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 88 Summary of PFAS in surface water associated with AIC 11W

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
6	PFOS	<0.01	0	0
6	PFOA	<0.01	0	0
6	PFOS + PFHxS	<0.01	0	0

10.3.11.2 AIC 17

Surface water PFAS analytical results are summarised in **Table 89** below, and are presented in **Table T10**, in **Appendix B**, and in **Figures 41** to **48**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples except BPS_A1C17_WG532 which was above LOR (0.02 µg/L).
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 89 **Summary of PFAS in surface water associated with AIC 17**

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
9	PFOS	<0.01	0	0
9	PFOA	<0.01 – 0.02	1	0
9	PFOS + PFHxS	<0.01	0	0

10.3.11.3 AIC 51-52

Surface water PFAS analytical results are summarised in **Table 90** below, and are presented in **Table T10**, in **Appendix B**, and in **Figures 41** to **48**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples except BPS_AIC5152_SW564 which was above LOR (0.01 µg/L)
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples except BPS_AIC5152_SW564 which was above LOR (0.01 µg/L

Table 90 **Summary of PFAS in surface water associated with AIC 51-52**

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
13	PFOS	<0.01 – 0.01	1	0
13	PFOA	<0.01	0	0
13	PFOS + PFHxS	<0.01 – 0.01	1	0

10.4 Locations Outside AICs

Surface water and sediment sample locations in the areas outside the five AICs are defined as part of either LPS (including Lake Liddell), BPS or the Hunter River. Observations noted during surface water sampling are summarised in **Table 91** below, and photographs of sample locations presented in **Appendix E** The surface water sampling locations tabulated below are illustrated in **Figures 46** to **48**,in **Appendix A**.

10.4.1 LPS

10.4.1.1 Surface Water Conditions

Surface water locations where sampled in locations outside of the AICs and within the LPS EPL boundary. Locations were chosen as representative of surface water leaving the AICs and EPL boundary or immediately upgradient of these. Observations noted during surface water sampling of these locations are summarised in **Table 91** below, and photographs of sample locations presented in **Appendix L**. The surface water sampling locations tabulated below are illustrated in **Figure 46**, **Appendix A**.

Table 91 Summary of surface water observations associated with areas outside the AICs and within the LPS boundary

Location	Sample Names	Observations
Tinkers Creek	LPS_WG515_0.0 LPS_WG515_0.5	Tinkers Creek at this sampling location is a fast running creek with low gradient banks. Vegetation was predominantly confined to the riparian zone and was reeds and mature trees with some aquatic weeds. The surface water sample collected at this location was clear and slightly turbid with a saline odour. Fish were observed in the creek.
V Notch Weir	LPS_WG516	The V Notch weir connects LPS with the Hunter River discharge point. This is a concrete channel approximately 3 m wide and 1 m deep with approximately 0.5 m water. A surface water sample was taken which was clear with no turbidity or odour.
Skimmer Dam	LPS_WG517	A surface water sample was collected at the Skimmer Dam which is a wide shallow dam, approximately 100 m across, 200 m long and 2 m deep. There is a water line apparent approximately 0.3 m higher than the present line. Vegetation is sparse and contained to the riparian zone. The surface water sample collected at this location was clear and slightly turbid with an organic odour.
Drayton Levee seepage	LPS_WG518	The seepage at the base of the Drayton Levee is a wide shallow area, approximately 5 m wide and 1 me deep, at the break of slope of the levee which is approximately 20 m high. The water is relatively still with some wind movement observed at the time of sampling. The levee was noted to be saturated to approximately 0.5 m higher than the current seep water level. The surface water sample collected at this location was clear with no turbidity or odour.
Tinkers Creek – adjacent to Lake Liddell	LPS_WG520	This area of Tinkers Creek, adjacent to Lake Liddell, is wider at around 7 m wide and 4 m deep with around 1.5 m of water and a medium flow rate. The banks are generally flat with evidence of bank erosion. Vegetation is sparse and generally confined to the riparian zone. A surface water sample was taken at this location which was clear and slightly turbid with no odour.
EPL Discharge Point #13	LPS_WG526_0.0 LPS_WG526_0.5	This location was a discharge outlet East of Liddell Power Station into Lake Liddell. The water was fast and turbulent, with a width of 4 m and depth of 1 m in a rock lined channel. The banks were mild with no evidence of bank erosion. Vegetation was sparse and confined to the riparian zone. The surface water samples collected here were clear, with no turbidity or odour.
EPL Discharge Point #12	LPS_WG544	This location was from a channel leading South into Lake Liddell from the Liddell Power Station. The channel was 20 m wide, more than 100 m in length, and the water flow rate was fast. Vegetation was dense and confined to the riparian zone. No evidence of contamination was noted but an oil boom was floating 10 m downstream of the sample location. The surface water sample collected here were clear, with no turbidity or odour.

Surface water geochemical parameters were measured prior to sampling surface water. A summary of the geochemical parameters are presented in **Table 92** below. Surface water sampling locations are shown in **Figures 46** to **48** in **Appendix A**. Analytical results are presented in **Section 10.4.1.2**. Stabilised geochemical parameter measurements were:

- pH: measurements were between 7.44 and 8.26 indicating neutral to slightly alkaline water.
- Electrical conductivity: measurements ranged between 2659 µS/cm and 4266 µS/cm.
- Dissolved oxygen: Dissolved oxygen measurements ranged between 3.64 mg/L and 7.63 mg/L.
- Temperature: measurements ranged from 20.3 °C to 33.8 °C.
- Redox Potential: measurements were between 98.5 mV and 201.6 mV indicating an aerobic environment.

Table 92 Summary of surface water geochemical parameters in surface water outside AICs and associated with LPS

Parameter	Minimum Recorded Value		Maximum Recorded Value	
	Minimum	Sample Location	Maximum	Sample Location
pH	7.44	LPS_WG516	8.26	BPS_WG544
EC (µS/cm)	2659	LPS_WG515	4266	LPS_WG516
Dissolved Oxygen (mg/L)	3.64	BPS_WG544	7.63	LPS_WG517
Temperature (°C)	20.3	LPS_WG518	33.8	BPS_WG544
Redox (ORP) (mV)	98.5	BPS_WG544	201.6	LPS_WG520

Note: [1]The theoretical maximum value of oxygen solubility, considering the water temperature and specific conductance conditions observed in the field is estimated to be 8.03 mg/L (USGS, 2016). Any value measured above this value has been considered to be erroneous.

10.4.1.2 Surface Water Analytical Results

A total of 13 surface water samples were collected ,during the Stage 2 PFAS Investigation, from 6 sampling locations outside the AIC boundaries and within the LPS site boundary. Prior to sampling in December 2018, 86.2 mm of rainfall was recorded for November which was within the range of the long term average of 84.9mm (refer to **Section 10.1**).

Surface water PFAS analytical results are summarised in **Table 93** below, and are presented in **Table T6** in **Appendix B**, and in **Figure 46**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 93 Summary of PFAS outside AICs and in surface water associated with LPS

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
13	PFOS	<0.01 - < 0.05	0	0
13	PFOA	<0.01 - < 0.05	0	0
13	PFOS + PFHxS	<0.01 - < 0.05	0	0

10.4.1.3 Sediment Observations

Conditions observed during sediment sampling at locations outside the AICs and within the LPS boundaries are summarised in **Table 94** below. Sediment sampling locations are shown in **Figure 54** in **Appendix A.** Analytical results are presented in **Section10.4.1.4.**

Table 94 Summary of sediment observations in areas outside the AIC boundaries and within the LPS boundaries

Location	Sample Name	Observations
Tinkers Creek	LPS_SD515_0.0	Tinkers Creek at this location is a small wide creek with shallow banks and a vegetated riparian zone. The sediment sample collected at this location was comprised of a soft brown/black sandy silt with fine, angular sands and a high dark brown/black organic matter.
V Notch Weir	LPS_WG516	There was no sediment present to sample at this location.
Skimmer Dam	LPS_SD517	The Skimmer Dam is a wide shallow dam, approximately 100 m across, 200 m long and 2 m deep. Vegetation is sparse and contained to the riparian zone. A sediment sample was collected from the dam edge and was comprised of light brown to white sand which is fine to medium grained with minor silt and clay and organic content.
Drayton Levee seepage	LPS_SD518	The Drayton Levee is steep sided with a wide shallow area at the break of slope of the levee. A sediment sample was taken adjacent to the seepage water at the base of the levee. The sediment was comprised of a gravelly sandy clay which was grey/brown, soft with e a low plasticity. The gravel was fine to coarse grained, up to 50 mm diameter, angular to rounded. Some coal fragments were noted and trace organic matter.
Tinkers Creek – adjacent to Lake Liddell	LPS_SD520	This Tinkers Creek sampling location, adjacent to Lake Liddell, is wider than upstream at approximately 7 m wide and 4 m deep with generally flat sides and evidence of bank erosion. Vegetation is sparse and generally confined to the riparian zone. A sediment sample was taken at this location and was comprised of brown/black sandy clay which is fine grained with angular sand and organic inclusions and trace gravel up to 18 mm.
EPL Discharge Point #13	LPS_SD526_0.0 LPS_SD526_0.5	This location was a discharge outlet East of Liddell Power Station into Lake Liddell. The water was fast and turbulent, with a width of 4 m and depth of 1 m in a rock lined channel. The banks were mild with no evidence of bank erosion. Vegetation was sparse and confined to the riparian zone. The sediment sample was brown/black sandy clay with some gravel and an organic odour.
EPL Discharge Point #12	LPS_SD544	This location was from a channel leading South into Lake Liddell from the Liddell Power Station. The channel was 20 m wide, more than 100 m in length, and the water flow rate was fast. Vegetation was dense and confined to the riparian zone. No evidence of contamination was noted but an oil boom

Location	Sample Name	Observations
		was floating 10 m downstream of the sample location. No sediment was collected from this location due to access restrictions from the sampling platform.

10.4.1.4 Sediment Analytical Results

Eight sediment samples were collected during the field program from 4 locations co-located with surface water samples, outside the AIC boundaries but within the LPS and BPS EPL boundaries. . Locations were chosen as representative of potential locations where sediment maybe leaving the AICs and EPL boundary or immediately upgradient of these.

Sediment PFAS analytical results are summarised in **Table 95** below, and are presented in **Table T7**, in **Appendix B**, and in **Figures 46** to **48**, in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at four locations; none of these samples exceeded the adopted ILs.
- PFOA concentrations were below the LOR at all locations.
- PFOS and PFHxS concentrations were above the LOR at four locations; none of these samples exceeded the adopted ILs.

Table 95 Summary of PFAS in sediment outside AICs and associated with LPS

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
8	PFOS	<0.0002 – 0.0019	4	0
8	PFOA	<0.0002 - <0.0005	0	0
8	PFOS + PFHxS	<0.0002 – 0.0019	4	0

10.4.1.5 Soil and Sediment Leachate Analytical Results

Three sediment locations from the LPS area were ASLP tested. None of these locations reported results exceeding the Freshwater guidelines. This indicates sediments at these locations are not acting as a secondary source of PFAS to surface water receptors.

10.4.2 BPS

10.4.2.1 Surface Water Conditions

Surface water locations where sampled which were located outside the AIC and within the BPS EPL boundary. Locations were chosen as representative of surface water leaving the AICs and EPL boundary or immediately upgradient of these. Observations noted during surface water sampling of these locations are summarised in **Table 96** below, and photographs of sample locations presented in **Appendix L**. The surface water sampling locations tabulated below are illustrated in **Figure 47**, in **Appendix A**.

Table 96 Summary of surface water observations associated with areas outside the AICs and within the BPS property boundary

Location	Sample Names	Observations
Pikes Gully	BPS_WG502	A surface water sample was collected at this location in Pikes Gully. This sampling location is a shallow pond with no obvious water flow. The gully has steep sides and evidence of some erosion along the creek banks. A surface water sample was collected and was green with low turbidity and an organic odour.
Ash Dam Seepage Collection	BPS_WG503	The sampling location at the Ash Dam Seepage Collection point was a wide shallow pond, approximately 15 m across with slow moving water. The water collected was clear and colourless with low turbidity and no odour.
Tinkers Creek – EPL discharge point #7	BPS_WG506	The sampling location at EPL7 was from a settling pond 2 m wide and 1 m deep. The water depth was 10 cm and the flow was still. Vegetation is dense and located within the channel and along the riparian zone. The water collected was clear, with a slight turbidity, organic sheen and no odour.
Coal Pad settling pond	BPS_WG508 BPS_WG509 BPS_WG510	The coal settling pond is a wide, shallow concrete channel, approximately 3 m wide and 1.5 m deep, with around 0.15 m of water with a flat base. Water is fast moving through the channel, skirting the edge of the coal pad to settle out fines before discharging into Tinkers Creek at EPL 7. A surface water sample was taken here and was clear and slightly turbid with no odour.
Tinkers Creek – downgradient from EPL 7 discharge point	BPS_WG519	Tinkers Creek at this location is approximately 4 m across and 3 m deep with around 1 m of fast flowing water. The banks are flat with some evidence of erosion. Vegetation is dense with reeds, salt marsh and young trees. A surface water sample was taken at this location and was clear with slight turbidity and no odour.
Tinkers Creek – adjacent to Lake Liddell	LPS_WG520	This area of Tinkers Creek, adjacent to Lake Liddell, is wider at around 7 m wide and 4 m deep with around 1.5 m of water and a medium flow rate. The banks are generally flat with evidence of bank erosion. Vegetation is sparse and generally confined to the riparian zone. A surface water sample was taken at this location which was clear and slightly turbid with no odour.
Drainage to Tinkers Creek	BPS_ WG536	The drain to Tinker's Creek is approximately 12 m below ground level, the flow is fast and turbulent and the drain receives waters from three separate pipes across Bayswater Power Station. The water sample collected was clear, with no turbidity and no odour.
EPL 8 Discharge Point	BPS_WG545 BPS_AIC5152_SW565	The EPL 8 discharge point was sampled for surface water at both the concrete lined channel at the point of discharge and downstream concurrently with a sediment sample. The water at both locations was clear with low turbidity and no odour.

Surface water geochemical parameters were measured prior to sampling surface water. A summary of the geochemical parameters are presented in **Table 97** below. Surface water sampling locations are shown in **Figure 47** in **Appendix A**. Analytical results are presented in **Section 10.4.2.2**. Stabilised geochemical parameter measurements were:

- pH: measurements were between 7.13 and 8.86 indicating neutral to slightly alkaline water.
- Electrical conductivity: measurements ranged between 222.8 µS/cm and 31921 µS/cm.
- Dissolved oxygen measurements were between 0.43 mg/L and 8.36 mg/L.
- Temperature: measurements ranged from 20.0 °C to 35.3 °C.
- Redox Potential: measurements were between -57.4 mV and 155.2 mV indicating.

Table 97 Summary of surface water geochemical in surface water outside AICs and associated with BPS

Parameter	Minimum Recorded Value		Maximum Recorded Value	
	Minimum	Sample Location	Maximum	Sample Location
pH	7.13	BPS_WG506	8.86	BPS_WG542
EC (µS/cm)	223	BPS_WG543	31921	BPS_WG502
Dissolved Oxygen (mg/L)	0.43	BPS_WG504	8.36	BPS_WG509
Temperature (°C)	20.0	BPS_WG504	35.3	BPS_WG502
Redox (ORP) (mV)	-57.4	BPS_WG506	155.2	BPS_WG519

Note: [1]The theoretical maximum value of oxygen solubility, considering the water temperature and specific conductance conditions observed in the field is estimated to be 8.03 mg/L (USGS, 2016). Any value measured above this value has been considered to be erroneous.

10.4.2.2 Surface Water Analytical Results

A total of 18 surface water samples were collected, during the Stage 2 PFAS Investigation, from 12 sampling locations outside the AIC boundaries and within the LPS site boundary.

Surface water PFAS analytical results are summarised in **Table 98** below, and are presented in **Table T6**, in **Appendix B** and in **Figure 46**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 98 Summary of PFAS in surface water, outside AICs and associated with BPS

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
18	PFOS	<0.01 - < 0.05	0	0
18	PFOA	<0.01 - < 0.05	0	0
18	PFOS + PFHxS	<0.01 - < 0.05	0	0

10.4.2.3 Sediment Observations

Conditions observed during sediment sampling in areas outside the AICs and within the BPS EPL boundary are summarised in **Table 99** below. Sediment sampling locations are shown in **Figure 55** in **Appendix A**. Analytical results are presented in **Section 10.4.2.4**.

Table 99 Summary of sediment observations in areas outside the AIC boundaries and within the BPS property boundary

Location	Sample Name	Observations
Pikes Gully	BPS_SD502	Pikes Gully at this sampling location is a shallow pond with no obvious water flow. The gully has steep sides and evidence of some erosion. Sediment sampled from Pikes Gully was comprised of a soft, black silt with a high organic content and trace sand. This location had a high amount of vegetation such as salt marsh, algae and mosses.
Ash Dam Seepage Collection	BPS_SD503	Sediment was collected from the Ash Dam Seepage Collection and described as a soft brown clay with organic inclusions, fine black silty sands and trace gravels; gravels are fine to coarse grained up to 30 mm, angular to subangular.
Tinkers Creek – EPL discharge point #7	BPS_SD506	The sampling location at EPL7 was from a settling pond 2 m wide and 1 m deep. The water depth was 10 cm and the flow was still. Vegetation is dense and located within the channel and along the riparian zone. The sediment was brown silty clay with trace sand, low plasticity and a high organic content. An organic sheen was also observed in the sediment.
Coal Pad settling pond	BPS_SD508 BPS_SD509 BPS_SD510	There was no sediment present to sample at this location.
Tinkers Creek – downgradient from EPL 7 discharge point	BPS_SD519	This location on Tinkers Creek is approximately 4 m across and 3 m deep with around 1 m of fast flowing water and some bank erosion. Vegetation is dense with reeds, salt marsh and young trees. A sediment sample was taken next to the creek as the creek bed was comprised of large gravel. The sediment was comprised of a silty sand which was brown, fine grained with organic inclusions and trace clay and poorly sorted gravel up to 20 mm.
Drainage to Tinkers Creek	LPS_ SD536	There was no sediment present to sample at this location.
EPL 8 Discharge Point	BPS_AIC5152_SW565	The EPL 8 discharge point was sampled at the closest available downstream location from the concrete lined discharge point. The sediment was clear with low turbidity and no odour.

10.4.2.4 Sediment Analytical Results

Ten sediment samples were collected during the field program from eight locations co-located with surface water locations outside the AIC boundaries but within the BPS EPL boundary. Locations were chosen as representative of potential locations where sediment maybe leaving the AICs and EPL boundary or immediately upgradient of these.

Sediment PFAS analytical results are summarised in **Table 100** below, and are presented in **Table T7**, in **Appendix B**, and in **Figure 55**, in **Appendix A**. In summary:

- PFOS concentrations were above the LOR at two locations; no samples exceeded the adopted ILs.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were above the LOR at two locations; no samples exceeded the adopted ILs.

Table 100 Summary of PFAS in sediment, outside AICs and associated with BPS

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
10	PFOS	<0.0002 – 0.0005	2	0
10	PFOA	<0.0002 – <0.0005	0	0
10	PFOS + PFHxS	<0.0002 – 0.0006	2	0

10.4.2.5 Soil and Sediment Leachate Analytical Results

Three sediment locations from the BPS area were ASLP tested. None of these locations reported results exceeding the Freshwater guidelines. This indicates sediments at these locations are not acting as a secondary source.

10.4.3 Hunter River

10.4.3.1 Surface Water Conditions

Surface water was sampled in locations outside of the AIC and within the BPS EPL boundary. Locations were chosen as representative of surface water leaving the AICs and EPL boundary or immediately upgradient of these. Observations noted during surface water sampling of these locations are summarised in **Table 101** below, and are presented in **Table T6**, in **Appendix B**, and in **Figure 56**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 101 Summary of surface water observations associated with areas outside the AICs and within the boundaries of the Hunter River

Location	Sample Names	Observations
Bayswater Creek	BPS_SD505	Bayswater Creek here is 3 m wide and 1 m deep within a floodplain area. There was no water present for sampling as the creek bed was dry. Vegetation was dense and consisted of reeds within the riparian zone. Bank erosion was also observed. The sediment sample consisted of hard brown grey clay, the clay was dry and friable, with organic matter present.
Plashett Reservoir near dam	BPS_WG511	A surface water sample was collected at Plashett Reservoir, near the dam, from a steep sided shallow creek with slow moving water. Water collected for sampling was light brown and clear with no turbidity or odour.
Hunter River discharge point	BPS_WG512_0.0 BPS_WG512_0.5	The Hunter River discharge point is a steep bank entering the Hunter River which at this location is wide and deep with steep sides and a moderate flow rate and wide floodplain. The abstraction/discharge point is a three level concrete structure. Water collected at this location was a green/brown colour and turbidity.
Hunter River downstream	BPS_WG513_0.0 BPS_WG513_0.5	A surface water sample was collected downstream from the Hunter River discharge point. The Hunter River at this location is wide and deep with steep sides and a moderate flow rate and wide floodplain. The surface water sample collected at this location was light brown and slightly turbid with no odour. Small microinvertebrates were observed.
Bayswater Creek near Hunter River	BPS_WG514	Bayswater Creek at this location near the Hunter River is a creek approximately 6 m across and 1.5 m deep with undercutting bank erosion. The creek was dry in this area; AECOM investigated up and downstream from this area and collaborated with AGL to attempt to find a sample location.
Hunter River – upstream	BPS_WG562	A surface water sample was collected upstream from the Hunter River discharge point. The Hunter River at this location is wide and deep with steep sides and a moderate flow rate and wide floodplain. The surface water sample collected at this location was light brown and slightly turbid with no odour.

Surface water geochemical parameters were measured prior to sampling surface water. A summary of the geochemical parameters are presented in **Table** 102 below and detailed in **Table T3**, **Appendix B**. Surface water sampling locations are shown in **Figure 48** in Appendix A. Stabilised geochemical parameter measurements were:

- pH measurements were between 7.7 and 8.0 indicating neutral conditions.
- Electrical conductivity measurements ranged between 653 µS/cm and 3612 µS/cm, the samples taken from the upstream and downstream Hunter River locations averaged 661 µS/cm indicating fresh water.
- Dissolved oxygen indicated anaerobic conditions, measuring between 3.16 mg/L and 5.89 mg/L.
- Temperature: measurements ranged from 18.9 °C to 22.5 °C, in the range of ambient air temperature.

- Redox Potential measurements were between -116.9 mV and 88.3 mV. Those samples taken from the Hunter River indicated neutral to mildly oxidising conditions.

Table 102 Summary of surface water geochemical parameters in areas outside the AIC boundaries and in and around the Hunter River

Parameter	Minimum Recorded Value		Maximum Recorded Value	
	Minimum	Sample Location	Maximum	Sample Location
pH	7.67	BPS_WG511	8.00	BPS_WG512
EC (µS/cm)	653	BPS_WG512	3612	BPS_WG511
Dissolved Oxygen (mg/L)	3.16	BPS_WG511	5.89	BPS_WG512
Temperature (°C)	18.9	BPS_WG511	22.5	BPS_WG512
Redox (ORP) (mV)	-116.9	BPS_WG511	88.3	BPS_WG513

Note: [1] The theoretical maximum value of oxygen solubility, considering the water temperature and specific conductance conditions observed in the field is estimated to be 8.03 mg/L (USGS, 2016). Any value measured above this value has been considered to be erroneous.

10.4.3.2 Surface Water Analytical Results

Seven surface water samples were collected ,during the Stage 2 PFAS Investigation, from five sampling locations outside the AIC boundaries and within the LPS site boundary. Prior to sampling in December 2018, 86.2 mm of rainfall was recorded for November which was within the range of the long term average of 84.9mm (refer to **Section 10.1**).

Surface water PFAS analytical results are summarised in **Table 103** below, and are presented in **Table T6**, in **Appendix B** and in **Figure 48**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 103 Summary of PFAS in surface water outside AICs and associated with the Hunter River

No. Samples Analysed	Compound	Concentration Range (µg/L)	No. Samples with Concentrations >LOR	No. Samples Exceeding ILs
7	PFOS	<0.01 - < 0.05	0	0
7	PFOA	<0.01 - < 0.05	0	0
7	PFOS + PFHxS	<0.01 - < 0.05	0	0

10.4.3.3 Sediment Observations

Conditions observed during sediment sampling in areas outside the AICs are summarised in **Table 104** below. Sediment sampling locations are shown in **Figure 56**, in **Appendix A**. Analytical results are presented in **Section 10.4.3.4**.

Table 104 Summary of sediment observations in areas outside the AIC boundaries

Location	Sample Name	Observations
Bayswater Creek	BPS_WG505	Bayswater Creek here is 3 m wide and 1 m deep within a floodplain area. There was no water present for sampling as the creek bed was dry. Vegetation was dense and consisted of reeds within the riparian zone. Bank erosion was also observed.
Plashett Reservoir near dam	BPS_SD511	Sediment collected from this location was a dark brown soft sandy clay; fine to medium grained and subangular to subrounded with a high organic component. This location is vegetated with reeds, grasses and mature trees.
Hunter River discharge point	BPS_SD512	This location was not accessible to collect a sediment sample. AECOM investigated up and downstream from this area and collaborated with AGL to attempt to find a sample location.
Hunter River downstream	BPS_SD513	Sediment collected from the near shore of the Hunter River was comprised of brown fine to coarse sands with a high organic content and poorly sorted gravels up to 30 mm, angular to sub rounded. The river was highly vegetated with reeds, shrubs and trees in the vicinity.
Bayswater Creek near Hunter River	BPS_SD514	Bayswater Creek at this location near the Hunter River is a creek approximately 6 m across and 1.5 m deep with undercutting bank erosion. A sediment sample was collected which was comprised of a sandy clay which was brown and friable with fine subrounded sand. The sample contained some organic matter (twigs, wood) and an organic odour.
Hunter River upstream	BPS_SD562	Sediment collected from the near shore of the upstream Hunter River location was comprised of brown fine to coarse sands with a high organic content and poorly sorted gravels up to 30 mm, angular to sub rounded. The river was highly vegetated with tall reeds and shrubs in the riparian zone.

10.4.3.4 Sediment Analytical Results

Four sediment samples were collected during the field program from four locations co-located with surface water samples, outside the AIC boundaries but within the LPS and BPS property boundaries. . Locations were chosen as representative of potential locations where sediment maybe leaving the AICs and EPL site boundary or immediately upgradient of these.

Sediment PFAS analytical results are summarised in **Table 105** below, and are presented in **Table T7**, in **Appendix B**, and in **Figure 56**, in **Appendix A**. In summary:

- PFOS concentrations were below the LOR in all samples.
- PFOA concentrations were below the LOR in all samples.
- PFOS and PFHxS concentrations were below the LOR in all samples.

Table 105 Summary of PFAS in sediment outside AICs and associated with the Hunter River

No. Samples Analysed	Compound	Concentration Range (mg/kg)	No. Samples with Concentrations > LOR	No. Samples Exceeding ILs
4	PFOS	<0.0002 - < 0.0005	0	0
4	PFOA	<0.0002 - < 0.0005	0	0
4	PFOS + PFHxS	<0.0002 - < 0.0005	0	0

10.4.3.5 Soil and Sediment Leachate Analytical Results

One sediment location from the Hunter River was ASLP tested. Both the total and ASLP results were below LOR and remained so after ASLP testing. This indicates sediment at this location is not acting as a secondary source.

11.0 Outside-In Receptor to Source Assessment

The following '*Outside-In Assessment*' of the results discussed in **Section 10** provides a description of the findings which starts with an assessment of potential risks to downstream/down gradient sensitive receptors and moves inward towards the source areas. It includes the AICs at both power stations, areas outside the AIC boundaries and in the case of the Hunter River in particular, locations which represent the downgradient receptors.

In summary, the lines of evidence presented below indicate that migration of PFAS impacts from the upstream/up-gradient AICs (source areas) is not occurring to receptors outside of the AICs, i.e. there are no complete source-pathway-receptor linkages. The sampling rationale used in this study has provided a sampling design which has generally delineated PFAS impacts downgradient of source areas, at the EPL boundary and therefore the interface with the sensitive receptor, .

11.1 Locations Outside the AICs

Surface water results at all sampling locations outside the AICs were below the LOR. Co-located sediment samples reported concentrations either below LOR or below adopted ILs. ASLP testing on a number of these sediment samples indicated potential leaching of PFAS was limited and concentrations were all less than the surface water ILs. This infers sediments are not acting as a secondary source of PFAS impact in these areas and there is not a complete exposure linkage between the sediments immediately downgradient of the source areas and adjacent surface water. It also indicates that soil and groundwater concentrations reported up gradient, at the AICs, are not impacting the surface water and sediments outside and immediately downgradient of the AIC source areas.

11.2 LPS

Groundwater at AIC NP and AIC 93-96 generally follows the surface topography with a shallow gradient which falls towards Lake Liddell. Seepage velocity is low across LPS, calculated to be between 0.00003 m/year and 0.38 m/year. This low groundwater velocity confirms the observations made during drilling and sampling of slow groundwater movement through the fine clays and silts.

Concentrations of PFAS reported in surface water samples taken from Lake Liddell locations downgradient of the source areas at AIC NP and AIC 93-96 were below the LOR. Co-located sediment samples reported concentrations either below LOR or below adopted ILs. This infers that these areas of surface water at Lake Liddell are unlikely to be impacted by the reported PFAS concentrations in sediments.

Groundwater results exceeded the adopted ILs at locations up gradient of the surface water sampling locations; three locations on the Northern Peninsula and 12 in total at AIC 93-96, two of which were located in drainage lines immediately up-gradient of surface water and sediment sampling locations. In both AICs these exceedances were found generally within historic source areas and in the general location of soil impacts at the fire training grounds at both AICs and the tank farm at AIC 93-96.

Groundwater data was collected from 13 wells at LPS which were sampled in a previous monitoring event (ES, 2015b). There was both increasing and decreasing variability when comparing results with historic results. Two sets of data are considered insufficient to accurately assess temporal trends in concentrations. Historic results are predominantly within the range of those reported in this investigation. Where some variability exists there is no discernible trends noted between the sampling rounds. The behaviour of PFAS in the environment and the fact it is an emerging contaminant in terms of sampling and analysis techniques, may cause some inconsistency in results between events.

Stratification of concentrations of PFAS in groundwater was assessed using low-flow sampling at the base and top of the well screen. Some apparent stratification can be seen in some monitoring wells but no clear trend was identified and it may be attributable to the sampling techniques rather than the hydrogeological conditions being conducive of a pathway. Multi-depth results may also be influenced by lithology such as layers of softer gravelly clays between very firm medium plasticity clays .

Groundwater exceedances at AIC NP appear to be localised. L_P_ESMW04, which reported no impacts is located between LPS_AICNP_MW129 and LPS_AICNP_MW105, both of which reported impacts above the ILs and have well screens starting at similar topographic heights. Survey data and bore logs where not available for L_P_ESMW04. LPS_AICNP_MW112 also reported groundwater results above the EILs, it is located approximately 180 m north west of LPS_AICNP_MW129, and screened within 0.5 mAHD LPS_AICNP_MW129 and LPS_AICNP_MW105,.

Soil concentrations at LPS_AICNP_MW129 and LPS_AICNP_MW112 were below ILs. Impacts in these locations are potentially due to localised historic source impacts due to fire training occurring in different areas of AIC NP. Borelogs and the groundwater velocity and direction do not indicated preferential groundwater flow paths between these locations.

The proximity of the groundwater impacts to the downgradient sediment and surface water sample locations infer that the migration pathway between groundwater, sediment and surface water is retarded in these areas by the aquifer lithology and groundwater flow parameters. LPS_NP_MW105 on the eastern edge of AIC NP reported the highest soil and groundwater results of the Stage 2 Investigation at LPS. The embankment immediately adjacent to this location has a rocky anchor wall which made it inaccessible to surface water and sediment sampling. Two adjacent surface water locations, accessed via boat, were each sample at 0.0 m and 3.0 m below the water surface and reported results below LOR.

Five groundwater locations immediately upgradient of surface water samples taken at Lake Liddell, on the eastern boundary of AIC 93-96, exceeded EILs and HILs. Sediment downgradient of these locations reported results below ILs and surface water was below LOR. Results for both AIC NP and AIC 93-96 infer there is not a complete migration pathway in these locations between groundwater and sediments or surface water.

Soil results above LOR were generally found in similar geographic locations to groundwater impacts. At AIC NP, 16 of the 23 locations analysed reported results above LOR, with only LPS_AICNP_MW105 exceeding EILs in the top 0.5 m of the soil profile.

Of the 30 locations analysed in AIC 93-96, 17 reported results above the LOR, with only two above the EILs in the top 0.5 m of the soil profile. These two locations where in known source areas at the fire training ground (LPS_AIC9396_SB118) and the tank farm (LPS_AIC9396_SB102). Concentrations above LOR but below ILs where reported down to 6 mbgl in locations adjacent to the fire training areas.

ASLP testing results of soil samples in these areas where compared to surface water guidelines to allow an inference of the potential for migration of PFAS from impacted soil through the underlying groundwater and onto surface water. Three soil locations at the Northern Peninsula and two locations at AIC 93-96 reported ASLP results above the Freshwater guidelines. All sediment ASLP testing results were below the surface water ILs.

There were no impacts to sediment or surface water down gradient of the soil and groundwater impacts indicating there is not a complete migration pathway between soil and groundwater impacts and down gradient sediments and surface water receptors.

The lines of evidence presented above infer that migration pathways from impacted soil and groundwater in the identified AIC NP and AIC 93-96 source areas, to downgradient sediment and surface water receptors are not complete. Sediment and surface water samples have been taken immediately down gradient of impacted soil and groundwater locations, reporting no impacts. It is inferred from this that the risk to receptors downstream of AIC NP and AIC 93-96 are low and acceptable.

11.3 BPS

Groundwater generally follows surface topography at AIC 11W, AIC 17and AIC 51-52, with a shallow gradient. Seepage velocity is low across BPS, calculated to be between 0.000079 m/year and 0.21 m/year. The low calculated seepage velocities confirm observations made at the time of drilling and sampling of slow groundwater recharge through the fine clays and silts.

Surface water PFAS results were generally below the LOR with the exception of two locations, the central drain at AIC 17 (BPS_AIC17_WG532) and the Process Water Dam at AIC 51-52, both of these locations were below the adopted ILs. Co-located sediment samples reported concentrations either below LOR or below ILs.

Groundwater results exceeded the adopted ILs at locations up gradient of the surface water samples which were above LOR at AIC 11W and AIC 51-52 but less than the ILs

- Four locations at AIC 11W exceeded HILs, all located in the western portion of the AIC. Groundwater locations in the eastern and central portion of AIC 11W, around the fire training area, reported below LOR.
- AIC 17 reported exceedances in the three groundwater monitoring locations on the western edge, outside and down gradient of the AIC boundary. In particular locations B_16_ESMW02 and B_16_ESMW03 are immediately downgradient of the western transformer source area.
- The two locations which exceeded HILs at AIC 51-52 where downgradient on either side of the tank farm. The groundwater contours at this AIC infer that groundwater sheds in either direction from the ridge the tank farm is located on.

Groundwater data was collected from 12 wells at BPS which were previously sampled (ES, 2015a). Two sets of data are considered insufficient to accurately assess temporal trends in concentrations. Historic results are predominantly within the range of those reported in this investigation. Where some variability exists there are no discernible trends noted between the sampling rounds. The behaviour of PFAS in the environment and the fact it is an emerging contaminant in terms of sampling and analysis techniques, may cause some inconsistency in results between events.

Stratification of concentrations of PFAS in groundwater was assessed using low-flow sampling at the base and top of the well screen. Some stratification of groundwater can be seen in one monitoring well at AIC 51-52(BPS_AIC5152_GWMW106) however no trend was identified. Multi-depth results may also be influenced by lithology such as layers of softer gravelly clays between very firm medium plasticity clays.

No soil samples analysed at BPS exceeded the adopted ILs. Soil results above LOR were generally found in similar geographic locations to groundwater impacts. Of the 33 locations analysed in AIC 11W, 16 of these locations reported results above the LOR and where generally at the fire training ground in the centre of the AIC and near the groundwater exceedances discussed above.

Soil results above LOR were predominantly reported in the upper 1.5 m of the soil profile, with concentrations above LOR reported down to 6 mbgl in only one location (BPS_AIC11W_SB120).

ASLP testing results of soil samples in these areas where compared to surface water guidelines to allow an inference of the potential for migration of PFAS from impacted soil through the underlying groundwater and onto surface water. Two soil locations at AIC 11W reported ASLP results above the Freshwater guidelines. All sediment ASLP testing results were below surface water ILs.

The lines of evidence presented above infer that migration pathways from impacted soil and groundwater at AIC 11W, AIC 17 and AIC 51-52 to downgradient sediment and surface water receptors are not complete. Sediment and surface water samples have been taken immediately down gradient of impacted soil and groundwater locations, reporting no impacts. It is inferred from this that the risk to receptors downstream of impacts at AIC 51-52, AIC 11W and AIC 17 are low and acceptable.

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12.0 Revised Conceptual Site Models

12.1 LPS

Based on the results of the sampling program, the revised LPS CSM including and assessment of the exposure pathways is presented in Table 106 and Figure 2.

Table 106 LPS Revised CSM

Source	Pathway	Receptor	Exposure Assessment
[illegible]			
Soils	• Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • PFAS concentrations in soils did not exceed the commercial/industrial HILs. Commercial and Intrusive Maintenance Workers have administrative controls and PPE to further reduce the potential complete exposure pathway.
	• Leaching of PFAS from soil into groundwater	Groundwater	Potentially COMPLETE Exposure Linkage • PFAS was reported in groundwater indicate a complete pathway.
	• Leaching of PFAS from soil into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • Whilst PFAS in soils confirmed to be leachable at concentrations greater than the ILs, no PFAS concentrations were reported in surface water above LORs at the time of sampling.

Source	Pathway	Receptor	Exposure Assessment
	- Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • PFAS impacts reported in soils at greater than the EILs, indicating that benthic biota may be impacted at the receptor, however no impacts were reported in surface water at the time of sampling. • No PFAS concentrations reported downgradient in sediments above the ECO ILs and no PFAS concentrations above LORs were reported in surface water at the time of sampling.
Sediments	- Incidental ingestion and dermal contact with sediment	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. • Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	- Leaching of PFAS impacts from sediment into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs and no PFAS concentrations above LORs were reported in surface water at the time of sampling.
	- Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported in sediments above the ECO ILs and no PFAS concentrations reported above LORs in surface water.
Surface Water (including Hunter River)	- Incidental ingestion and dermal contact with surface water	Outdoor Commercial workers Potential unauthorised recreational use of Lake Liddell	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations above LORs were reported in surface water at the time of sampling. • Lake Liddell itself is permanently closed to public access, hence recreational exposure scenarios are not applicable (but cannot be discounted entirely as there maybe be unknown illegal recreationalist of Lake Liddell, the assessment of which is outside the scope of this investigation)

Source	Pathway	Receptor	Exposure Assessment
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations above LORs were reported in surface water at the time of sampling.
Groundwater	• Incidental ingestion and dermal contact with groundwater	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** • PFAS impacts reported in groundwater at greater than the HILs. Risk is considered low due to: - Groundwater depth >4 mbgl with an average of 7.3 mbgl across AIC NP, greater than is expected to be intercepted by Commercial and Intrusive Maintenance Workers. - Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from groundwater into sediments	Sediments	**INCOMPLETE Exposure Linkage** • While PFAS impacts were reported in groundwater risks to sediment are considered low due to: - depth to groundwater >4 mbgl with an average of 7.3 mbgl across AIC NP; - groundwater hydraulic conductivity is low; and - reported concentrations in sediment did not exceed ILs.
	• Leaching of PFAS impacts from groundwater into surface water	Surface water	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, reported concentrations in surface water were all below LOR at the time of sampling.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, downgradient surface water were results were all below LOR at the time of sampling.

Source	Pathway	Receptor	Exposure Assessment
Soils	- Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** - Whilst PFAS impacts in soils confirmed, impacts did not exceed HILs. Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	- Leaching of PFAS impacts from soil into groundwater	Groundwater	Potentially COMPLETE Exposure Linkage - PFAS impacts reported in groundwater – refer to impacted groundwater
	- Leaching of PFAS impacts from soil into surface water	Surface water	**INCOMPLETE Exposure Linkage** - Whilst PFAS impacts in soils confirmed to be leachable, no PFAS concentrations above LORs were reported in surface water at the time of sampling .
	- Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** - PFAS impacts reported in soils at greater than the ECO ILs, indicating that aquatic biota may be impacted at the receptor, however downgradient surface water results were below LORs at the time of sampling.
Sediments	- Incidental ingestion and dermal contact with sediment	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** - No PFAS concentrations in sediments reported above ILs. Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks
	- Leaching of PFAS impacts from sediment into surface water	Surface water	**INCOMPLETE Exposure Linkage** - No PFAS concentrations in sediments reported above ILs and no PFAS concentrations above LORs were reported in surface water at the time of sampling..

Source	Pathway	Receptor	Exposure Assessment
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported in sediments above the ECO ILs and no PFAS concentrations above LORs were reported in surface water at the time of sampling.
Surface Water (including Hunter River)	• Incidental ingestion and dermal contact with surface water	Outdoor Commercial workers Potential unauthorised recreational use of Lake Liddell	**INCOMPLETE Exposure Linkage** • No PFAS concentrations above LORs were reported in surface water at the time of sampling. • Lake Liddell itself is permanently closed to public access, hence recreational exposure scenarios are not applicable (but cannot be discounted entirely as there maybe be unknown illegal recreationalist of Lake Liddell, the assessment of which is outside the scope of this investigation).
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations above LORs were reported in surface water at the time of sampling.
Groundwater	• Incidental ingestion and dermal contact with groundwater	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater confirmed, groundwater is >2 mbgl with an average of 3.8 mbgl across AIC 93-96. Commercial and Intrusive Maintenance Workers are unlikely to encounter groundwater in this area and will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from groundwater into sediments	Sediments	**INCOMPLETE Exposure Linkage** • While PFAS impacts were reported in groundwater risks to sediment are considered low due to - groundwater hydraulic conductivity is low; and - reported concentrations in sediment did not exceed ILs.

Source	Pathway	Receptor	Exposure Assessment
	• Leaching of PFAS impacts from groundwater into surface water	Surface water	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, no PFAS concentrations above LORs were reported in surface water at the time of sampling.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, no PFAS concentrations above LORs were reported in surface water at the time of sampling.

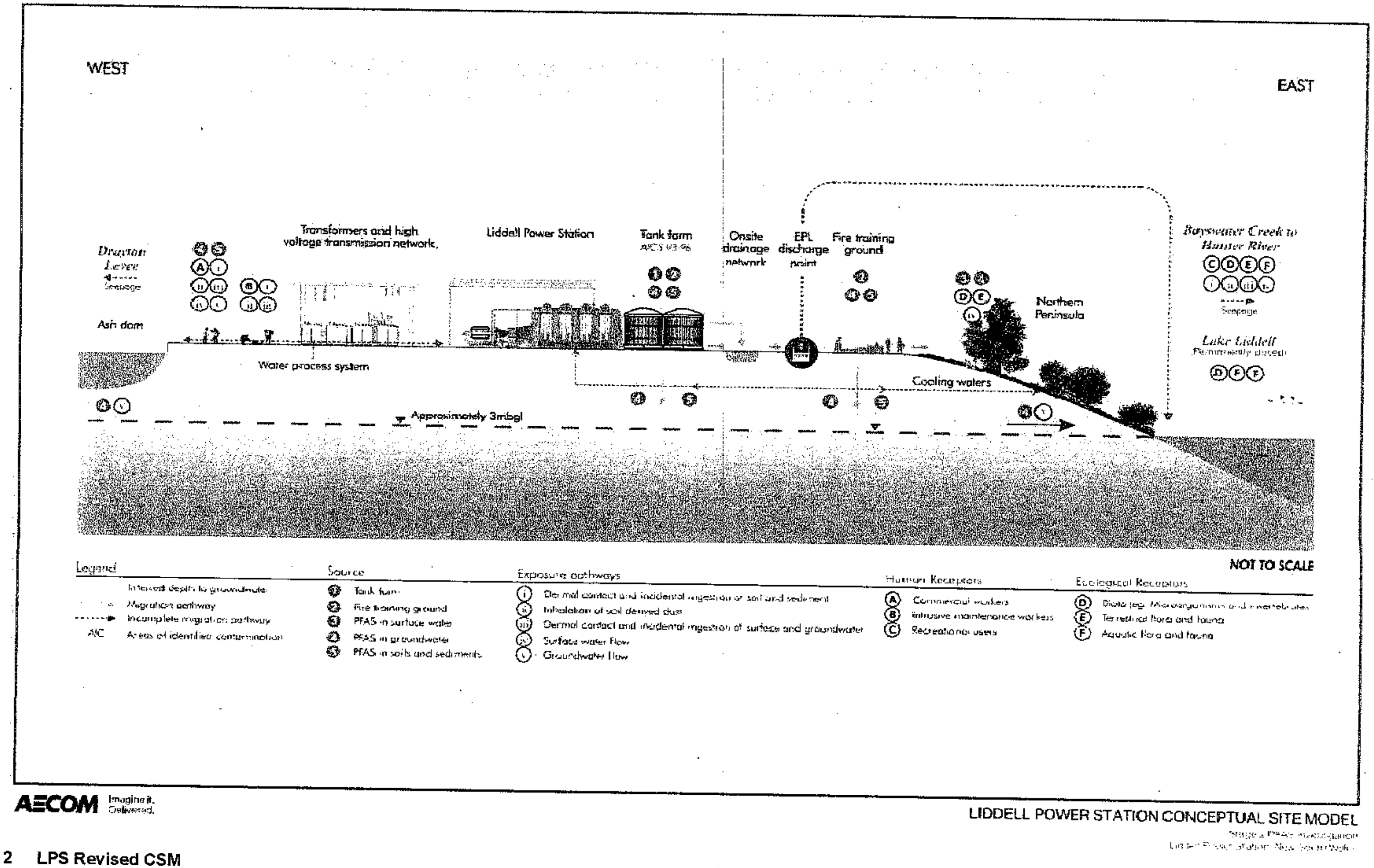

Figure 2 LPS Revised CSM

12.2 BPS

Based on the results of the sampling program, the revised CSM including and assessment of the exposure pathways is presented in **Table 107**.

Table 107 BPS Revised CSM

Source	Pathway	Receptor	Exposure Assessment
Soils	• Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in soils reported above HILs. • Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks
	• Leaching of PFAS impacts from soil into groundwater	Groundwater	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in soils reported above ILs. • PFAS impacts reported in groundwater – refer to impacted groundwater.
	• Leaching of PFAS impacts from soil into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in soils reported above ILs. • No PFAS concentrations above LORs were reported in surface water at the time of sampling.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported in soils greater than the ECO ILs. • No PFAS concentrations above LORs were reported in surface water at the time of sampling.

Source	Pathway	Receptor	Exposure Assessment
Sediments	• Incidental ingestion and dermal contact with sediment	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. • Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from sediment into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. • No PFAS concentrations above LORs were reported in surface water at the time of sampling.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported in sediments above the ECO ILs. • No PFAS concentrations above LORs were reported in surface water at the time of sampling.
Surface Water (including Hunter River)	• Incidental ingestion and dermal contact with surface water	Outdoor Commercial workers Potential unauthorised recreational use of Lake Liddell	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations above LORs were reported in surface water at the time of sampling. • Lake Liddell itself is permanently closed to public access, hence recreational exposure scenarios are not applicable (but cannot be discounted entirely as there maybe be unknown illegal recreationalist of Lake Liddell, the assessment of which is outside the scope of this investigation).
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations above LORs were reported in surface water at the time of sampling.

Source	Pathway	Receptor	Exposure Assessment
Groundwater	• Incidental ingestion and dermal contact with groundwater	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** • PFAS impacts reported in groundwater at greater than the HILs, Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from groundwater into sediments	Sediments	**INCOMPLETE Exposure Linkage** • While PFAS impacts were reported in groundwater risks to sediment are considered low, due to: - groundwater hydraulic conductivity is low; and - reported concentrations in sediment did not exceed ILs.
	• Leaching of PFAS impacts from groundwater into surface water	Surface water	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, no PFAS concentrations above LORs were reported in surface water at the time of sampling.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, no PFAS concentrations above LORs were reported in surface water at the time of sampling.
Soils	• Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** • No PFAS impacts reported in soil.

Source	Pathway	Receptor	Exposure Assessment
	• Leaching of PFAS impacts from soil into groundwater	Groundwater	**INCOMPLETE Exposure Linkage** • No PFAS impacts reported in soil.
	• Leaching of PFAS impacts from soil into surface water	Surface water	**INCOMPLETE Exposure Linkage** • No PFAS impacts reported in soil.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS impacts reported in soil.
Sediments	• Incidental ingestion and dermal contact with sediment	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks
	• Leaching of PFAS impacts from sediment into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs and no PFAS concentrations above ILs were reported in surface water .
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported in sediments above the ECO ILs and no PFAS concentrations above ILs were reported in surface water .
Surface Water (including Hunter River)	• Incidental ingestion and dermal contact with surface water	Outdoor Commercial workers Potential unauthorised recreational use of Lake Liddell	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in surface water were reported above ILs. • Lake Liddell itself is permanently closed to public access, hence recreational exposure scenarios are not applicable (but cannot be discounted entirely as there maybe be unknown illegal recreationalist of Lake Liddell, the assessment of which is outside the scope of this investigation).

Source	Pathway	Receptor	Exposure Assessment
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations in surface water were reported above ILs.
Groundwater	• Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • Whilst PFAS impacts in groundwater are greater than HILs, groundwater at these locations is >4 mbgl. Commercial and Intrusive Maintenance Workers are unlikely to encounter groundwater in this area and will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from groundwater into sediments	Sediments	**INCOMPLETE Exposure Linkage** • While PFAS impacts were reported in groundwater risks to sediment are considered low due to - groundwater hydraulic conductivity is low; and - reported concentrations in sediment did not exceed ILs.
	• Leaching of PFAS impacts from groundwater into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • Whilst PFAS impacts in groundwater were confirmed, no PFAS concentrations in surface water were reported above ILs.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, no PFAS concentrations in surface water were reported above ILs.

Source	Pathway	Receptor	Exposure Assessment
Soils	• Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported above ILs in soil.
	• Leaching of PFAS impacts from soil into groundwater	Groundwater	**INCOMPLETE Exposure Linkage** • No PFAS concentrations reported above ILs in soil – refer to impacted groundwater.
	• Leaching of PFAS impacts from soil into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in soils or leachable concentrations above ILs. • No PFAS concentrations in surface water were reported above ILs.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations were reported above ILs in soil. • No PFAS concentrations were reported in surface water above ILs.
Sediments	• Incidental ingestion and dermal contact with sediment	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. • Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from sediment into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. • No PFAS concentrations in surface water were reported above ILs.

Source	Pathway	Receptor	Exposure Assessment
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS impacts reported in sediments above the ECO ILs. • No PFAS concentrations were reported in surface water above ILs.
Surface Water (including Hunter River)	• Incidental ingestion and dermal contact with surface water	Outdoor Commercial workers Potential unauthorised recreational use of Lake Liddell	**INCOMPLETE Exposure Linkage.** • No PFAS impacts reported in surface water above ILs. • Lake Liddell itself is permanently closed to public access, hence recreational exposure scenarios are not applicable (but cannot be discounted entirely as there maybe be unknown illegal recreationalist of Lake Liddell, the assessment of which is outside the scope of this investigation).
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No impacts reported in surface water above ILs.
Groundwater	• Incidental ingestion and dermal contact with soil	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • Whilst PFAS impacts in groundwater confirmed, groundwater is >3.6 mbgl with an average of 7.2 mbgl across AIC 51-52. Commercial and Intrusive Maintenance Workers are unlikely to encounter groundwater in this area and will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from groundwater into sediments	Sediments	**INCOMPLETE Exposure Linkage** • While PFAS impacts were reported in groundwater risks to sediment are considered low due to - groundwater hydraulic conductivity is low; and - reported concentrations in sediment did not exceed ILs.

Source	Pathway	Receptor	Exposure Assessment
	• Leaching of PFAS impacts from groundwater into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • Whilst PFAS impacts in groundwater were confirmed, no PFAS impacts in surface water were reported above ILs.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • Whilst PFAS impacts in groundwater were confirmed, no PFAS impacts in surface water were reported above ILs.

12.3 Areas Outside AICs Revised Conceptual Site Model

Based on the results of the sampling program, the revised CSM including and assessment of the exposure pathways is presented in **Table 108**.

Table 108 Areas Outside AICs Revised CSM

Source	Pathway	Receptor	Exposure Assessment
Sediments	• Incidental ingestion and dermal contact with sediment	Outdoor Commercial workers Intrusive Maintenance Workers	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs. • Commercial and Intrusive Maintenance Workers will work with administrative controls and PPE to further reduce potential exposure risks.
	• Leaching of PFAS impacts from sediment into surface water	Surface water	**INCOMPLETE Exposure Linkage.** • No PFAS concentrations in sediments reported above ILs and no PFAS concentrations above LORs were reported in surface water at the time of sampling.
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS impacts reported in sediments above the ECO ILs and no PFAS concentrations above LORs were reported in surface water at the time of sampling .
Surface Water (including Hunter River)	• Incidental ingestion and dermal contact with surface water	Outdoor Commercial workers. Potential unauthorised recreational use of Lake Liddell	**INCOMPLETE Exposure Linkage.** • No impacts in surface water reported. • Lake Liddell itself is permanently closed to public access, hence recreational exposure scenarios are not applicable (but cannot be discounted entirely as there maybe be unknown illegal recreationalist of Lake Liddell, the assessment of which is outside the scope of this investigation). •
	• Indirect Exposure	Biota	**INCOMPLETE Exposure Linkage** • No PFAS concentrations above LORs were reported in surface water at the time of sampling .

13.0 Conclusions

13.1 Objectives

The objectives of the Stage 2 PFAS Investigation, as described in Section 1.3, are:

1. **Principals Objective**

To address the EPA's request, the Principals have engaged AECOM to carry out this Stage 2 PFAS Investigation with the following objectives:

- to refine the existing CSM and better define the potential risk posed to sensitive off-site human health and ecological receptors.
- Make recommendations for additional investigations, if required.

2. **Project Objective**

The specific project objective is to build on the existing data set obtained during the ERM (2014a), ERM (2015b) and ES (2017) investigations by obtaining additional soil, sediment, leachate, surface water and groundwater at the existing AICs and at additional locations at The Sites.

13.2 Conclusions

The following conclusions are made based on the data collected during the investigation as assessed against the Principals' and project objectives detailed in **Section 1.3** above.

The objectives have been met by revising the CSMs, specifically based on:

- Lateral and vertical soil sampling in the AICs and surrounding areas has demonstrated that PFAS concentrations are generally less than the laboratory LORs and/or ILs. Where ILs are exceeded in 3 of 274 soil samples, nearby sediment and surface water results were all less than the LOR and or ILs, indicating no complete exposure linkage.
- Sampling of groundwater in the AICs and surrounding areas indicated that while PFAS has migrated to groundwater at concentrations exceeding ILs in 21 of 74 monitoring well locations, nearby downgradient sediment and surface water results were all less than the LOR and/or ILs, indicating no complete exposure linkage. Whilst the full vertical and lateral extent of PFAS impacts may not have been fully defined at each AIC (which was not the purpose of this investigation), the refined CSMs, based on the data obtained, infer that PFAS does not appear to be impacting off-site receptors and has been assessed relative to the downgradient receptors.
- Sampling from nearby drainage lines, receiving waters and sediments has demonstrated that PFAS has not migrated from the AICs at concentrations greater than the ILs, indicating no complete exposure linkage.
- Investigation of potential off-site migration of impacts at EPL discharge points, specifically EPL8, has demonstrated that PFAS concentrations are less than the laboratory LORs at all locations, indicating no complete exposure linkage with surface water receptors.

While there is no evidence of a complete exposure linkage between the impacts reported in groundwater down gradient of AIC 17 and potential down gradient receptors, further investigation would be necessary to fully delineate the reported concentrations.

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