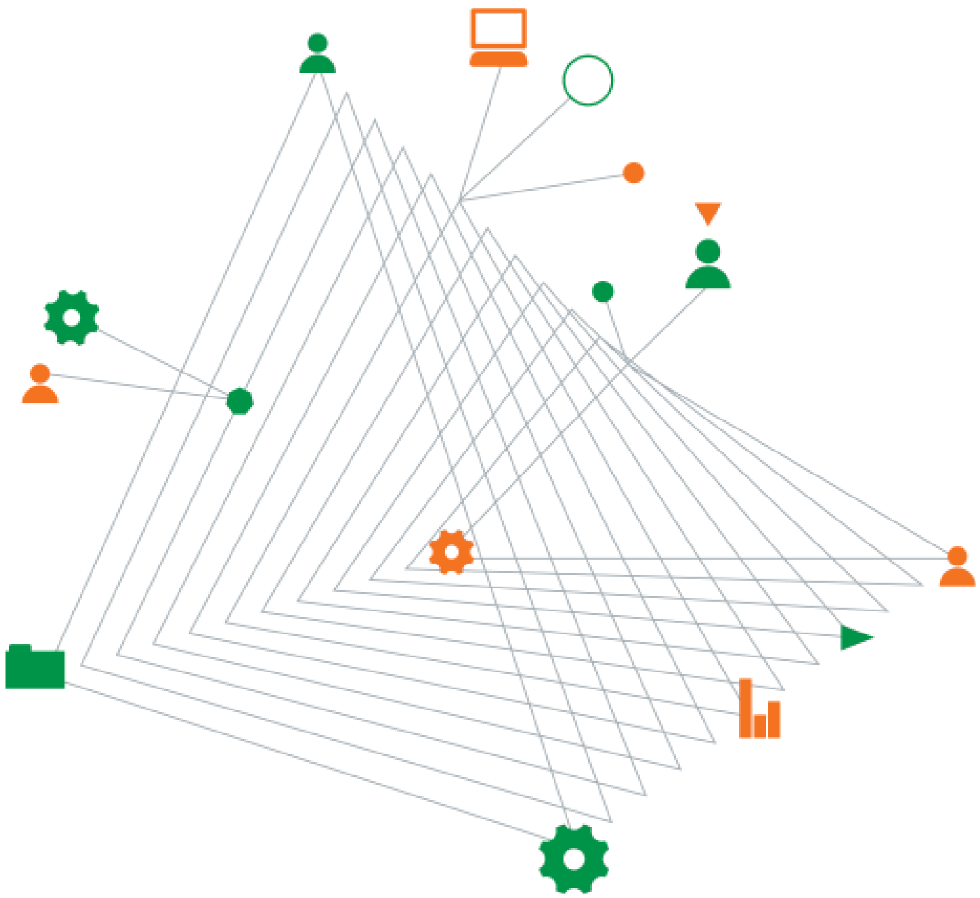
Flinders Power Partnership

Detailed Site Investigation – Version 2

Augusta Power Stations

28 February 2017



Experience
comes to life
when it is
powered by
expertise

This page has been left intentionally blank

Detailed Site Investigation – Version 2

Prepared for
Flinders Power Partnership

Prepared by
Coffey Environments Australia Pty Ltd
Coffey World Park 33-39 Richmond Rd
Keswick SA 5035 Australia
t: +61 8 8375 4523 f: +61 8 8375 4499
ABN: 65 140 765 902

Project Director	Dr David Tully Senior Principal Geoenvironmental Engineer
Project Manager	Felicia Mellors Senior Environmental Scientist

28 February 2017

754-ENAUKESW01445AD-R01 Version 2

Quality information

Revision history

Revision	Description	Date	Author	Reviewer
0	754-ENAUKESW01445AD-R01A	15/12/2016	Felicia Mellors	David Tully
1	754-ENAUKESW01445AD-R01 Version 1	20/02/2017	Felicia Mellors	David Tully
2	754-ENAUKESW01445AD-R01 Version 2	28/02/2017	Felicia Mellors	David Tully

Distribution

Report Status	No. of copies	Format	Distributed to	Date
Version 2	1	PDF	Flinders Power Partnership	28/02/2017
Version 2	1	PDF	Kirsa Environmental	28/02/2017
Version 2	1	PDF	SA EPA	28/02/2017

Executive summary

Background Information	The Leigh Creek Coal Mine supplied coal exclusively for Flinders Power Partnership (FPP) Augusta Power Stations (APS). The coal was transported by rail to Port Augusta which is approximately 250 km south of the mine. The mine, the power stations and the railway facilities linking the two sites are known collectively as the Flinders Operations. FPP have appointed Coffey Environments Australia Pty Ltd to undertake a Detailed Site Investigation (DSI) of APS was part of a phased program of site contamination assessment works. The power station was in operation since the mid 1950's with the full extent of operations from 1985 with the Northern Station commencing production. FPP has had site ownership since 2000 with the Electricity Trust of South Australia formerly owning and operating the site until that time. Prior to the 1940's the site was primarily mangrove swamps associated with Northern Spencer Gulf. Two portions of the mangrove swamp habitat along the eastern edge of the Spencer Gulf were reclaimed, initially to create the power station facility associated with the Playford Stations and later to construct water channels for the Northern Station. The site ceased power generation in May 2016 and entered site closure with the demolition program commencing in June 2016. Some infrastructure such as road ways, northern infrastructure pad, cooling water inlet/outlet infrastructure, sheds, switch yards and site drainage infrastructure including ABC Lake (situated immediately south of the ash storage area) are expected to remain at the site for future use. A number of options for site reuse including the ash ponds are being considered that will benefit the local community. A Preliminary Site Investigation (PSI) was completed for the site which identified 52 areas of environmental concern (AEC) from site historical activity that had the potential to cause site contamination at 18 defined areas across the site. On the basis of the PSI, a Sampling, Analysis and Quality Plan (SAQP) was developed to facilitate further detailed investigation of the site. It is noted that prior to land transfer to FPP from the state government, reports were undertaken by FPP and BRW into the site contamination issues at the site that may present liability risks to FPP. These reports were utilised in our development of the PSI. A Site Contamination Auditor, Steven Kirsanovs of Kirsa Environmental has been appointed to the site by FPP to undertake a site contamination audit as part of the closure plan. The DSI is also a requirement of a Voluntary Site Contamination Assessment Proposal (VSCAP), dated 9 September 2016, which the South Australia Environment Protection Authority (SA EPA) has reviewed and considered appropriate for the site. Ultimately, the phased assessments being undertaken at the site will assist in FPP's process to divest the site and/or hand back the lease(s) for future ongoing non-sensitive commercial/industrial land use.
Objective	The objective of this DSI was to assess the nature and extent of potential site contamination within the AECs, determine if a potential risk exists to the identified potential receptors from identified site contamination, and provide recommendations for further assessment or risk mitigation (Phase 3), if required to facilitate site closure.
Scope of works	The fieldworks program undertaken at the site in accordance with the SAQP was completed between 23 May and 19 July 2016 and 7 and 9 November 2016 and comprised of the following: • Underground service location across the site; • Drilling of a total of 36 soil bores across the AECs with completion of 25 soil bores as monitoring wells including four monitoring wells installed into the secondary aquifer; • Excavation of a total of 151 test pits across the AECs; • Collection of 13 soil/sediment samples from within mangrove areas; • Collection of six grab soil samples from a fuel infrastructure bund; • Sampling & analysis of soil samples for a range of chemicals of potential concern (COPCs); • Gauging, purging and sampling of 64 existing and newly installed monitoring wells for submission of chemical analysis of COPCs; • Investigation of historical waste dumps across the site; and • Engagement of a suitably qualified subcontractor to complete a flora and fauna assessment of particular mangrove areas at the site. The data collected was used to undertake tier one screening assessment in line with a non-sensitive site use and update the exposure scenarios established by the preliminary conceptual site model set out in the PSI. An ecological risk assessment was completed for the assessment of historical activities on the mangrove swamp adjacent to the site.

Conclusions	The subsurface conditions encountered beneath the site have indicated deeper fill areas are present closer to the Spencer Gulf where reclamation of land was undertaken for the site construction, and at lesser extents where site surface build up for construction occurred. Where the site surface has been built up outside of the Playford areas, ash material is present in the fill. The natural soil surface is encountered at shallower depths further from the Spencer Gulf which is consistent with the site construction through land reclamation over time. Unburnt coal remains at the site in a defined area west of the coal loading area and fuel pad and this area will be included in the future management plan for the site. With the exception of previously known areas of historical fuel losses, gross soil and groundwater impacts have not been identified from the DSI works completed in relation to the previously defined AECs. Minor hydrocarbon impacts not previously identified have been noted in shallow soils in various areas within the site but are generally considered to be isolated and unlikely to present an unacceptable dermal contact or inhalation risk to current and future identified receptors with respect to ongoing commercial/industrial land use. Localised previously identified hydrocarbon impacts to the primary aquifer have been confirmed, however, there is potential for natural attenuation to be occurring and occur into the future which will continue to reduce the severity and extent of these impacts. The secondary aquifer was investigated in areas of historical petroleum hydrocarbon impacts. Vertical migration of impacts into the secondary aquifer was not apparent. Known historical impacts associated with the Playford fuel oil loss (AEC 1) in the 1990s have been confirmed within the unsaturated zone and within the primary aquifer. The impacts identified are considered to potentially pose an unacceptable dermal contact and ingestion risk to current workers if the ground surface in this area is disturbed and to future users and structures, if the impacts remain following closure and if strict management protocols are not implemented. The previous DRA completed for the Playford fuel oil loss indicated that the plume is stable and shrinking and unlikely to expand to reach the marine ecosystem. Information obtained from the DSI support these findings. Petroleum hydrocarbons are also present in soils and dissolved in groundwater in the vicinity of the sea wall adjacent to Playford B Station and adjacent to the SPEL tank and sump (AEC 7A) to the north west of Playford B Station. The impacts noted are considered to be at concentrations that are unlikely to pose a potential risk to current and future identified receptors unless the area is excavated and appropriate management protocols are not implemented. Hydrocarbon impacts were noted at concentrations above generic ecological screening levels locally at the vehicle storage and maintenance area (AEC 25) which potentially pose a risk to ecological receptors. The soils in the vicinity of the fuel transfer pipeline (AEC 31B) and wash down bay (AEC 32) reported some minor petroleum hydrocarbon impacts at the depth of groundwater. It is considered likely that these sources have been sources of impact to the soils and groundwater historically and have been reported in the smear zone in the current investigation. The soils and groundwater in the vicinity of the northern store underground storage tank (UST) (AEC 35) located at the Northern Station are confirmed to be impacted in line with historical data and confirm an unleaded petrol source based on the composition of chemicals reported. The impacts noted are considered unlikely to present an unacceptable risk to current and future receptors, unless the subsurface is removed and contact with the impacted soils and groundwater occurs. A trace concentration of perfluorooctane sulfonate (PFOS) was reported in the groundwater in the vicinity of the firefighting training area (fire extinguisher training) (AEC 43B). Around the fuel pad (AEC 44) at the coal loading area, soil and groundwater impacts have been reported that could pose a potentially unacceptable risk to current workers if the ground is disturbed and to future users and structures if the impacts remain following closure and if strict management protocols are not implemented. The groundwater impacts reported to the south of the fuel pad remain undelineated down gradient to the south west. It is understood that this area is to be revegetated and the fuel pad will be removed. Previous testing of the ash material within the ash storage area (ash pond) (AEC 50A) reported the material to be consistent with bottom ash and within the expected ranges for this type of material. The ash pond is well defined with an up to date survey plan which will be included in the future management plan for the site. It is considered unlikely that given the chemicals reported in the ash material, dust migration to the residential occupants and commercial workers within Port Augusta Township to the north/north west is unlikely to cause potential risks to human health. It is also unlikely an inhalation risk from ash pond material is present to the nearby receptors given the ash pond has since been covered with a dust suppressant and revegetation is to commence in the near future. However it is noted that SA Health have expressed concern about the high overall dust level measured on 1 January 2017 at monitoring stations in Stirling North and at Lea Memorial Oval in the southern outskirts of Port Augusta Township immediately after the dust suppressant had been degraded due to a storm and heavy rain, with that they refer to as "*a high fraction of particulate matter less than 10 microns in diameter (PM10)*". It is considered unlikely chemicals from the ash pond would have leached to the subsurface and the groundwater conditions reported around the ash pond support this conclusion. Engineering solutions to avoid seepage from the ash pond are understood to have been implemented in the 1980's following seepage from the ash pond to the subsurface.

	Groundwater testing completed in the vicinity of the ash pond did not report chemicals above background concentrations. The ecological risk assessment undertaken for the small area of mangrove swamp located in the man-made inlet south of the Playford Stations has identified that sediments from site drainage water may have impacted the mangrove area with concentrations of some metals and heavy end petroleum hydrocarbons reported at levels that may present an unacceptable risk to ecological receptors within the mangrove in this small localised area. The extent of metal and petroleum hydrocarbon impact in sediments appear to be localised. The flora and fauna assessment completed determined that the mangrove area consisted of a poor habitat for marine fauna, however this area is highly disturbed from known diebacks in the 1950's and construction of the Northern Station and infrastructure including the water inlet/outlet channel in the 1980's. A number of replanting events have also occurred over time in this area. Historical aerial photography between 1963 and 2016 shows the mangroves recovered from the 1950's dieback, and stabilised following the Northern Station construction disruption. Seagrass monitoring has been undertaken in the area since the 1980's has determined no significant changes in the seagrass communities in and around the power station indicating any discharge from the mangroves to the Spencer Gulf is not having a detrimental effect on the marine ecosystem.
Recommendations	Based on the results of this investigation as described in the Sections above, the following recommendations will be considered for the next phase of contamination assessment, Phase 3 remediation.

Area/AEC	Recommendations
Area 1 – AEC 1 Playford fuel oil loss Petroleum hydrocarbon impacts to soils and shallow groundwater may potentially pose an unacceptable dermal contact and ingestion risk to current workers if the ground surface in this area is disturbed and to future users and structures, if the impacts remain following closure and if strict management protocols are not implemented	Following the demolition works, the impacts noted are to be further assessed and appropriate mitigation measures will be implemented to manage identified potential risks to human health, likely to comprise removal of gross impacted soils
Area 1 – AEC 5 Transformers and AEC 7A SPEL sump and tank Minor petroleum hydrocarbon impacts to groundwater are unlikely to pose a potential risk to current and future identified receptors unless the area is excavated and appropriate management protocols are not implemented	Future potential risk associated with excavation works can be managed through the implementation of a site management plan following completion of Phase 3 works
Area 3 – Playford buildings Limited assessment to date due to access constraints	Following demolition, soil validation beneath the building footprints
Area 6 – AEC 7B SPEL drain outlets Discharge to mangroves may be contributing to the overall health of the mangrove ecosystem, however a number of factors are considered to be affecting the highly disturbed ecosystem	Inclusion in the future management plan to continue discharge monitoring as well as monitoring of the mangrove ecosystem health
Area 7 – AEC 23A & 23B Fuel storage area Limited assessment to date due to access constraints	Validation following removal of fuel infrastructure
Area 8 – AEC 25 Maintenance shed and wash down bay Petroleum hydrocarbon impacts to soils potentially pose a risk to ecological receptors	Additional tiers of risk assessment to further evaluate potential risks or potential risk mitigation by remediation of the impacted soils
Area 11 – AEC 31B fuel transfer pipeline Limited assessment to date due to access constraints	Validation following removal of fuel infrastructure
Area 12 – AEC 35 Northern store UST Petroleum hydrocarbon impacts to groundwater unlikely to present an unacceptable risk to current and future receptors, unless the	Validation following the excavation and removal of the UST, dispensing pump, and any other fuel related infrastructure in the area and the impacted soils.

subsurface is removed and contact with the impacted soils and groundwater occurs	
Area 14 – AEC 43B Firefighting area PFOS reported in groundwater at the laboratory LOR	Soil testing to determine if gross impacts to the soils are present from firefighting activities
Area 15 – AEC 44 Fuel pad Petroleum hydrocarbon impacts to soils and groundwater that may pose a potentially unacceptable risk to current workers if the ground is disturbed and to future users and structures if the impacts remain following closure and if strict management protocols are not implemented	Further assessment and/or risk mitigation following removal of the fuel pad and associated infrastructure
Area 15 – AEC 45 Diesel ASTs Limited assessment to date due to access constraints	Validation following removal of fuel infrastructure
Area 17 – AEC 50A Ash pond Discrepancies in the results of testing conducted by FPP and Coffey in June 2016 from wells around the ash pond	Groundwater sampling to confirm the chemical concentrations
Area 17 – AEC 51E Acid clean pit dump Known material deposited in this dump comprises hydrochloric acid and stabilised cyanide (<1kg)	Further investigation of the acid clean pit

Monitoring wells within areas to be subject to excavation during Phase 3 works are likely to be destroyed through this process. It is recommended that prior to any excavation works commencing, wells likely to be destroyed are decommissioned by a licensed driller and following excavation works, replacement monitoring wells are installed to determine the success of remediation activities undertaken. Any additional delineation wells required can also be installed at this time.

Historical waste dumps were investigated with the extents defined and it is considered that potential risks associated with these areas can be managed through implementation of a site management plan.

Bulk fuel storage areas are to be removed including any bunds as part of the site closure and following removal will be required to be validated along with any building footprints, wash down bays, sumps, tanks etc. if they are removed.

This sheet is intended to provide a summary only of the assessment of the site. It does not provide a definitive environmental or engineering analysis and is for an introduction only. It should be read in conjunction with the full report. Limitations and assumptions used to reach the conclusions of the executive summary are contained within the report and have not necessarily been included in this executive summary. This report must be read in conjunction with the attached 'Important information about your Coffey environmental report" included in Section 13.

Abbreviations

ACM	Asbestos Containing Material
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
APS	Augusta Power Stations
AEC	Area of Environmental Concern
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
AST	Aboveground Storage Tank
C_6-C_{40}	Hydrocarbon chainlength fraction
bgs	Below ground surface
BTEXN	Benzene, Toluene, Ethylbenzene, Xylenes and Naphthalene
btoc	Below top of casing
COC	Chain of Custody
COPC	Chemical of potential concern
CSM	Conceptual Site Model
DEWNR	Department of Environment, Water and Natural Resources
DO	Dissolved Oxygen
DSI	Detailed Site Investigation
EC	Electrical Conductivity
eH	Oxidation/Reduction Potential
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
Eurofins	Eurofins Environment Testing Australia Pty Ltd, trading as Eurofins MGT
FPP	Flinders Power Partnership
IP	Interface Probe
LNAPL	Light Non-Aqueous Phase Liquid
LOR	Limit of Reporting
µg/L	micrograms per litre
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
MW	Monitoring Well
NATA	National Association of Testing Authorities
OCP	Organochlorine Pesticide

OPP	Organophosphorous Pesticide
PAH	Polycyclic Aromatic Hydrocarbon
PCA	Potentially Contaminating Activity
PCB	Polychlorinated Biphenyl
PID	Photoionisation Detector
ppm_v	parts per million by volume
PSI	Preliminary Site Investigation
QA	Quality Assurance
QC	Quality Control
RPD	Relative Percent Difference
SA EPA	South Australian Environment Protection Authority
SAQP	Sampling, Analysis and Quality Plan
SB	Soil Bore
SMF	Synthetic Mineral Fibre
SWL	Standing Water Level
TDS	Total Dissolved Solid
TOC	Top of Casing
TP	Test Pit
TRH	Total Recoverable Hydrocarbon
UST	Underground Storage Tank
VHC	Volatile Halogenated Compound
VOC	Volatile Organic Compound

Table of contents

In-text Tables

In-text Figures

Appendices

1. Introduction

1.1. Background

Flinders Power Partnership (FPP) required a Detailed Site Investigation (DSI) to be undertaken at the Augusta Power Stations, located between Power Station and North Power Station Road, Port Augusta, South Australia ('the site') as part of a phased approach to site contamination assessment at the site. A site location plan is provided as Figure 1.

Coffey Environments Australia Pty Ltd (Coffey) have completed a Preliminary Site Investigation (PSI) (Coffey 2016a) for the site as the first phase of the site contamination assessment which identified key areas of environmental concern (AEC) requiring further assessment. On the basis of the PSI findings, a Sampling, Analysis and Quality Plan (SAQP) (Coffey 2016b) was developed to facilitate further investigation of the identified AECs.

A Site Contamination Auditor, Mr Steven Kirsanovs of Kirsa Environmental has been appointed to the site by FPP to undertake a site contamination audit as part of the closure plan.

The DSI is also a requirement of a Voluntary Site Contamination Assessment Proposal (VSCAP), dated 9 September 2016, which the South Australia Environment Protection Authority (SA EPA) has reviewed and considered appropriate for the site (SA EPA letter to FPP ref:61672;05/23359, dated 22 September 2016).

The site ceased power generation in May 2016 and entered site closure with the demolition program commencing in June 2016. Some infrastructure such as road ways, northern infrastructure pad, cooling water inlet/outlet infrastructure, sheds, switch yards and site drainage infrastructure including ABC Lake (situated immediately south of the ash storage area) are expected to remain at the site for future use. A number of options for site reuse including the ash ponds are being considered that will benefit the local community.

The Leigh Creek Coal Mine supplied coal exclusively for FPP's Augusta Power Stations. The coal was transported by rail to Port Augusta which is approximately 250km south of the mine. The rail service was provided by Pacific National under contract. The Leigh Creek Coal Mine, Augusta Power Stations and the Leigh Creek to Port Augusta Railway facilities are known collectively as the Flinders Operations.

Ultimately, the phased assessments being undertaken at the site will assist in FPP's process to divest the site and/or hand back the lease(s) for future ongoing non-sensitive commercial/industrial land use.

The site was notified to SA EPA under Section 83A of the EP Act (1993) of site contamination to underground water on the basis of the results of this investigation on 7 February 2017.

1.2. Objective

The objective of the DSI was to assess the nature and extent of potential site contamination within the AECs, determine if a potential risk exists to the identified potential receptors from identified site contamination, and provide recommendations for further assessment or risk mitigation (Phase 3), if required to facilitate site closure.

1.3. Standards and guidance documents

The DSI was performed general accordance with the following:

- National Environment Protection Council (NEPC) (1999) *National Environment Protection (Assessment of Site Contamination) Measure* (ASC NEPM) as amended in 2013;
- Standards Australia (2005) *Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 1: Non-volatile and semi-volatile compounds*, AS 4482.1-2005;
- Standards Australia (1999) *Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 2: Volatile substances*, AS 4482.2-1999; and
- Current relevant South Australian Environment Protection Authority (SA EPA) guidelines including:
  - SA EPA (2008) Guideline Site Contamination: Determination of background concentrations;
  - SA EPA (2009) Site Contamination: Guidelines for the Assessment and Remediation of Groundwater Contamination; and
  - SA EPA (2015) Environment Protection Policy (Water Quality EPP).

2. Geoenvironmental setting

2.1. Location and history

The site is located in the south of the Port Augusta Township, to the west of the Stirling North Township. The site is accessed by both the Power Station Road in the north and Northern Power Station Road in the east.

The power station was in operation since the mid 1950's with the full extent of operations from 1985 with the Northern Station commencing production. FPP has had site ownership since 2000 with the Electricity Trust of South Australia (ETSA) formerly owning and operating the site until that time. Prior to the 1940's the site was primarily mangrove swamps associated with Northern Spencer Gulf. Two portions of the mangrove swamp habitat along the eastern edge of the Spencer Gulf were reclaimed, initially to create the power station facility associated with the Playford Stations and later to construct water channels for the Northern Station.

Site operations ceased completely with power generation ceasing at the Northern Station on 9 May 2016. The site commenced closure works at this time with demolition works commencing at the Playford Stations.

2.2. Site description and identification

Site plans showing land tenure and key features (including designated investigation areas) are included as Figures 2A and 2B respectively.

The power generation infrastructure is located in the western portion of the site, adjacent to the tip of Spencer Gulf with the Playford Stations on the western boundary adjacent to Spencer Gulf, the Northern Station in the south west. The ash ponds make up the northern portion of the site and the former coal loading area and the railway loop make up the eastern portion. The railway line from Leigh Creek enters the site from Stirling North in the north east and extends into the site and loops around the former coal loading area. To the south is vacant land formerly owned by Primary Industries and Regions SA (PIRSA) which operated as a marine research centre up to approximately four years ago.

A number of site buildings associated with the former power station operations are located in the central and southern portion of the site adjacent to the Playford and Northern Stations. These include transformers, switch yards, maintenance and workshop sheds/buildings, steel laydown/recycling areas, fuel oil storage and dispensing (former and current), waste oil storage and the water infrastructure across the site. Some of these structures have since been cleared with steel and other materials for recycling removed and other items auctioned.

Demolition works were in progress at the site at the time of the investigation fieldworks in the second half of 2016. At this time demolition works were primarily focussed in the area of the Playford Stations. Site photographs are provided in Appendix A from the DSI investigation. Detailed site photographs are provided in Coffey's (2016a) PSI report.

Site identification details are provided below in Table 2.1.

Table 2.1: Site identification

Site Location	Power Station and Northern Power Station Roads, Port Augusta
Property description and Certificate of Title	• Certificate of title CT 6134/241, Allotment 1; • Certificate of title CT 5843/692, Allotment 2; • Certificate of title CT 6134/240, Allotment 6; and • Certificate of title CT 5843/691, Allotment 8. Note a portion of the site is land not within a plan/parcel, located to the west of the ash ponds. Refer Figure 2A for site area details.
Surrounding environment	• Bird Lake is located to the north of the ash ponds; • To the north west is the Port Augusta Township, residential allotments; • To the east is pastoral land and the Princes Highway; • To the west and south is Spencer Gulf and associated mangroves. It is noted that a sea wall provides the site boundary on the west of the Playford stations.
Zoning information	The site is currently zoned as 'Industry in the Development Plan for Port Augusta (City) (DPTI, 2012). The zone's objectives are: 1. A zone primarily accommodating a wide rand of industrial, warehouse, storage and transport land uses; and 2. Development that contributes to the desired character of the zone. The land within Allotment 8, 9 and land not within a plan/parcel in the north west of the site are zoned within the Coastal Conservation Zone.

2.3. Previous environmental investigations

A number of previous environmental investigations have been undertaken at the site focused in areas of fuel infrastructure. Groundwater monitoring commenced at the site due to a fuel oil leak detected in April 1995 between the Playford A and B stations. Following the soil and groundwater investigations of the fuel oil loss area, the assessment areas were expanded from 1998 onwards to include other potential areas of groundwater contamination from petroleum hydrocarbon sources. Recovery of light non aqueous phase liquid (LNAPL) commenced in February 1998 at the wells located within the Playford fuel oil loss area ceasing sometime in 2015.

A detailed summary of the previous environmental investigations is provided within the PSI report (Coffey 2016a).

2.4. Geology

2.4.1. Regional geology

According to the Geological Survey of South Australia, Port Augusta Mapsheet (1968), the geological profile beneath the area of investigation is generally characterised by the St Kilda Formation: Sands, shelly silts and clays of the littoral lagoons and mangrove swamps.

2.4.2. Local geology

Information reviewed as part of the PSI (Coffey 2016a) details local geological profile beneath the site to comprise of sand, silty clays and sandy silts with shell grit a common component given the location of the site.

Monitoring wells installed at the site around the ash pond and the rail loop in the 1990s (Woodward-Clyde, 1994) indicated the site lithology comprises of silt/silty sand with shell grit of the St Kilda Formation underlain by clays of the Pooraka Formation.

The Playford and Northern Stations are constructed on reclaimed land incorporating imported fill and ash. Dredged spoil from construction of the cooling water channels was also utilised as fill in the vicinity of the Northern Station. The spoil from a channel cut to divert Saltia Creek to the south when the rail loop was constructed, was used to build the coal stockpile pad.

Further information on the local geology encountered during the DSI is provided in Section 5.1. Geological cross sections of the Playford Stations (Area 1), Northern Station (Area 12) and coal loading area (Area 15) are provided as Figures 3E, 14E and 17F respectively.

2.5. Hydrogeology

2.5.1. Regional hydrogeology

A registered groundwater bore search was undertaken during the PSI (Coffey 2016a) which reported numerous groundwater bores registered within the Port Augusta Township to the north of the site. These are primarily registered as observation, monitoring or investigation bores with the depth to standing water levels (SWLs) recorded as between 0.05m and 10m below the surface with the majority of the wells having SWLs recorded at less than 3m. Relatively high total dissolved solids (TDS) values are recorded for the registered bores given the proximity of the Spencer Gulf, which would limit the beneficial use of the aquifer for any use in accordance with the SA EPA (2015) Environment Protection Policy (Water Quality EPP).

A deeper underlying aquifer is expected to exist beneath the site between 8 and 10m below ground surface (bgs) within the gravelly sand lithology encountered at the base of the deeper bores installed in the vicinity of the Playford power stations (wells installed to 8mbgs).

2.5.2. Local hydrogeology

In 1994 AGC Woodward-Clyde Pty Ltd (Woodward-Clyde) undertook an assessment of the groundwater characteristics and flow patterns at the site, primarily focused around the coal loading area and rail loop which was at the time proposed as a potential area for a secondary ash pond for the Northern Station.

As part of the investigation Woodward-Clyde installed 11 monitoring wells to the south of the ash pond, around and to the south of the coal loading area/rail loop and to the east of the ash ponds. These wells still remain at site and are named APS 1 through to APS 11 (refer Figure 19E). A further 11 monitoring wells were found in the southern area of the site during the investigation, installed by others and were numbered from 12 through to 22, within current nomenclature APS 12 to APS 22. A monitoring installed by Port Augusta City Council (APS 23) at the north of the ash pond, adjacent to Hospital Creek was also utilised for the investigation.

The investigation determined that the shallow groundwater gradient flows south west towards the Spencer Gulf. A shallower gradient was present in the vicinity of the rail loop where low lying ground and salt encrustation was present and groundwater mounding was present in the vicinity of the ash pond, particularly around the southern area. It was noted that relatively high TDS values were recorded in the vicinity of the rail loop where the low lying area and salt evaporation was present.

Investigations undertaken to date at the site have identified groundwater to be encountered between 2 and 4mbgs across the site with groundwater flow west towards the Spencer Gulf. Relatively high TDS values are recorded for the groundwater system (PB, 2015).

2.6. Hydrology

2.6.1. Surface water bodies

Spencer Gulf is located adjacent to the site's western boundary.

Saltia Creek enters the site from the south east with a channel diversion present to the south of the rail loop that discharges to the Spencer Gulf.

Seawater from Spencer Gulf was used as cooling water at the station and mixed with ash from the boilers to allow the waste ash to be pampered as a slurry to the Ash Storage Area.

In order to improve the appearance of the entrance to the township of Port Augusta it is understood that in the late 1960s ETSA diverted discharge water from the power station to create Bird Lake, an artificial lake on dry clay pans to the north of the site. Bird Lake was fed through overflow from the ash ponds on-site via the final polishing pond with a levee which was constructed in 1987. Water discharges into Spencer Gulf via Hospital Creek which is a mainly natural tidally influenced creek system (see Figure 2.1 below).

There is community concern that following the closure of the site, Bird Lake is expected to become dry as water is no longer pumped into the ash ponds as part of the power generation process. Port Augusta City Council is leading the process of identifying and implementing a solution to the drying out of the lake, and working to identify a long-term solution to this issue, with support from the EPA and the state government.

2.6.2. Surface water monitoring

Surface water monitoring has been undertaken at regular intervals from a number of points across the site, particularly around the ash storage area as part of the marine monitoring program required for the site EPA license agreement(s). The results were included in annual verification reports conducted by an independent auditor, EnviroManagement Pty Ltd. A summary of these reports are provided in the PSI (Coffey, 2016a).

Coffey has been provided with water quality data collected between May 2007 and August 2015 from Hospital Creek, Bird Lake Jetty, Mid Gulf Point and at a background location called Transect 7. Water collected at each event was tested for trace elements and nutrients, results are presented in Table 24 and locations are presented below.

Figure 2.1: Surface water quality collection points (FPP)

Figure 2.2: Surface water quality collection points – Transect 7 (FPP)

The results reported over this time period have been compared against the SA EPA (1994) Environment Protection (Marine) Policy (superseded) and SA EPA (2003) Environment Protection (Water Quality) Policy criteria (superseded) as reported within the verification reports. Some trace metals have been reported above the criteria at some instances, however these were not considered to be an indication of a pattern of concentrations above the criteria for the trace elements monitored as no significant changes to the concentrations were observed (EnviroManagement, 2014).

In 2010, the South Australian Research and Development Institute (SARDI) completed an assessment of the potential impacts of Hospital Creek discharges to the Spencer Gulf from the power station activities. The process water from power generation at the site was previously discharged into the ash storage area where the most of the ash settled, and flowed through to the polishing pond before being discharged into the upper end of Hospital Creek and into the Spencer Gulf.

Four components of the ecosystem were investigated (sediment, mangroves, seagrasses and infauna) at the outflow of Hospital Creek as well as at three control mangrove creeks in the Upper Spencer Gulf. In addition the area around the inflow from the polishing pond to Hospital Creek was assessed. The results of the assessment concluded that the environment at Hospital Creek was within the range of natural variability of the region and did not appear to be affected by site activities (SARDI 2010).

2.6.3. Site drainage water infrastructure on-site

Site drainage water infrastructure is present across the site for the purpose of draining surface water, infrastructure water and recycling of the process water. It is understood that the drainage water infrastructure will remain in place following site demolition works for future use.

In Area 1 – Playford Stations, surface and formerly process water from the stations and water from the basements was drained to a tank which overflows to the adjacent sump located in the north western portion of the area (Figure 3A, AEC 7A). The water from the sump was pumped through underground pipes to the 'SPEL' drain (oil interceptor) located to the east and then to the ash pond sump located within Area 2 – Playford B switch yard (Figure 4A). Water from the ash pond sump was transferred via surface pipework to the ash pond Stage 2 pumps which pumped the water into the ash storage area (Figure 19A).

Three 'SPEL' drains are located along the southern boundary of the Playford area. These drains were utilised for the collection of surface water from the Playford infrastructure such as the buildings, switch yards, maintenance and workshop sheds, equipment laydown areas and the transformer bunds. The water drains out to the mangrove area and ultimately the Spencer Gulf (Area 6, Figure 9A). The health of the mangrove swamp in this small area was observed to be poorer than nearby mangrove areas. Anecdotal evidence of dieback occurring in the mangroves south of the Playford area suggests two dieback events occurred in the 1980s and 1990s, with replanting of the mangroves following at least one of these events. A fourth SPEL drain is also located adjacent to the south of the Playford A Station which drains directly to the Spencer Gulf.

The 'SPEL' system is believed to have been installed at the site in the year 2000. Prior to the SPEL system installation, the drainage system existed predominately in its current form. Outfalls were directed into the Spencer Gulf around the Playford Stations – this was redirected to the SPEL tank and sump following SPEL installation, and into the Spencer Gulf south of the Playford buildings and SA Power Networks (SAPN) switch yard where SPEL drain outlets have since been installed.

The Northern Station (Area 12) contains a series of spoon drains surrounding the station for surface/storm water and spill/leak management that drained to an oily water skimmer pit to the south west of the station (Figure 15A), followed by the intermediate oily water skimmer pit located to the west of the station and north of administration building (Figure 14A). The water was separated from product and pumped via sub-surface water pipework to the main 'contaminated drains pond' (Figure 13A). The product (oil) formerly was skimmed from both pits into 205L drums that when full were triggered through an internal system and stored in a designated waste oil storage area (Figure 15A) pending collection for off-site disposal.

Water from the 'contaminated drains pond' (Figure 13A) flows through an interceptor weir and is pumped to the ABC Lake to the east (Figure 17A). During site operation, when the ABC Lake reached capacity through this process, the overflow water was pumped into the ash storage area. The ABC Lake also collects seepage water from the ash storage area and surface water from the immediate vicinity.

2.6.4. Site drainage water monitoring

The water infrastructure including the 'SPEL' drains and sumps across the site, various drains, sumps, weirs and groundwater wells around the ash pond and the 'contaminated drains pond' were monitored annually for chemicals of potential concern. The results from the SPEL drain monitoring is provided in Table 8B.

Seepage from the ash pond to the surrounding environment has been assessed from the monitoring of site drainage water, reported annually within the verification reports prepared by EnviroManagement Pty Ltd. The samples collected have been tested for trace metals as well as nutrients and Coffey has been provided with the results of this testing between 2007 and 2016 as presented in Tables 25A and 25B. Locations of monitoring are provided on Figure 21.

It is noted that data from the locations in the vicinity of the SA Water Port Augusta East Waste Water Treatment Ponds in the north west area of the ash pond have reported nutrients ammonia, phosphorus and nitrogen above data collected from other locations around the ash pond. Coffey have been provided with SA Water data collected from the effluent post treatment between 2011 and 2017 which reports median concentrations of ammonia at 12mg/L, nitrogen at 35mg/L and phosphorus at 9mg/L which are in some cases an order of magnitude higher than the data collected by FPP from the locations around the waste water treatment ponds (sewer pond north, sewer pond south, Playford Drain 5 and Playford Drain 8) indicating seepage from these waste treatment ponds is not considered to be significantly impacting the surrounding environment.

2.7. Mangroves

Prior to the construction of the Northern Station, an Environmental Impact Statement was undertaken by Kinhill Stearn in 1985, with a supplementary statement provided in 1986 (Kinhill Stearn, 1985 and 1986). Within the assessment, mangrove health around the power station was discussed. Figure 2.3 shows the areas that had been surveyed and were the subject of the assessment:

Figure 2.3: Mangrove areas surveyed (Kinhill Stearn, 1985)

Prior to 1961, it is recorded that the mangroves to the north (Area A) and south (Area C) of the Playford Stations had a number of die backs. It was determined that this was caused by sulphur dioxide emissions from the Playford chimneys (six short 40m high chimneys), these chimneys were replaced in 1961 by one 80m chimney (Kinhill Stearn, 1985). Aerial photographs reviewed between 1972 and 1984 showed a recovery and stabilisation of the mangrove community in these areas (Kinhill Stearn, 1986).

Further dieback to the mangroves north of the Playford (Area A) was observed in 1985 and it was determined that this was due to a 'slug' of highly saline groundwater migrating through these mangroves from the ash pond. It was recommended to direct water flows into the eastern side of the ash pond during summer to avoid future die back from saline water as well as installing a drain system along the Playford Station access road on the western side of the ash pond (Kinhill Stearn, 1986). It is understood both of these measures were implemented at the site.

It was also noted that through the construction of the Northern Station including the cooling water channels, some areas of the mangroves, particularly Transect 4 and 5 and the southern area of Area C as shown in Figure 2.3 above were markedly changed by mechanical disruption (Kinhill Stearn, 1986) and as such, the mangrove community within this area has been highly modified.

2.8. Seagrass monitoring

Seagrass monitoring has been undertaken regularly for the site as part of the Environmental Improvement Program (Schedule 1, Environmental Compliance Agreement) for the site (EnviroManagement, 2014). The seagrass monitoring was undertaken by assessment from biennial aerial photographs of the area (map land) and observations based on historical data, results of which were presented in the annual verification reports by EnviroManagement Pty Ltd. Monitoring of the seagrass since 2002 has been observed to not report significant changes in the seagrass communities in and around the power station (Alinta Energy, 2015).

An assessment of the growth of seagrass in the vicinity of the power station discharge to the Spencer Gulf was undertaken in 1994 (Ainslie, et al, 1994.) This assessment included monitoring three areas of seagrass between 1986 and 1990, one in the vicinity of the discharge point, one at a Gulf ambient site and one at a site in Port Paterson (approximately 3km south east of the site). The assessment concluded that relatively minor growth reductions were present in the seagrass in the vicinity of the discharge point when compared to the Gulf ambient seagrass, despite the higher summer water temperatures.

However, the seagrass in the vicinity of Port Paterson, where naturally warm waters are present, was observed to have significant growth reduction in relation to the ambient Gulf seagrass. It was noted that the higher water temperatures observed at Port Paterson were the upper limits of what the seagrass are comfortable with and as such, any future localised increases in water temperature around the power station discharge point may cause seagrass growth reductions.

The seagrass assessed as part of the SARDI assessment (SARDI, 2010) indicated that the seagrass observed within the control sites and within the area of discharge did not have any significant differences. It was also observed that there had been no significant decline in seagrass health since the assessment conducted in 1994 (Ainslie, et al, 1994).

2.9. Waste dumps

Information obtained in the PSI (Coffey 2016a) from site interviews conducted identified seven waste dumps were known to exist across the site area from historical practices (pre 2000). The staff interviewed to obtain this information as presented in the PSI are:

Table 2.2: Staff interviewed during PSI

Staff name	Role	Approximate years of experience at APS
Kym Maule	Facility Manager, APS	15
Terry Manning	Environmental Coordinator	39
Brendan Lynch	Superintendent Site Services Augusta	45
John Atkinson	Specialist Contract Services	44
Bruce French	Manager Production Augusta	41
Robert Ash	Superintendent Lubrication Augusta	43

The approximate locations of the waste dumps are indicated on the site figures and are summarised as follows:

- Within the steel laydown area (Figure 16A), there is a former waste dump for chlorine plant residue and waste treatment plant residue. Anecdotal evidence suggests this dump was removed/excavated in 2000 (AEC 51C);

- A chlorine plant residue waste dump is located adjacent to the rail line loop and the ABC Lake (AEC 51D, Figure 17B);
- A synthetic mineral fibre (SMF) (AEC 51A) and a general waste dump (AEC 51B) are located adjacent to each other to the south of the train unloading area (Figure 18B). It was noted that this area was regularly checked for any material on the surface by FPP staff;
- An acid clean pit is located within the southern portion of the ash pond (AEC 51E, Figure 19C). The BRW Land Contamination Issues report (2000) noted that the acid clean pit contained small quantities of stabilised sodium cyanide. The Contaminated Lands Identification, Management and Liability report by FPP in 2000 further confirmed material disposed of in the acid clean pit as low level hydrofluoric acid from acid cleaning of the Northern Station boilers in the mid-1980s as well as minor quantities (up to 1kg) of stabilised sodium cyanide; and
- To the north west of the former coal loading area, two general waste dumps (AEC 51F) were located adjacent to each other (Figure 19B).

It is also noted that general construction type waste (i.e. concrete and scrap metal) was dumped along South Coast Road on the southern site boundary, outside of FPPs' lease boundary (Figure 6A). It is understood that the construction waste located in this area is from upgrades to the SAPN switch yard undertaken by SAPN.

2.10. Ash storage area (Ash Pond)

In January 2016 Golder Associates Pty Ltd (Golder) collected three samples of ash from the ash storage area for geotechnical and chemical testing to provide a 'Product Data Sheet' for the ash (Golder, 2016). The results of the chemical testing reported dry weight concentrations of barium and manganese exceeding the SA EPA waste fill criteria (SA EPA, 2013).

To provide further data to complement the Golder data, during the course of the DSI fieldworks, an assessment of chemicals concentrations within ash samples from the ash storage area was undertaken by Coffey and reported separately (Coffey, 2016c). The objective was to determine reuse options for the ash material including potential use as backfill material at the site following demolition of surface infrastructure. Coffey collected 15 samples of ash material from four locations across the ash pond as directed by FPP (for safety) with samples submitted for a range of chemical testing.

The chemical results indicated the ash sampled had chemical concentrations typical for bottom ash and in line with Golder investigation indicating the material within the ash pond is likely to be consistent. Barium and manganese were reported above the SA EPA waste fill criteria (SA EPA, 2013) but below the relevant health guidance.

The assessment concluded that the ash material within the storage area may be suitable for reuse in a commercial/industrial land use setting, would be unlikely to degrade concrete foundation piles and may be suitable for reuse as a recycled material for transport infrastructure.

It is noted that the coal from Leigh Creek has been tested as part of the "A Survey of Naturally Occurring Radioactive Material Associated with Mining" (Australian Radiation Protection and Nuclear Safety Agency, 2013). Previous elemental and radiological analysis of Leigh Creek coal and ash from APS indicate levels of natural radiation that are extremely low and analogous with the background natural environment. The Resources and Energy Branch of the SA EPA has directed FPP to assess if naturally occurring radioactive materials (NORMs) present in coal and ash continue to be present on site during closure and demolition.

As documented in the FPP Environmental Closure and Post Closure Plan for APS (October 2016), during the closure process:

- FPP will assemble available test data which will form the basis of an environmental and safety risk assessment;

- A NORM screening assessment will be undertaken by competent FPP personnel, utilising a radiation survey meter to the satisfaction of the SA EPA Resources and Energy Branch, particularly focussing on the ash storage area, along with heat exchangers and locations within the boiler structures of the Northern Station and Playford Stations where NORMs may be present; and
- FPP will assess test data against screening limits provided by the SA EPA Resources and Energy Branch, appropriate actions resulting from exceedances of screening limits will be taken in consultation with SA EPA.

Following cessation of power generation operations and the pumping of cooling water/ash slurry into the ash storage area in May 2016, and after the storage area had dried sufficiently FPP instigated the aerial application of an acrylic polymer dust suppressant in November 2016 as an interim measure prior to capping of the ash storage area.

In late December 2016, approximately 60mm of rain flooded parts of Port Augusta. The rainfall created pooling and ponding on the ash storage area surface and caused degradation of the dust suppressant layer. Immediately after this occurred, strong southerly winds caused dust from the ash storage area to migrate towards the Port Augusta Township.

SA Health completed a risk assessment of airborne dust from the ash pond in early January 2017. The results of the dust samples tested reported concentrations of metallic fractions in the nanogram and microgram level. The levels for many metals were consistent with normal background levels elsewhere. Other metal concentrations are consistent with levels found near coal/oil/industrial combustion sites worldwide (SA Health 2017a). SA Health have confirmed that the ash analysis has shown it “to be very similar to dusts from the desert” (SA Health, 2017b). SA Health have expressed concern about the high overall dust level measured on 1 January 2017 at monitoring stations in Stirling North and at Lea Memorial Oval in the southern outskirts of Port Augusta Township, with that they refer to as “*a high fraction of particulate matter less than 10 microns in diameter (PM10)*” (SA Health 2017a).

SA EPA received information from a member of the local community that the ash storage area may contain asbestos. The EPA acted immediately to analyse existing dust samples for asbestos. The results confirmed that no asbestos fibres were present. To further confirm these results, six samples were sent to an independent specialist NATA accredited laboratory for asbestos analysis and results confirmed that asbestos was not detected in the samples (Bureau Veritas, 2017). Five out of six samples were collected on 1 January 2017 in residential areas and the other sample was collected immediately adjacent to the ash storage area over a two and a half week period in October 2016 (SA EPA, 2017).

A survey plan of the ash storage area completed by Greenhill Engineers Pty Ltd on behalf of FPP in 2016 indicates the maximum depth of ash to be approximately 8m from the surface in the southern portion (where the ash material was discharged) to 4-5m below the surface in the north (adjacent to the polishing pond). This survey plan is provided in Appendix C.

To rehabilitate the ash storage area, FPP proposes to cover the area with soil and vegetate with plant species suited to local conditions.

2.11. Coal remaining at the site

Unburnt coal that is remaining at the site comprises of coal rejects that could not be burned in the power generation process, unburnt coal removed from the coal conveyor including the bins and bunkers over time as well as the coal cleaned out of the coal conveyor bins during the site demolition works. The unburnt coal is deposited in the area as shown in Figure2.4 below, east of the fuel pad and rail loop (Area 15) with an approximate volume, as of December 2016, estimated to be 5,200m^3 (1.2m deep). There is approximately 200m^3 of coal remaining within the coal conveyor bins to be added to this area. This area is noted to be included within the future management plan for the site and is currently intended to be revegetated.

Figure 2.4: Unburnt coal remaining (FPP)

In addition, some coal that could not be removed from the coal loading area surface during the clearance of this area was ripped and mixed into the subsurface of the stockpile pad fill. It is noted that this area has since been revegetated.

2.12. Background concentrations

2.12.1. Overview

As part of the process to establish if site contamination exists within the area of investigation and the nature of any site contamination, a process to establish background concentrations of chemical substances in soil and groundwater has been undertaken in accordance with SA EPA Guideline Site Contamination: Determination of background concentrations (EPA 838/08, 2008). SA EPA defines the conditions that contribute to the background concentration as:

- **Natural:** This is the amount of naturally occurring chemical substances derived/originating from natural processes in the environment as close as possible to natural conditions, exclusive of specific anthropogenic activities or sources; and
- **Ambient:** The concentration of chemical substances in the environment that are representative of the area surrounding the site not attributable to a single identifiable source. These are typically from historic activities, widespread diffuse impacts, e.g. fallout from motor vehicles.

2.12.2. Soil

Much of the site comprises reclaimed land and is therefore in effect a man-made structure. Given the site area is primarily reclaimed land, limited soil data related to natural soils is available to establish background soil conditions. Based on the data collected from natural soils across the site within Areas 1, 8, 11, 12, 15 and 16, background soil conditions are considered to be less than the laboratory limits of reporting (LOR) for petroleum hydrocarbons (benzene, toluene, ethylbenzene, and xylenes and naphthalene (BTEXN compounds and total recoverable hydrocarbons (TRH)), volatile halogenated compounds (VHCs), polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).

As limited data is available for background concentrations of metals across the site, the following typical range of metals concentrations in soils in South Australia have been adopted as background concentrations of metals, along with the available data from one soil sample collected from natural soils within Area 14 (the steel laydown area) that was analysed for metals.

Table 2.3: Background concentrations – metals in soils

Metal	Typical range* (mg/kg)	Concentration reported at Area 14 (mg/kg)
Antimony	**	<10
Arsenic	0.2-16	3.1
Beryllium	**	<2
Boron	**	75
Cadmium	0.1-4.7	<0.4
Chromium	2-31	17
Cobalt	**	5.3
Copper	4-128	32
Iron	**	-
Lead	16-185	15
Manganese	**	96
Mercury	0.01-2.3	<0.1
Molybdenum	**	<10
Nickel	3-41	10
Selenium	**	<2
Silver	**	<5
Tin	**	<10
Vanadium	**	41
Zinc	12-420	10

* based on data available from Australian literature as published in "An Investigation of Inorganic Background Soil Constituents with a Focus on Arsenic Species" (Diomides, C.J. 2005)
** data not available

Further discussion of ambient concentrations of chemicals of potential concern for each area investigated at the site is presented in Section 6.2.2.

2.12.3. Sediment

In the discharge assessment conducted by SARDI in 2010, sediment samples were collected from three control sites as well as at the Hospital Creek discharge point. These samples were tested for heavy metals as well as other property characteristics and the data collected from the three control sites is considered likely to be representative of background concentrations for the mangrove sediments in the area. The areas sediments were collected from are indicated on the plan below:

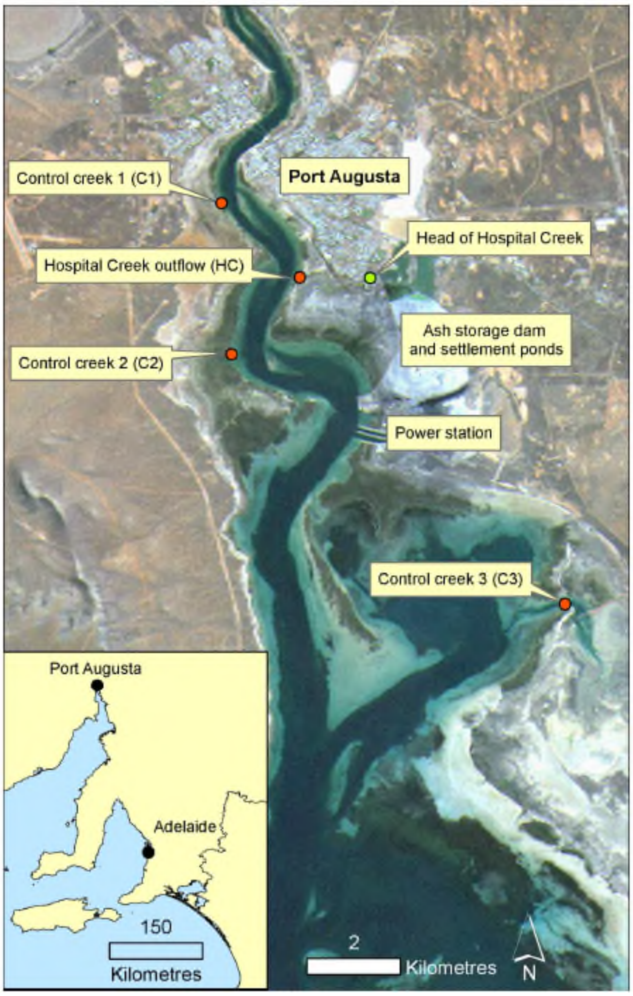


Figure 2.5: Mangrove sediment background locations (SARDI 2010)

As part of the assessment of the three SPEL drains discharging on the mangrove ecosystem located to the south of the Playford areas (Area 6, formerly Area C as referenced in Kinhill Stearn, 1985), Coffey collected two background sediment sample locations (BGSS1 and BGSS2) from the mangrove area located to the north east of the Playford B Station (refer Figure 8C, formerly Area A as referenced in Kinhill Stearn, 1985). There appears to be limited runoff from the site to this area of mangroves and historical anecdotal information available from FPP indicates there have been no known diebacks in this mangrove area since the mid 1980's (refer to Section 2.10 above). Following the initial sampling conducted at Area 6 (refer Section 4.2), further sampling was conducted to collect more data and in addition, two additional background locations were collected from within Area 6 mangrove area, as far from influence as possible (BS1 and BS2, refer Figure 4B).

The data from the SARDI (2010) assessment as well as the sediment data collected from background locations within this DSI assessment are provided below.

Table 2.4: Background concentrations – mangrove sediments

Analyte	SARDI (2010) background locations concentration range (mg/kg)	Coffey DSI background locations concentration range (mg/kg)
TRH C_6-C_{40}	-	<100
BTEXN	-	<LOR
PAHs	-	<LOR
PCBs	-	<LOR
Arsenic	3-13	<2-13
Barium	-	960
Beryllium	-	<2-3.4
Boron	-	160-220
Cadmium	<0.2	<0.4-0.5
Chromium	5-19	5.8-26
Cobalt	-	7.7-17
Copper	4-13	5.2-43
Lead	6-31	<5-32
Manganese	-	185-500
Mercury	<0.05-0.07	<0.1
Nickel	2-9	<5-26
Vanadium	-	58
Zinc	11-45	16-300

<LOR = less than laboratory LOR
- = not tested

2.12.4. Groundwater

There are a number of groundwater wells installed at the site for licensing requirements outside of the main infrastructure areas that are considered to be background locations as site activities would have limited influence on the groundwater system in these areas (refer Figure 19D and 19E). The historical data from compliance monitoring between June 2008 and June 2016 is presented in Table 22B and a median concentration value is presented on Figure 19E.

APS wells APS 9 and APS 10 are considered to provide information on background chemical concentrations as they are located far from areas of potentially contamination activities. However on review of logs within the Woodward-Clyde (1994) report, the response zones for these two wells appear to be installed within a different lithology to the majority of wells within the site (Pooraka Formation with no occurrence of St Kilda Formation) and as such, groundwater chemical data from these locations are not considered to be representative of background concentrations for the shallow groundwater body beneath most of the site.

APS wells APS 7, APS 30, APS 32, APS 33 and APS 34 are located to the east of the ash pond, and are assumed to be installed within the same lithology as the wells across the majority of the site based on the log for well APS 7 (Woodward-Clyde 1994) and the total depth of wells gauged during the current event. Given the location of the wells, the groundwater flow and gradient (see Section 5.2), it is considered that the ash pond would have limited effect on the groundwater within these wells and as such, it is considered that samples from these wells provide background information with regard to shallow groundwater beneath much of the site.

It is noted there are no logs available for wells APS 30, APS 32, APS 33 and APS 34, it is understood that these were installed by push tube method by on-site staff.

It is noted that there are a number of APS wells installed to the south of the ash pond, around the rail loop and further to the south. Based on the log available for APS 11 only (Woodward-Clyde 1994), it is considered that the sample data from wells located to the south of the rail loop (APS 11, APS 12, APS 15 to APS 18) area are also likely to be representative of background information for the groundwater system at the site.

Coffey sampled 12 of the APS wells located around the ash pond as part of the current investigation including wells APS 7, APS 30, APS 32, APS 33 and APS 34, the results of which are presented in Table 19B. The current data collected from these wells as well as the median concertation value from FPP data for background locations as noted above is presented below.

It is noted that on comparison of data collected from APS wells in June 2016 by FPP staff versus data collected from the same APS wells by Coffey staff in June 2016, discrepancies between metal concentrations tested are present. This may be due to different sampling techniques such as filtration of groundwater samples prior to submission to the analytical laboratory or different extraction process at different analytical laboratories. It is recommended that a further round of groundwater sampling of the identified background well locations (at least) is undertaken to confirm the chemical concentrations.

It is noted that wells located to the south, APS 12, APS 15 to APS 18 appear to have lower metal concentrations than the wells located to the east of the ash pond, this may be due to the low lying ground in this area of the site creating surface water infiltration. The median concentrations are overall similar to those observed to the east of the ash pond and as such this is not considered to have an effect on the background concentrations discussion.

It is also noted that samples from well APS 11 located adjacent to Saltia Creek diversion in the south appear to have generally higher metal concentrations than samples from other wells at the site, this may be due to higher volume of surface water in this area due to the diversion, however the median concentrations are overall similar to those observed in this area of the site. A review of activities undertaken in the area of well APS 11 revealed that in 2015 SunDrop constructed an access road and water pipeline near APS 11, based on the data collected this does not appear to have influenced the groundwater conditions in this area of the site.

Table 2.5: Background concentrations – groundwater

Analyte	Coffey DSI testing - APS 7, APS 30, APS 32, APS 33 & APS 34 concentration range (mg/L)	FPP historic groundwater testing concentration range, 2008 to 2016 (mg/L)
TRH C_6-C_{40}	<100	-
Antimony	<0.005 to <0.025	<0.0005 to 0.008
Arsenic	<0.005 to 0.007	<0.003 to 0.386
Barium	-	0.02 to 1.08
Beryllium	<0.001 to <0.01	-
Boron	<0.25 to 19	3.1 to 18.6
Cadmium	<0.0002 to <0.002	<0.001 to 0.005
Chromium	<0.001 to <0.01	<0.001 to 0.158
Cobalt	<0.005 to 0.022	<0.001 to 0.082
Copper	<0.001 to <0.005	<0.010 to 0.441
Iron	-	0.09 to 169
Lead	<0.001 to <0.01	<.0.01 to 0.174
Manganese	0.12 to 3.7	<0.001 to 6
Mercury	<0.0001 to 0.001	-
Molybdenum	<0.025 to 0.052	0.008 to 0.221
Nickel	<0.005 to 0.01	<0.001 to 0.119
Selenium	<0.005 to 29	<0.001 to 0.117
Silver	<0.005 to <0.025	<0.0003 to 0.0049
Thallium	-	<0.0001 to 0.002
Tin	<0.005 to <0.025	-
Titanium	-	<0.003 to 3
Vanadium	<0.02 to 0.005	<0.001 to 0.628
Zinc	0.006 to 0.053	<0.003 to 0.296
Ammonia	0.07 to 6.1	-
Nitrate	<0.02 to 0.05	-
Phosphate	0.14 to 0.97	-
Sulphate	-	3,510 to 9,960
TDS	76,000 to 190,000	57,000 to 230,000

<LOR = less than laboratory LOR
- = not tested

3. Preliminary conceptual site model

3.1. Elements of a conceptual site model

A preliminary conceptual site model (CSM) was formulated during the PSI (Coffey 2016a) utilising available information to determine the presence of plausible exposure pathways and hence the presence of significant risk to susceptible receptors such as humans, ecosystems or the built environment. For a significant or identifiable risk to exist an exposure pathway must be present which requires each of the following to be identified:

- The presence of substances that may cause harm (SOURCE);
- The presence of a receptor which may be harmed at an exposure point (RECEPTOR); and
- The existence of means of exposing a receptor to the source (EXPOSURE ROUTE).

In the absence of a plausible exposure pathway there is no risk. Therefore, the presence of measurable concentrations of chemical substances resulting from previous site activities does not automatically imply that the impacts will cause harm. In order for this to be the case a plausible exposure pathway must be present allowing a source to adversely affect a receptor. The nature and importance of both receptors and exposure routes, which are relevant to any particular site, will vary according to its characteristics, intended end-use and its environmental setting.

3.2. Identified or potential sources of site contamination

During the development of the PSI (Coffey 2016a), 51 AECs within the following areas at the site (shown on Figure 2B) were identified:

- Area 1 – Playford A and B Stations;
- Area 2 – Playford B Switch Yard;
- Area 3 – Playford Buildings;
- Area 4 – SAPN Switch Yard;
- Area 5 – Steel laydown area;
- Area 6 – SPEL drain outlets;
- Area 7 – Fuel oil storage area;
- Area 8 – Storage and maintenance area (AEC 24 to 27);
- Area 9 – Recycling area;
- Area 10 – Former coal loading area;
- Area 11 – Waste water, fuel storage and wash down area (AECs 30 to 32);
- Area 12 – Northern station;
- Area 13 – Northern station infrastructure;
- Area 14 – Steel laydown area;
- Area 15 – Coal loading area;
- Area 16 – Train unloading area and waste dumps;
- Area 17 – Ash pond (ash storage area); and
- Area 18 – Rail filling area.

Chemicals of potential concern (COPCs) associated with the potentially contaminating activities undertaken at the site have been identified as including:

- Petroleum hydrocarbons, including benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN compounds) and volatile and semi-volatile aliphatic and aromatic compounds ranging up to carbon fraction C_{40} (most commonly evaluated by determination of 'total recoverable hydrocarbon' (TRH) concentrations);
- Volatile halogenated compounds (VHCs);
- Polycyclic aromatic hydrocarbons (PAHs);
- Polychlorinated biphenyls (PCBs);
- Perfluorinated chemicals (PFCs);
- Asbestos containing materials (ACMs);
- Heavy metals and metalloids; and
- Nutrients.

3.3. Potential transport mechanisms and exposure routes

The main transport mechanisms and exposure routes that could be feasible for the future use(s) of the site are:

- Via dermal contact by on-site workers and subsurface utility and demolition/excavation workers;
- Surface water infiltration leading to downward leaching of contaminants within shallow soils and in collection ponds/sumps;
- Inhalation of asbestos during asbestos removal;
- Airborne migration of coal, ash, impacted dust and/or soil particles leading to inhalation. Although it is noted that potential dust migration from the ash storage area is currently managed by a dust suppressant layer and will be managed by construction of a permanent vegetated cover layer in the future;
- Groundwater and surface water infiltration via backfilled areas and waste dumps;
- Via leaching of surface water in the ash ponds to groundwater; and
- Migration of groundwater.

3.4. Groundwater beneficial use assessment

A groundwater beneficial use assessment (BUA) was undertaken within the PSI (Coffey 2016a) which identified the groundwater system beneath the site is required to be protected given the locality of the site to Spencer Gulf and the possibility of aquaculture use in the site vicinity.

3.5. Potential receptors

The following key site specific receptors are feasible:

- Current and future workers of the site (limited);
- Current and future users of the site including decommissioning workers;
- Residential occupants and commercial workers of Port Augusta Township to the north/north west;
- Mangroves and marine ecosystems within Spencer Gulf; and
- Users of Spencer Gulf.

3.6. Plausible exposure pathways

On the basis of the available information gathered as part of the PSI, the preliminary CSM in terms of site conditions known prior to any intrusive assessment, other than what has been documented in background reports associated with the fuel oil leaks between the Playford buildings and other known hydrocarbon source areas on-site, is provided in the following table:

Table 3.1: Plausible potentially complete exposure pathways

Hazard/source of contamination	Key areas affected	Potential transport mechanisms and exposure routes	Key potential receptors
Hydrocarbon impacted soils and groundwater	• Playford stations • Northern station • In the vicinity of the unleaded underground storage tank (UST) at the Northern station store • Bulk fuel oil storage areas • Fuel oil pumping station and along the transfer pipeline • Diesel above ground storage tanks (ASTs) adjacent to the coal loading area • Fuel pad within the coal loading area • Former UST locations – within Playford buildings and adjacent to the water tanks • Steel laydown areas and recycling area • Waste oil storage area to the south of the Northern station • Within and surrounding the maintenance and workshop sheds across the site • To the south of the Northern station in and around the diesel generator shed and AST • Waste water collection and treatment system (i.e. ponds, interceptors and drains) across the site • Former coal loading areas • Train unloading and refuelling areas • Wash down bays associated with workshop areas, fuel oil storage area, fuel oil pumping station and train unloading wash down area • In vicinity of the waste dumps • Potentially all areas of the site adjacent to roadways	• Dermal contact & ingestion • Surface water infiltration • Volatilisation leading to inhalation • Inhalation of dust • Lateral and vertical migration through permeable strata and groundwater	• Current and future workers at the site • Current and future users of the site • Mangrove ecosystems • Marine ecosystems within Spencer Gulf • Users of Spencer Gulf
PCB impacted soils and groundwater	• Switch yards • Current and historical areas of transformer storage in the vicinity of the stations • Waste water system across the site • Historic storage of PCBs within the shed adjacent to Northern station	• Dermal contact & ingestion • Surface water infiltration • Lateral and vertical migration through permeable strata and groundwater	• Current and future workers at the site • Current and future users of the site • Mangrove ecosystems • Marine ecosystems within Spencer Gulf • Users of Spencer Gulf

Hazard/source of contamination	Key areas affected	Potential transport mechanisms and exposure routes	Key potential receptors
Metals impacted soils and groundwater	• Waste water system across the site • Within and surrounding the maintenance and workshop sheds across the site • In the vicinity of the grit blasting shed • In the vicinity of the waste dumps • Steel laydown areas and recycling area • Waste oil storage area to the south of the Northern station • Along the length of the coal conveyor • Surrounding the ash pond • Area of firefighting training	• Dermal contact & ingestion • Inhalation of dust • Surface water infiltration • Lateral and vertical migration through permeable strata and groundwater	• Current and future workers at the site • Current and future users of the site • Mangrove ecosystems • Marine ecosystems within Spencer Gulf • Users of Spencer Gulf
PFC impacted soils and potentially groundwater	• Area of firefighting training – it is noted that this area of firefighting training has since been confirmed as fire extinguisher training with fires set within a drum and extinguished. Little firefighting foam from the fire extinguishers would have connected with the ground surface	• Dermal contact & ingestion • Surface water infiltration • Lateral and vertical migration through permeable strata and groundwater	• Current and future workers at the site • Current and future users of the site • Mangrove ecosystems • Marine ecosystems within Spencer Gulf • Users of Spencer Gulf
Asbestos impacted soils	• Known asbestos waste dump • In the vicinity of the grit blasting shed	• Inhalation of fibres	• Current and future workers at the site • Current and future users of the site
Solvents	• Within and surrounding the maintenance and workshop sheds across the site • In the vicinity of the grit blasting and spray painting area • In the vicinity of the waste dumps • Waste oil and lubricant/chemical storage area to the south of Northern station	• Dermal contact & ingestion • Surface water infiltration • Volatilisation leading to inhalation • Lateral and vertical migration through permeable strata and groundwater	• Current and future workers at the site • Current and future users of the site • Marine ecosystems within Spencer Gulf • Users of Spencer Gulf
Material within the ash pond	• Surrounding the ash pond	• Airborne migration leading to inhalation of fine particulates should the dust suppressant suffer degradation or future proposed management measures not be fully implemented	• Current and future on-site workers • Residential occupants and commercial workers within Port Augusta Township to the north/north west

4. Fieldwork and laboratory testing

4.1. Fieldwork methodologies

4.1.1. Field staff

The fieldworks program undertaken at the site in general accordance with the SAQP (Coffey 2016b), was completed between 23 May and 19 July 2016 and 7 and 9 November 2016.

Coffey's field staff utilised for the fieldworks program are well experienced for the tasks undertaken and their details are as follows:

Table 4.1: Field staff

	Geoff Harris	Andrew James
Tasks completed	Supervision and direction of: • Underground service location; • Soil bore drilling; • Monitoring well installations and development; and • Test pit excavation. Soil sampling from soil bores and test pits and sediment sampling. Groundwater gauging and sampling.	Supervision and direction of: • Underground service location; and • Test pit excavation. Soil sampling from test pits and sediment sampling. Groundwater gauging and sampling, aquifer hydraulic tests.
Number of years' experience	Over 10 years' experience with Coffey.	Five years' experience with Coffey.
Competency training	• Coffey's Health, Safety, Security and Environment induction training and yearly refresher; • First aid; • Driver training; • Fire extinguisher training; • Work Place Clearance Group; • FPP on-line and on-site safety induction.	

4.1.2. Underground services location

Prior to the DSI fieldworks commencing, Dial Before You Dig (DBYD) plans along with the service plans provided by FPP were reviewed. Professional underground service location was completed across the areas to be investigated between 23 and 27 May 2016.

In addition, FPP ground disturbance permits were acquired for all works, issued on-site.

4.1.3. Soil/sediment assessment methodology

The following methodology was undertaken across the site during the soil assessment fieldworks:

- All test pits were excavated across the site through use of a backhoe with excavated material utilised to backfill each individual test pit;
- Soil samples from test pits were collected either from the test pit walls or directly from the excavator bucket (from soils that had not come into contact with the bucket);
- The soil bore and monitoring well locations were completed using a hand auger to a depth of 1.0mbgs. Some locations could only be hand augered to 0.5mbgs due to encountering refusal or compacted materials;
- Following hand auger clearance, soil bores and monitoring wells were mechanically drilled using push tube and hollow auger split spoon drilling methods to the target depths;
- Excess drilling spoil from the soil bores was used to backfill each individual soil bore with drilling spoil from the monitoring well drilling placed at a designated area on-site;
- Soil samples collected from sediment areas and bund walls were collected utilising a stainless steel trowel or hand auger;
- Soil samples were typically collected at each investigation location from the surface (0-0.2m), sub surface (0.5m) and at one metre intervals and where changes in lithology were observed and visual/olfactory observations indicate the presence of impacts for submission of selected laboratory analysis;
- Soil returns were logged in accordance with the Unified Soil Classification System (USCS) and field screened for the presence of volatile organic compounds (VOCs) using a photoionisation detector (PID) that was calibrated daily;
- All equipment used to collect soil samples (i.e. augers, hand trowels) was decontaminated between sample locations by removing soil, washing with a solution of Decon 90 (or similar), rinsing with potable water and then with distilled water;
- Soil samples were collected in new laboratory supplied containers and placed in a cooler with ice for transport under chain of custody procedures to the analytical laboratories; and
- Quality assurance/quality control samples were collected and analysed in accordance with the ASC NEPM and Coffey's SAQP (2016b).

4.1.4. Groundwater assessment methodology

The following methodology was undertaken across the site during the groundwater assessment fieldworks:

- Following drilling to the target depths as described above, the monitoring wells were completed in accordance with the SAQP (Coffey 2016b) with slotted 50mm PVC screen installed generally 2m below the depth of water cut and 1m above with slotted PVC casing to surface. The well annulus was backfilled with graded sand and bentonite, with wells finished with flush mounted gatic covers or stand pipes where required;
- Monitoring wells targeting the secondary aquifer were drilled and installed through double completion method. Drilling was undertaken to the primary aquifer using a 9 inch solid auger, installing a pre-collar 150-200mm PVC casing and grouting the annulus to surface to ensure no cross contamination of the aquifers occurs and following a week of stabilisation, drilling to the secondary aquifer for well completion;
- Following installation, the new wells were developed by removing water and purging the standing water column using a stainless steel bailer until a minimum of three well volumes were removed, and the produced water shows significant reduction in suspended sediment;

- A registered surveyor was engaged to survey the location of the new groundwater monitoring well (MGA coordinates), and the elevation of each well (to Australian Height Datum) and in addition, a number of existing monitoring wells were also surveyed;
- Following at least a seven days after installation to allow for stabilisation, the groundwater monitoring event (GME) was conducted at all new and existing monitoring wells;
- All groundwater monitoring wells were gauged for depth to water, total depth and depth to LNAPL (if present) from a clearly marked and designated point at the top each well casing using an interface probe (IP). The IP was decontaminated using a solution of Decon 90 (or similar), followed by rinsing in potable water between locations;
- Monitoring wells not containing LNAPL were purged using a new dedicated disposable bailer for each location until groundwater quality parameters stabilised and sampled thereafter;
- Groundwater field quality parameters were collected during the purging of the monitoring wells where hydrocarbon sheen was not encountered;
- All purged water was disposed of in an on-site container;
- Groundwater samples were collected in new laboratory supplied containers and placed in a cooler for transport under chain of custody procedures to the analytical laboratories;
- Quality assurance/quality control samples were collected and analysed in accordance with the ASC NEPM (2013) and Coffey's SAQP (2016b); and
- The monitoring well installed and sampled within Area 14 for the assessment of PFCs was undertaken in accordance with the WA DER (2017) Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS):
  - Field clothing worn was clothing that had been worn and washed at least six times and no water resistant clothing was worn during the installation and sampling;
  - Drilling fluid containing PFAS was not utilised;
  - No waterproof notebooks or sample labels were used;
  - Reusable field equipment (IP and water quality probe) were decontaminated with water only prior to use;
  - The new dedicated disposable bailer utilised for groundwater development, purging and sampling did not contain any Teflon material;
  - Purged groundwater was emptied to the site surface in the vicinity of the well;
  - All disposable material used for the sampling was bagged separately and disposed of in an on-site container; and
  - The sample was collected into a new laboratory supplied container specifically for PFC analysis and placed in a cooler with free ice double bagged in plastic (polyethylene) bags.

Aquifer hydraulic tests

During the GME, aquifer hydraulic tests were conducted at three wells within Area 1 – Playford Stations at two wells within AEC 1 – Playford fuel oil loss (GW1 and GW3) and one well located down gradient on the sea wall (GW8) to confirm the hydraulic conditions of the aquifer. The following was conducted on 14 June 2016:

- Prior to conducting slug tests, the pre-test water-levels were measured and noted;
- Each data logger was placed in the well below the pre-test water level at a sufficient depth to permit testing (removing a "slug" of water);
- The data logger recorded water depth above before, during, and after the "slug" of water was removed;

- The "slug" was removed by a bailer at each well location by lowering the water level and a series of water level versus time measurements were made as the water level changed toward an equilibrium situation;
- The measurements were collected automatically by the data-logger, at pre-programmed time intervals of one second; and
- At equilibrium, the data loggers were removed and the water level recorded.

The data logger interpretation is provided in Section 5.2.2.

4.2. Intrusive investigations

Table 4.1 details the intrusive investigation scope of works completed for each area during the fieldworks program. Deviations from the scope set out in the SAQP occurred due to site conditions, these are noted in Table 4.1.

Some well repairs were completed at existing wells to replace gatics/standpipes as required and where this occurred, the existing wells were resurveyed.

Note, no assessment works were required at the following AECs:

- AEC 6 – Cooling water inlet (Area 1) given the activities associated with the cooling water inlet did not comprise of any chemical introduction as the cooling water inlet does not include any treatment of the sea water;
- AEC 20 – SAPN switch yard (Area 4) was not required to be investigated as part of the DSI given the use of the area and ownership;
- AEC 22 – General waste dump (Area 6) as this area is outside of FPPs lease boundary and known to be of origin from SAPN activities;
- AEC 38 – Chlorine treatment plant (Area 13) given the use of this AEC did not introduce chemicals into the environment, it is unlikely any impacts to the surrounding environment would be present. No intrusive investigation of this area was considered to be warranted;
- AEC 41 – Ammonia gas storage (Area 13) given the use of this AEC, and the fact that the ammonia solutions stored is a gas, it is unlikely any impacts to the surrounding environment would be present from activities in this area. No intrusive investigation of this area was considered to be warranted;
- AEC 46 – Coal loading activities (Area 15). The use of heavy machinery for coal loading may have the potential to cause impacts to surrounding soils and groundwater, however given the remnant inert coal remaining after closure was removed including some surface soils, the soils were not investigated in this area as it is considered that any impacts to soils would have been removed. It is noted this area has since been revegetated. Groundwater is assessed by the wells located around AEC 44; and
- AEC 51E – Waste dumps: Acid clean pit (Area 17) as historical aerial photography was provided to indicate the extent of this dump located on the boundary of the ash pond. In addition, due to safety reasons, excavating within the ash pond could not be undertaken. While the area of this known waste dump is clearly defined, given the material disposed in this dump (low level hydrofluoric acid and up to 1kg of stabilised sodium cyanide), further assessment in Phase 3 may be required to determine if any of this material has leached into the groundwater system. It is noted that water from the former coal loading area adjacent to the waste dump may be able to be sampled in Phase 3 for this purpose (refer Figure 19C).

Table 4.2: Intrusive investigations completed

AEC	Scope of works	Investigation location
Area 1 – Playford A & B Stations (Figure 3A)		
1 Playford fuel oil loss	Two monitoring wells installed into the secondary aquifer to determine if vertical migration of the known impacts had occurred.	Area1-MW101 and Area1-MW102 installed to depths of 12.2 and 12.3mbgs respectively. Wells were completed with a 2m screen with the secondary aquifer encountered at 11.7 and 11.2mbgs respectively.
	Groundwater monitoring of all new and existing wells to update the groundwater conditions beneath the area.	Existing wells WC, GW1 to GW5, GW7 to GW9 and GW11A and new wells Area1-MW101 and Area1-MW102. Area1-MW107 was resampled in November 2016 to confirm the chemical concentrations reported from sampling conducted in June 2016.
2 & 5 Storage and use of transformers	To assess potential leaks/spills from the most current transformer use, two soil bores were drilled adjacent to the transformers located east of the administration building and two monitoring wells were drilled and installed adjacent to the transformers on the sea wall.	Area1-SB101 and Area1-SB102 were drilled to depth of 2.0mbgs. Area1-MW103 and Area1-MW104 were drilled and installed to a depth of 5.5mbgs and completed with a 3m screen.
	Groundwater monitoring of the new wells to determine the groundwater conditions beneath the area.	New wells Area1-MW103 and Area1-MW104.
3 Historic storage of transformers	To assess potential leaks/spills from the historic transformer use, two soil bores and two monitoring wells were drilled and installed in the areas of historic transformer storage between the Playford A Station and Administration Building. Groundwater monitoring of the new wells to determine the groundwater conditions beneath the area.	Area1-SB103 and Area1-SB104 were drilled to depth of 2.0mbgs. Area1-MW105 and Area1-MW106 were drilled and installed to a depth of 5.5 and 5.0mbgs respectively and completed with a 3m screen. New wells Area1-MW105 and Area1-MW106. One of the monitoring wells (Area1-MW106) was drilled to the south east of the Administration Building due to access restrictions in regard to safety concerns regarding the Playford A stack.
4 Compressor shed	To assess for significant impacts to the subsurface from this activity, one soil bore in conjunction with AEC 3 was drilled adjacent to the compressor shed.	Area1-SB104 was drilled to depth of 2.0mbgs.
7A Waste water system	To assess for leaks from the SPEL tank and sump, one monitoring well was drilled and installed.	Area1-MW107 drilled to a depth of 3.0mbgs and completed with a 2.5m screen. It is noted that this area of the site is approximately 2.0mbgs below grade (at basement level).
	Groundwater monitoring of the new well to determine the groundwater conditions beneath the area	New well Area1-MW107. Note this well was resampled on 7 November 2016 to confirm the June 2016 results.
Area 2 – Playford buildings (Figure 4A)		
7B Waste water system	Two soil bores targeting the SPEL drains to assess for any leaks over time.	Area2-SB105 and Area2-SB106 were drilled to 2.0mbgs.

AEC	Scope of works	Investigation location
8 **Switch yard**	Existing groundwater wells monitored to update the groundwater conditions.	Existing wells GW25 and GW27.
9 **Workshop activities (coal/ash workshop)**	Existing groundwater well located adjacent monitored to update groundwater conditions.	Existing well GW25.
10 **Waste water system** **Ash pond sump**	Two soil bores targeting the ash pond sump to determine if leaks had occurred over time.	Area2-SB107 and Area2-SB108 were drilled to 4.0mbgs.
Area 3 – Playford buildings (Figure 5A)		
11, 12, 13A, 13B 15, 16 & 17 **Maintenance and workshop activities**	To assess the soil conditions surrounding the maintenance and workshop activities, 12 soil bores were targeted across the area.	Area3-SB109 to Area 3-SB120 were drilled to 2.0mbgs.
14 **Storage and dispensing of diesel**	To understand what material was utilised to backfill the UST pit following removal and if remnant impacts exist in shallow soils, one soil bore was drilled. Existing groundwater well located in the area of the former UST monitored to update groundwater conditions.	Area3-SB108 to a depth of 4.0mbgs. GW14
18 **Grit blasting and spray painting**	Two soil bores in conjunction with the above works were targeted around the grit blasting and spray painting area.	Area3-SB119 and Area3-120 were drilled to 2.0mbgs.
Area 5 – Steel laydown area (Figure 7A)		
21 **Steel laydown area**	To determine site characterisation and identify hot spots from historical storage, 21 test pits were undertaken across the area.	Area5-TP102 to Area5-TP105, Area5-TP107 to Area5-TP110, and Area5-TP113 to Area5-TP125 were excavated to 2.0mbgs. 25 test pits were to be undertaken in this area, however due to site conditions (services), particularly in the western half of the area which is bituminised, four of these locations could not be completed.
Area 6 – SPEL Drain outlets (Figure 8A)		
7B **SPEL drains**	It is noted this area is outside of FPP's lease boundary. Assessment of the SPEL drain outlets (AEC 7B) has been undertaken given these SPEL drain outlets discharge the surface water collected from across Area 3 workshop and maintenance areas. At each SPEL drain (3), three soil samples were collected initially in June 2016 at the sediment/soil area at each outlet. To aid in the assessment of the effect of the discharge from the SPEL drain outlets to the mangroves at Area 6, a flora and fauna assessment was completed by Ecological Associates for the mangrove area in Area 6 and for comparison	Surface samples Area6-SPEL1-2 to 1-3, Area6-SPEL 2-1 to 2-3, Area6-SPEL 3-1 to 3-3 and background locations BGSS1 and BGSS2 within the control site. Hand auger locations Area6-SPEL1-4 to 1-6 to depths of 1.0, 0.8 and 0.9mbgs respectively; Area6-SPEL2-4 to 2-6 to depths between 0.5 and 0.6mbgs; Area6-SPEL3-4 to 3-6 to depths between 0.5 and 0.6mbgs and locations BS1 and BS2 to depths of 0.1mbgs. The hand auger locations were completed at the site in November 2016 following review of the data collected from the surface samples.

AEC	Scope of works	Investigation location
	purposes, also of the control site (refer Section 9, Figure 8C).	
Area 7 – Fuel oil storage area (Figure 9A)		
23A & 23B Storage and dispensing of diesel	To assess the ground conditions around the fuel storage area, six test pits were excavated around the AST infrastructure including the former AST repair pad and one monitoring well was drilled and installed to the south west of the AST farm. Groundwater monitoring of the new well and three existing wells to update the conditions of the groundwater beneath this area of the site.	Area7-TP262 to Area7-TP267 to depths between 2.1 and 2.4mbgs. Area6-MW108 was drilled to a depth of 5.3mbgs and installed with a 3m screen. Area6-MW108, GW12, GW13 and GW6. The SAQP detailed six hand auger bores to be completed within the AST tank farm bund. Due to the bund floor comprising of concrete of unknown thickness, the hand auger bores could not be undertaken in this area. Four test pits were completed around the bund during the current works as an alternative to determine if gross contamination existed. Soil testing beneath the bund will form part of Phase 3 works at the site. Four soil bores were to be drilled within the area of the former AST repair pad, three test pits were completed in this area instead to provide a more visual assessment of the area.
Area 8 – Storage and maintenance area (Figure 10A)		
24 Former UST location	One soil bore drilled within area of former UST excavation to understand what material was utilised to backfill the UST pit and identify residual impacts in shallow soils. Groundwater monitoring of the existing wells to update the conditions of the groundwater beneath this area of the site.	Area8-SB125 drilled to a depth of 4.0mbgs. GW26A and GW30. Existing well GW28A could not be located.
25 & 26 Maintenance and wash down bay activities	To assess the subsurface conditions, six test pits were excavated around the maintenance shed and wash down bay along with one monitoring well drilled and installed. Groundwater monitoring of the new well to understand the groundwater conditions.	Area8-TP131 to Area8-TP136 were excavated to depths between 1.8 and 2.0mbgs. Area8-MW109 was drilled to a depth of 4.3mbgs and installed with a 3m screen.
26 Former coal line maintenance workshop activities	To assess the subsurface conditions, two test pits were excavated around the former coal line maintenance workshop along with one monitoring well drilled and installed. Groundwater monitoring of the new well to understand the groundwater conditions.	Area8-TP137 and Area8-TP138 were excavated to a depth of 2.0mbgs. Area8-MW110 was drilled to a depth of 6.5mbgs and installed with a 3m screen.
27 Storage of PCB containing equipment	Two test pits were excavated around the shed to determine the soil conditions.	Area8-TP139 and Area8-TP140 were excavated to a depth of 2.0mbgs.

AEC	Scope of works	Investigation location
Area 9– Recycling area (Figure 11A)		
28 Recycling area	To determine site characterisation and any hot spots from historical storage, 20 test pits were excavated across the area in a grid based pattern.	Area9-TP141 to Area9-160 were excavated to depths between 1.3 and 1.9mbgs.
Area 10 – Former coal loading area (Figure 12A)		
29 Former coal loading area	To determine site characterisation and residual impacts from historical storage, 15 test pits were excavated around the former coal loading area. To understand the condition of the surface water within the former coal loading area, a sample was collected.	Area10-TP161 to Area10-TP175 were excavated to depths between 0.7 and 2.0mbgs. Area10-GS101 A total of 20 test pits were intended to be completed at Area 10, however the north eastern area could not be accessed due to a number of services being present and this area consisting of the ash dam wall.
Area 11 – Waste water, fuel storage and wash down area		
30 Waste water system Main 'contaminated drains pond'	To provide information up and down the hydraulic gradient around the pond, two monitoring wells were drilled and installed. Groundwater monitoring of all new and existing wells to update the groundwater conditions beneath the area.	Area11-MW112 and Area13-MW113 were drilled to a depth of 4.3mbgs and installed with 3m screens. Area11-MW112, Area11-MW113, GW23A and GW24.
31A & 31B Former fuel oil pumping station	For assessment of the soils within the former AST area, four test pits were excavated and six samples of the bund material were collected. To determine if historical leaks have impacted the surrounding soils along the fuel transfer pipeline from the former AST to the northern station, ten test pits were excavated. One monitoring well was drilled and installed adjacent to the fuel transfer pipeline valve box to assess groundwater conditions. Groundwater monitoring of all new and existing wells to update the groundwater conditions beneath the area.	Area11-TP181 to Area11-TP184 were excavated to a depth of 2.0mbgs. Area11-GS102 to GS107 were collected. Area8-TP187 to Area8-TP196 were excavated to depths between 1.7 and 2.2mbgs. Area11-MW114 was drilled to a depth of 4.3mbgs and installed with a 3m screen. Area11-MW114 and GW15. Eight samples of the bund material were to be collected. The north eastern bund wall had been removed since development of the SAQP for access into the bund and the western side of the bund could not be accessed due to the pipework present.
32 Wash down bay	For the assessment of shallow soils, two test pits were excavated. To determine impacts from the wash down bay and nearby surface water run-off pond, one monitoring well was drilled and installed. Groundwater monitoring of the new well to understand the groundwater conditions.	Area11-TP185 and Area11-TP186 were excavated to a depth of 1.9mbgs. Area11-MW111 was drilled to a depth of 4.0mbgs and installed with a 3m screen. Area11-MW111.

AEC	Scope of works	Investigation location
		Three test pits were intended in this area, due to the concrete base of the wash down bay, only two test pits were completed.
Area 12 – Northern Station (Figure 14A)		
33 Main fuel oil service ASTs	A monitoring well was drilled and installed to the south west (down hydraulic groundwater gradient) of the ASTs for groundwater data collection in this area of the site. Groundwater monitoring of the new and existing wells to update the groundwater conditions beneath the area.	Area12-MW117 was drilled to a depth of 4.5mbgs and installed with a 3m screen. Area12-MW117, GW22 and GW29.
34 Waste water system Intermediate oily water skimmer pit	To determine if any leaks have occurred over time from this infrastructure, one soil bore was drilled and one monitoring well was drilled and installed. Groundwater monitoring of the new well to understand the groundwater conditions.	Area12-SB127 was drilled to a depth of 4.0mbgs and Area12-MW118 was drilled to a depth of 4.5mbgs and installed with a 3m screen. Area12-MW118.
35 Northern store UST	To assess the soils in the vicinity of the UST and dispensing pump, determine if the deeper underlying aquifer is impacted and to provide vertical delineation, one monitoring well was drilled and installed. Groundwater monitoring of the new and existing wells to update the groundwater conditions beneath the area.	Area12-MW115 was drilled to a depth of 12.5mbgs and installed with a 2m screen. The secondary aquifer was encountered at 11.0mbgs. Area12-MW115 and GW16.
36 & 37 Workshop and maintenance activities	To assess the ground conditions, one monitoring well was drilled and installed targeting the Mills workshop wash down bay and one soil bore was drilled targeting the flammable shed. Groundwater monitoring of the new well to understand the groundwater conditions.	Area12-MW116 was drilled to a depth of 4.5mbgs and installed with a 3m screen. Area12-SB126 was drilled to a depth of 2.0mbgs. Area12-MW116.
Area 13 – Northern station infrastructure (Figure 15A)		
5 Storage and use of transformers	To assess for potential leaks/spills from the most current transformer use, two soil bores were drilled.	Area13-SB113 and Area13-SB134 were drilled to a depth of 2.0mbgs.
39 Backup diesel generator	Two soil bores were drilled to determine if leaks or spills have occurred that have impacted the surrounding environment.	Area13-SB130 and Area13-SB131 were drilled to a depth of 2.0mbgs. A third soil bore was intended for this area, however due to the presence of services, this third location could not be accessed.
40 Waste water system Main oily water skimmer put	To determine the soil and groundwater conditions, two soil bores were drilled and one monitoring well was drilled and installed.	Area13-SB128 and Area13-SB129 were drilled to a depth of 3.6mbgs. Area13-MW119 was drilled to a depth of 4.5mbgs and installed with a 3m screen.

<table>
<tr><th>AEC</th><th>Scope of works</th><th>Investigation location</th></tr>
<tr><td></td><td>Groundwater monitoring of the new well to understand the groundwater conditions.</td><td>Area13-MW119</td></tr>
<tr><td>42
Waste oil storage</td><td>Five soil bores were drilled around the waste oil storage area with one monitoring well drilled and installed targeting the bulk storage shed and AST (south eastern corner of area).

Groundwater monitoring of the new well to understand the groundwater conditions.</td><td>Area13-SB135 to Area13-SB139 were drilled to a depth of 2.0mbgs.
Area13-MW120 was drilled to a depth of 4.5mbgs and installed with a 3m screen.

Area13-MW120.</td></tr>
<tr><td colspan="3">Area 14 – Steel laydown area (Figure 16A)</td></tr>
<tr><td>43A
Steel laydown area</td><td>To determine site characterisation and hot spots from historical storage, 24 test pits were excavated in a grid based pattern.</td><td>Area14-TP197 to Area14-TP203 and Area14-TP205 to Area14-TP221 were excavated to depths between 1.8 and 2.2mbgs.

A total of 25 test pits were planned for this area, however one test pit could not be completed due to services.</td></tr>
<tr><td>43B
Firefighting activities</td><td>One monitoring well was drilled and installed to assess the soil and groundwater conditions.

Groundwater monitoring of the new well to understand the groundwater conditions.

It is noted that this area of firefighting training has since been confirmed as fire extinguisher training with fires set within a drum and extinguished. Little firefighting foam from the fire extinguishers would have connected with the ground surface.</td><td>Area14-MW121 was drilled to a depth of 4.8mbgs and installed with a 3m screen.

Area14-MW121.

The monitoring well was installed and sampled prior to test pitting in this area to determine if impacts to soils and groundwater were present within this AEC and if additional soil testing was required.</td></tr>
<tr><td>51C
Waste dump</td><td>One grid based test pit for AEC 43A was undertaken in this area to determine the backfill material used.</td><td>Area14-TP203 was excavated to a depth of 2.0mbgs.</td></tr>
<tr><td colspan="3">Area 15 – Coal loading area (Figure 17A)</td></tr>
<tr><td>19
Coal conveyor sediment ponds (several locations)</td><td>To target the run-off from the sediment pond in this area, eight test pits were excavated.</td><td>Area15-TP224 to Area15-TP231 to depths between 0.1 and 0.2mbgs.</td></tr>
<tr><td>44
Fuel pad</td><td>To assist in the delineation of the known impacts, two monitoring wells were drilled and installed within the primary aquifer.

To determine if the deeper underlying aquifer is impacted and to provide vertical delineation, one monitoring well was drilled and installed within the secondary aquifer.

Groundwater monitoring of the new and existing wells to update the groundwater conditions beneath the area.</td><td>Area15-MW123 and Area15-MW124 were drilled to a depth of 4.5mbgs and installed with a 3m screen.

Area15-MW122 was drilled to a depth of 11.5mbgs and installed with a 2m screen. The secondary aquifer was not encountered at this location when drilling, groundwater was present during the groundwater sampling.

Area 15-MW122 to Area15-MW124, GW18 and GW21A.
Area15-MW123, Area15-MW124 and GW21A were resampled in November 2016 to confirm the chemical concentrations reported from sampling conducted in June 2016.</td></tr>
</table>

AEC	Scope of works	Investigation location
45 **Diesel ASTs**	To assess the soil conditions, two test pits were excavated around the ASTs and six test pits were excavated along the alignment of fuel oil transfer line between ASTs bund and fuel pad. Groundwater monitoring of the existing well to update the groundwater conditions beneath the area.	Area15-TP232 to Area15-TP239 were excavated to depths between 2.0 and 2.1mbgs. GW17
47 **Coal line workshop**	To assess historic activities associated with the coal line workshop, two test pits were excavated.	Area15-TP222 and Area15-TP223 were excavated to depths of 2.0 and 2.4mbgs respectively.
51D **Waste dump, chlorine plant residue**	To determine the extent and nature of the waste dump, test pitting was undertaken across the area.	Refer Figure 17B. No soil sampling was required, visual assessment only.
Area 16 – Train unloading area (Figure 18A)		
48A & 48B **Train unloading area**	To determine if leaks or spills have occurred over time from train unloading activities, three test pits were excavated across the area, one soil bore was drilled and one monitoring well was drilled and installed adjacent to carriage gripper unit that was noted to have had a leak historically. Groundwater monitoring of the new well to understand the groundwater conditions.	Area 16-TP240 to Area16-TP242 and Area16-SB140 were excavated to a depth of 2.0mbgs. Area16-MW125 was drilled and installed to a depth of 5.5mbgs with a 3m screen. Area6-MW125. It is noted that a test pit was planned for the same location as Area16-SB140, however due to the bitumen surface, a soil bore was drilled to cause less impact.
49A & 49B **Wash down of carriages**	To assess the wash down practices, nine shallow test pits were excavated along the soil swale alignment.	Area16-TP244 to Area16-TP253 were excavated to a depth of 0.1mbgs.
51A & 51B **Waste dumps, SMF/asbestos and general waste**	To determine the extent and nature of the waste dump, test pitting was undertaken across the area.	Refer Figure 18B. No soil sampling was required, visual assessment only.
Area 17 – Ash pond (Figure 19A)		
50A **Ash pond**	Groundwater monitoring of the selected existing wells to understand the groundwater conditions.	APS-1, APS-5, APS-7, APS-23 and APS-30 to APS-37.
50B **Waste water system Ash pond Stage 2 pumps**	To determine if any leaks have occurred over time from the ash pond stage 2 pumps, two test pits were excavated.	Area17-TP254 and Area17-TP255 were excavated to a depth of 0.5mbgs.
51F **Waste dump, general waste**	To determine the extent and nature of the waste dump, test pitting was undertaken across the area.	Refer Figure 19B. No soil sampling was required, visual assessment only
Area 18 – Rail filling area (Figure 20A)		
52 **Rail diesel filling area**	To assess the soils for spill/leaks that may have occurred over time, six test pits were excavated along the alignment of HDPE liner under railway line.	Area18-TP256 to Area18-TP261 were excavated to a depth of 2.0mbgs.

4.3. Laboratory testing

Laboratory testing of soil and groundwater samples was completed in accordance with the SAQP (Coffey 2016b) and was undertaken for the following numbers of primary samples at each area:

Table 4.3: Primary laboratory analysis – number of samples

Area	Matrix	TRH	BTEXN	PAHs	Metals	PCBs	VHCs	Solvent screen	PFCs	Nutrients
1	Soil Groundwater	23 14	10 12	3 1	5 9	13 3	10 11	- 11	-	-
2	Soil Groundwater	8 2	8 2	8 2	8 -	8 2	- 2	-	-	-
3	Soil Groundwater	22 1	20 -	22 1	22 -	-	8 1	6 1	-	-
5	Soil	26	26	26	-		7	-	-	-
6	Soil/sediment	30	11	11	30	30	-	-	-	-
7	Soil Groundwater	8 4	-	8 4	-	-	-	-	-	-
8	Soil Groundwater	16 4	14 2	16 4	-	4 -	10 2	1 2	-	-
9	Soil	32	31	31	30	-	12	-	-	-
10	Soil Surface water	19 1	7 -	19 1	-	-	7 -	7 -	-	-
11	Soil Groundwater	35 7	5 -	31 6	1 -	-	8 5	- 4	-	-
12	Soil Groundwater	12 7	5 3	13 7	2 1	1 -	8 4	- 4	- 1*	-
13	Soil Groundwater	24 2	- 1	21 2	7 1	5 1	16 2	- 1	-	-
14	Soil Groundwater	32 1	30 -	32 1	30 1	-	15	12	2 1	-
15	Soil Groundwater	26 9	5 8	18 6	9 -	-	3 -	3 -	-	-
16	Soil Groundwater	18 1	11 -	18 1	-	-	15 1	11 1	-	-
17	Soil Groundwater	4 12	-	- 12	4 12	-	-	-	-	- 12
18	Soil	12	-	12	-	-	-	-	-	-

* PFCs tested at Area 12 existing well GW16 as part of the assessment works at Area 14.

Laboratory analysis also included ASC NEPM soil screen for selected soils samples across the site, total organic carbon (TOC) nitrate and phosphate at selected soil samples within Area 1, AEC 1 – Playford fuel oil loss and monitored natural attenuation evaluation parameters for groundwater at selected wells across the site.

4.4. Analytical laboratories

All soil and groundwater primary and intra-laboratory replicate (duplicate) sample analysis was undertaken by Eurofins mgt (Eurofins) and all soil and groundwater inter-laboratory replicate (triplicate) sample analysis was undertaken by ALS Global (ALS). Eurofins and ALS are National Association of Testing Authorities (NATA) accredited for all requested analyses.

5. Ground conditions encountered

5.1. Site specific geology

The subsurface conditions encountered beneath the areas of investigation comprised the following lithology, generally consistent with previous investigations undertaken across the site:

- Fill materials associated with the reclamation of land and build up of the site levels extending to a maximum encountered depth of 7.2mbgs within Area 1 and consisting of sands and clays including some material with sea shells present and some material with ash;
- Fill materials are generally underlain by silts, sands and silty clays to a maximum depth of investigation at 12.3mbgs;
- Fill materials were encountered at greater depths closer to the Spencer Gulf, particularly around Areas 1, 12 and 13;
- The secondary aquifer was encountered within a clay layer between the depths of 11.2 and 12.0mbgs; and
- The lithology encountered in Area 6, at the SPEL drain outlets consisted of silty clayey sand fill materials underlain by silty and gravelly sands to at least the maximum depth of investigation at 1.0mbgs.

Observations that indicated potential impacts to the subsurface were observed as follows:

- Hydrocarbon odour noted at soils from:
  - Area1-MW101 between 2 and 5mbgs;
  - Area1-MW102 between 3.5-5.6mbgs;
  - Area8-SB125 between 1.7-2.0mbgs;
  - Area11-TP189 between 1.0-1.2mbgs;
  - Area12-MW115 between 4.0 to 8.9mbgs; and
  - Area15-MW122 at 2.0mbgs.
- Slag material was noted in fill materials across Area 5. It is likely that this material is ash fragments rather than slag; and
- PID readings were recorded between 0.0ppm$_v$ at many locations to 121ppm$_v$ at Area8-TP136 0.4-0.5mbgs.

Geological cross sections of the Playford Stations (Area 1), Northern Station (Area 12) and coal loading area (Area 15) are provided as Figures 3E, 14E and 17F respectively.

The cross section of the Playford Stations (Figure 3E) shows that within this area of the site where the reclamation of the land for the Playford Stations was undertaken, fill materials extend to a depth of 7.2mbgs. The natural surface, comprising the St Kilda Formation with sea shells and seaweed present in some locations is encountered from approximately 5.0mbgs with clays present from depths of 8.0mbgs.

The cross section through the Northern Station area (Figure 14E) shows a generally shallower depth of fill material is present, which correlates with the construction of this area of the site comprising of build up of the surface level rather than reclamation of land. There is ash material present in some of the fill, indicative of anecdotal evidence of utilising ash material for fill at the site. The natural surface, comprising the St Kilda Formation with sea shells and seaweed present in some locations is encountered from approximately 3.0mbgs with clays present from depth of 10.0mbgs. It is noted that fill materials were found to extend to 4.5mbgs adjacent to the intermediate oily water skimmer pit, north west of the Northern Station. It is considered likely that these fill materials are associated with fill material from the construction of the skimmer pit rather than build up of surface levels in this area.

Fill material with ash present is shown in the cross section of the coal loading area (Figure 17F) to depths of 2.4mbgs, this fill is associated with the locations being present in the coal loading area and in areas where surface level build up was undertaken for construction of the coal conveyor infrastructure. Natural soils comprising of silts, sands and clays are encountered beneath the fill. It is noted that sea shells and seaweed was observed in some shallower soils.

Overall the cross sections show the lithology of the site with deeper fill areas closer to the Spencer Gulf where reclamation of land was undertaken, and at lesser extents where site surface build up for construction occurred. Where site surface has been built up outside of the Playford areas, ash material is present in the fill. The natural soil surface is encountered at shallower depths further from the Spencer Gulf which is consistent with the site construction over time.

A historical photograph during the construction of Playford A Station is provided below that shows the natural layout of the site:

Figure 5.1: Playford A Station foundation construction, circa 1950's (FPP)

Monitoring well, soil bore and test pit locations are presented the figure sets marked A. A detailed description of the lithology logged in each soil bore, monitoring well and test pit location and the field VOC screening results are given on investigation logs included in Appendix B. Well permit and survey documentation is included in Appendix C.

5.2. Site hydrogeological information

5.2.1. Overview

The groundwater assessment of the site undertaken by Woodward-Clyde in 1994 determined the shallow groundwater gradient flowed south west towards the Spencer Gulf. A shallower gradient was present in the vicinity of the rail loop where low lying ground and salt encrustation was present and groundwater mounding was present in the vicinity of the ash pond, particularly around the southern area. It was noted that relatively high TDS values were recorded in the vicinity of the rail loop where the low lying area and salt evaporation was present and data from previous environmental investigations (PB 2015) as well as the current investigation report high TDS values across the site.

5.2.2. Groundwater elevation and LNAPL

Current groundwater gauging data collected during field activities conducted between 15 and 29 June 2016 and on 7 November 2016 is presented in attached Table 1. Current groundwater gauging results as recorded in June 2016 indicate groundwater flows generally to the west, towards the Spencer Gulf. Results are summarised in Table 5.1 as follows:

Table 5.1: Groundwater gauging data

Area	Depth to water	Groundwater elevation	Presence of LNAPL
1 (Figure 3C)	Within the primary aquifer, ranged between 3.197mbtoc at GW1 to 3.791mbtoc at GW9 Area1-MW107 located adjacent to the SPEL tank and sump, which is located approximately 2m below grade reported depth to water at 0.446mbtoc Within the secondary aquifer, at 4.193 and 4.135mbtoc. This depth was indicative of the groundwater being under pressure and rising within the well casing	Ranged between -0.380mAHD at Area1-MW103 located on the sea wall to 0.599mAHD at GW1 located to the east of the Playford stations Elevation at Area1-MW107 - 1.095mAHD Elevation at secondary aquifer wells was recorded at -0.334 and - 0.244mAHD	Hydrocarbon sheen was noted at well GW2 and LNAPL apparent thickness was noted at WC (0.273m), GW4 (0.004m) and GW5 (0.005m) located within AEC 1, Playford fuel oil loss Hydrocarbon sheen was noted at Area1-MW107 located adjacent to the SPEL tank and sump (AEC 7A) and was confirmed during resampling in November 2016
2 (Figure 3C)	3.210mbtoc at GW25 and 3.439mbtoc at GW27	Ranged between 0.253mAHD at GW27 located to the north to 0.463mAHD at GW25 located in the south west	Nil
3 (Figure 3C)	3.080mbtoc at GW14	0.892mAHD at GW14	Nil
7 (Figure 9B)	Between 2.472mbtoc at GW6 to 3.693mbtoc at GW13	Ranged between 0.981mAHD at GW13, the western most well to 1.756mAHD at GW6, located	Nil

Area	Depth to water	Groundwater elevation	Presence of LNAPL
		adjacent to the former coal loading area	
8 (Figure 10C)	Between 1.893mbtoc at Area8-MW109 and 2.734mbtoc at GW30 It is noted that existing well GW28A could not be located during the works	Groundwater elevations were recorded between 1.465mAHD at Area8-MW110 located in the south west to 1.639mAHD at GW26A located in the north of the area It is noted that well survey data does not exist for existing well GW30	Nil
11 (Figure 13C)	Depth to water ranged between 2.224mbtoc at Area11-MW111 to 2.843mbtoc at Area11-MW114	Ranged between 1.602mAHD at Area11-MW114 located to the north west to 2.220mAHD at Area11-MW111, the eastern most well	Nil
12 (Figure 14C)	Within the primary aquifer, ranged between 2.245mbtoc at GW29 to 3.506mbtoc at Area12-MW118 Within the secondary aquifer, at 2.830mbtoc. This depth was indicative of the groundwater being under pressure and rising within the well casing	Ranged between 1.005mAHD at Area12-MW117 the south western most well to 1.512mAHD at GW16 located to the north east of the station building in the vicinity of the northern store UST (AEC 35) Elevation at secondary aquifer well was recorded at 0.933mAHD	Nil
13 (Figure 14C)	2.395mbtoc at Area13-MW119 and 2.711mbtoc at Area13-MW120	0.958mAHD at Area13-MW119 located in the south west to 0.981mAHD at Area13-MW120 located in the east of the area	Nil
14 (Figure 14C)	2.934mbtoc at Area14-MW121	1.466mAHD at Area14-MW121	Nil
15 (Figure 17D)	Within the primary aquifer, ranged between 2.184mbtoc at GW19 to 2.976mbtoc at Area15-MW124 Within the secondary aquifer, at 2.740mbtoc. This depth was indicative of the groundwater being under pressure and rising within the well casing It was noted that existing well GW18 situated within the fuel pad area (AEC 44) could not be located	Ranged between 2.102mAHD at GW17 located adjacent to the diesel ASTs (AEC 45) to 2.602mAHD at GW19 located to the north east of the fuel pad (AEC 44) Elevation at secondary aquifer well was recorded at 2.281mAHD	Hydrocarbon sheen was noted at well Area15-MW124 located to the south west of the fuel pad (AEC 44) and was confirmed during resampling in November 2016
16 (Figure 18C)	3.893mbtoc at Area16-MW125	1.425mAHD at Area16-MW125	Nil
17 (Figure 19D)	0.603mbtoc at APS-34 to 1.276mbtoc at APS-1	Ranged between 1.345mAHD at APS-37 located at the south western most area to 4.210mAHD at APS-33 located to the east of the ash pond	Nil

Notes:
mbtoc = metres below top of casing
mAHD = metres Australian Height Datum

5.2.3. Aquifer hydraulic testing

Aquifer hydraulic testing was completed at three wells within Area 1 – Playford A & B Stations at two wells within AEC 1 – Playford fuel oil loss (GW1 and GW3) and one well located down gradient on the sea wall (GW8) to confirm the hydraulic conditions of the aquifer previously calculated by PPK in 1996, presented in the Environmental Projects (EP) Detailed Risk Assessment (DRA) report, conducted specifically for the Playford fuel oil loss (EP 2014).

The tests were completed as single-well rising-head slug tests and the data from EP DRA (2014) was also reviewed to ensure that consistent assumptions were adopted across all wells tested. The rising-head test data was analysed using the Bouwer-Rice and Dagan solutions, the results of which are presented in Table 5.2. Analytical outputs are provided in Appendix D.

Table 5.2: Rising head test result summary

	Test Date	Screened Formation	Screened Interval (mbgs)	Unconfined Bouwer-Rice		Unconfined Dagan	
Parameter				K	y_o	K	y_o
Well/Unit				m/day	m	m/day	m
GW1	14 June 2016	Fill: clayey sand	2.0-8.0	0.081	0.6933	0.07821	0.6727
GW3	14 June 2016	Fill: clayey sand	2.0-8.0	0.05057	0.3538	0.04801	0.3576
GW8	14 June 2016	Fill: silty sand	2.0-8.0	0.1355	0.4054	0.1289	0.3671

K = Hydraulic conductivity

The hydraulic conductivites ranged from 0.04m/day at GW3 to 0.13m/day at GW8. Previous conductivity calculations in this area in 1996 (EP 2014) were calculated at 0.04 to 0.24m/day. Based on the lithology across the site where the primary aquifer was encountered is generally consistent as sand material, the conductivity calculated from the hydraulic aquifer tests completed is considered to be representative of the site.

In addition, Coffey completed an assessment of this area in regard to tidal influence, reported in Coffey's letter report 'Tidal logging results, Augusta Power Stations' (Coffey 2016d) to determine the extent of potential tidal influences in the vicinity of the Playford Stations basements and across the inferred extent of the fuel oil plume. This assessment concluded the tidal effects are present in this area of the site with observed tidal efficiencies and the distance from the tidal boundary correlating with the general form of the relationship predicted by the theory, an exponential decrease of tidal efficiency with distance. This report is provided in Appendix L.

5.2.4. Groundwater flow characteristics

The hydraulic gradient and seepage velocity was calculated as follows in each of the assessment areas where monitoring wells exist. It is noted that areas in close vicinity to another, hydraulic gradient and flow characteristics were calculated in a wider sense. The effective porosity was estimated to be approximately 0.20 (Domenico and Schwartz, 1990), based on the saturated sand soil profile.

The general groundwater flow across the site is to the west, towards the Spencer Gulf.

Table 5.3: Groundwater flow characteristics

Areas of assessment	Hydraulic gradient	Seepage velocity
Area 1 – Playford A & B Stations Area 2 – Playford Switch Yard Area 3 – Playford Buildings	0.005 north west	0.46 to 1.2m/year
Area 7 – Fuel oil storage area	0.004 north west	0.37 to 0.95m/year
Area 8 – Storage and maintenance area	0.003 west-south west	0.3 to 0.7m/year
Area 11 – Wastewater, fuel storage and wash down area	0.003 west-south west	0.3 to 0.7m/year
Area 12 – Northern Station Area 13 – Northern Station Infrastructure Area 14 – Steel Laydown Area	0.002 south west	0.18 to 0.5m/year
Area 15 – Coal Loading Area	0.007 west	0.64 to 1.7m/year
Area 17 – Ash Pond	0.002 west-south west	0.2 to 0.5m/year

5.2.5. Groundwater quality results

Current groundwater quality results collected during field activities conducted between 15 and 29 June 2016 and on 7 November 2016 is presented in Table 2 with field data sheets presented in Appendix E. Current groundwater quality results as recorded in June 2016 are summarised in Table 5.4 as follows:

Table 5.4: Groundwater quality results

Parameter	Range	Comment
Dissolved oxygen (DO)	0.1mg/L (Areas 7, 8 and 15) to 5.3mg/L (Area 12)	Indicates groundwater with a range of low to moderate oxygen content.
Redox potential (Eh)	-391mV (Area 8) to 88mV (Area 1)	Indicates that reducing and oxidising conditions exist in groundwater across the site.
pH	6.19 (Area 7) to 8.43 (Area 1)	Indicates groundwater has generally neutral pH.
Electrical conductivity (EC)	2,222 µS/cm (Area 1) to 465,965µS/cm (Area 17)	Indicates saline conditions.
Estimated total dissolved solids (TDS)	1,444 to 302,877 mg/L	
Temperature	13.9°C (Area 17) to 24.5ºC (Area 1)	Is within expected range for a shallow aquifer during the winter season.

5.2.6. Historical groundwater elevation and LNAPL

A comparison of historical groundwater elevation and LNAPL data for existing monitoring wells installed prior to the 2016 DSI works is presented in Table 3 (where data was available) with observations over time noted below:

- LNAPL apparent thickness within the Playford fuel oil loss (AEC 1, Area 1) has been generally consistent since 1996 with some variations where groundwater elevations have varied;
- Groundwater elevations have generally fluctuated within 0.1m over time; and
- LNAPL apparent thickness and/or hydrocarbon sheen at the fuel pad (AEC 44, Area 15) has not been observed within the existing monitoring wells since the monitoring event in August 2006. It is noted that newly installed monitoring well Area15-MW124 was observed with a hydrocarbon sheen during the 2016 monitoring event.

5.3. Presence of waste dumps

During the DSI fieldworks, the presence of recorded waste dumps across the site was investigated visually by test pitting/trenching through nominated areas. The following visual conditions were noted and the areas as defined in this investigation are to be included in the future management plan for the site:

- A series of trenches were undertaken across the area of AEC 51A SMF dump and AEC 51B general waste dump located to the south of the train unloading area (refer Figure 18B). The works identified general waste and SMF waste buried in the area with the maximum vertical extent noted at 3mbgs. No asbestos containing material was encountered within this dump.
- A test pit (Area14-TP203) was undertaken in the area of the former waste dump (AEC 51C) located in the steel laydown area (Area 14, Figure 16A). The test pit confirmed that the waste in this area had previously been excavated and backfilled with fill material.
- A series of trenches and test pits were undertaken across the area of AEC 51D chlorine plant residue waste dump (refer Figure 17B) following discussions with on-site staff about the likely location of the waste dump area. The trenches completed identified some salt like residue in the trenches, indicative of chlorine residue and were excavated to a maximum of 3mbgs.
- Three test pits were undertaken in the area of the general waste dumps (AEC 51F). The area was fenced and the test pits did not identify any waste buried in this area (refer Figure 19B). It is possible this area was previously excavated and backfilled with fill materials. It appeared the area had been used as a trial revegetation plot.
- The acid clean pit (AEC 51E, Figure 19C) was clearly defined through provision of aerial photographs. While the area of this known waste dump is clearly defined, given the material disposed in this dump (low level hydrofluoric acid and up to 1kg of stabilised sodium cyanide), further assessment in Phase 3 may be required to determine if any of this material has leached into the groundwater system. It is noted that water from the former coal loading area adjacent to the waste dump may be able to be sampled in Phase 3 for this purpose.

Field data sheets are provided in Appendix E.

6. Tier 1 screening assessment

6.1. Overview of Tier 1 assessment process

Tier 1 screening assessment criteria was selected during the development of the SAQP (Coffey 2016b) and were selected with consideration of the site conditions and the proposed land use to continue as commercial/industrial. The criteria presented below are generic Tier 1 risk based criteria. Where concentrations of a COPC exceed the generic assessment criteria, then further consideration of the specific exposure pathway is required which may warrant further investigation, assessment or the development of a strategy to mitigate the potential risks identified.

6.2. Soil screening assessment criteria

6.2.1. Overview

The screening criterion has been derived on the basis of conservative assumptions relating to land use, receptor behaviour, site, building and soil characteristics.

Within the body of this report soil analytical results have been discussed against ASC NEPM (NEPC 2013) Health Investigation Levels (HILs) HIL D – commercial/industrial developed based on assumptions regarding exposure settings related to non-sensitive land use.

Discussion of results has also been related to the ASC NEPM Health Screening Levels (HSLs) (derived from CRC CARE HSLs (CRC CARE, 2011)) for vapour intrusion for further evaluation of potential risks to human health resulting from intrusion of hydrocarbon vapours emanating from soil impacts at the site. HSLs have been adopted based on the potential receptors, subsurface lithology and depth of impacts to soil. In addition, to assess the top 2 metres of soil for potential risks associated with dermal contact with petroleum hydrocarbons and vapour intrusion for maintenance workers, the CRC CARE (2011) direct contact and vapour intrusion HSLs for have been adopted.

To assess the top 2 metres of soils for potential effects of petroleum hydrocarbons associated with formation of LNAPL, fire and explosives hazards and effects on buried structures, the ASC NEPM (2013) Management Limits for TRH have also been adopted.

The ASC NEPM (NEPC 2013) requires consideration of Ecological Investigation Levels (EILs) and Ecological Screening Levels (ESLs) on sites (relevant to soils that will be within 2m of the surface). Soil data from the top 2m was also compared to these EILs and ESLs and site specific data collected to determine site specific EILs with calculations presented in Appendix F and summarised below. The commercial and industrial criteria have been adopted. It should be noted that the ASC NEPM states that ESLs presented for hydrocarbon fractions >C_{16} are regarded as being of low reliability.

Applicable screening criteria are listed as follows:

- **ASC NEPM (NEPC 2013)** HIL D Commercial/Industrial;
- **ASC NEPM (NEPC 2013)** HSL D, Commercial/Industrial, sandy, 0 to 4m+;
- **ASC NEPM (NEPC 2013)** Management Limits for TRH Fractions F1-F4;
- **ASC NEPM (NEPC 2013)** EIL Commercial/Industrial;
- **ASC NEPM (NEPC 2013)** ESL Commercial/Industrial;
- **CRC CARE (2011)** Direct Contact HSL D Commercial/Industrial & Intrusive Maintenance Workers; and
- **CRC CARE (2011)** HSL Intrusive Maintenance Worker, sandy, 0 to 4m+.

The soil screening assessment criteria are for comparative purposes only and should not be regarded as “clean-up” levels. The HSL checklist is provided in Appendix G. The screening assessment criteria are included in the soil analytical tables Table 4A, 5A, 6A, 7, 9A, 9B, 10A, 10B, 11, 12A, 13A, 13B, 14A, 15A, 16A, 16B, 17A, 17B, 18A, 18B, 19A and 20.

Aesthetic issues for soil at the site in accordance with Section 3.6 of ASC NEPM (NEPC 2013 (Schedule B1) has also been considered.

6.2.2. EIL calculations

The ASC NEPM provides an approach for calculating soil-specific EILs for copper, nickel and zinc. This requires consideration of the added contaminant limit (ACL), ambient background concentration (ABC) and key soil characteristics (i.e. pH, cation exchange capacity (CEC), clay content). Chromium speciation has not been considered as part of this assessment as chromium VI is not considered as a COPC. Calculation of an EIL for chromium III has therefore not been conducted in this assessment.

Much of the site comprises reclaimed land and is in effect a man-made structure. The relevance of ecological risk assessment following the ASC NEPM methodology for much of the reclaimed land could therefore be questioned. However, for the purposes of this assessment in order to evaluate the potential impact of identified potentially contaminating activities (PCAs) on soil with respect to ecological receptors, the ASC NEPM approach has been followed. Key soil characteristics for EIL calculation have been determined for fill soils within the top 2m within 10 assessment areas and are presented in Table 6.1.

Also shown in Table 6.1 are the average concentrations of copper, nickel and zinc within the fill calculated from the chemical analytical data for the purposes of estimating ambient concentrations for calculating EILs. These have been calculated for the fill materials in the top 2m across the site from the data collected in each area. These are not considered to be natural background concentrations of metals in soils as described in Section 2.9.2, these are specific to the fill material in each area of the site. However it is noted that the average ambient concentrations calculated are all within the relevant typical ranges for South Australian soils and are of a similar order of magnitude to the natural soil background concentrations at Area 14 presented in Table 2.2 (Section 2.9.2).

Table 6.1: Key soil characteristics

Area	Soil characteristic concentrations					Average metal concentrations		
	Iron %	Clay %	pH	CEC meq/100g	Carbon content %	Copper mg/kg	Nickel mg/kg	Zinc mg/kg
Area 1	0.8	20	8.8	27	0.4	4.4	3.5	9
Area 2	1.2	25	8.6	32	0.05	2.5	2	5.2
Area 3	5.5	7.5	8.2	25	2.9	5.8	6.3	31.2
Area 8 & 9	10	5	7.8	16	3.3	11.4	4.9	8.1
Area 11	3.6	6.8	7.7	14	1.1	36	10	10
Area 12	6.5	6.3	8.3	32.5	1.4	47.6	12	11.7
Area 13	3.9	18	8.9	32	1	10.5	36.8	26.3
Area 15	3.5	18	11	72	4.7	23.9	6.1	41.6
Area 16	1.2	13	8.6	32	0.05	27.5	13.5	48.8

CEC = Cation exchange capacity

EIL calculations are presented in Appendix F.

6.2.3. Sediment screening criteria

For the assessment of the SPEL drain outlets in Area 6 (AEC 7B), Coffey has compared results reported against both the soil assessment screening criteria as detailed above as well as the following guideline:

- **ANZECC & ARCMANZ (2000)** Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Interim Sediment Quality Guidelines (ISQG).

The assessment criteria is included in the analytical Table 8A.

6.3. Soil screening assessment

6.3.1. Data presentation

Soil analytical results are presented in the appended tables and figures as noted below. Chain of custody documentation and laboratory certificates of analysis are presented in Appendices J and K respectively.

6.3.2. Soil analytical results

The soil analytical results reported across the site were generally representative of background levels and were reported below the nominated screening assessment criteria. Where impacts have been reported, these are in areas where previous impacts were known to exist.

The following petroleum hydrocarbon impacts to soils above background levels were noted:

Table 6.2: Soil analytical results

<table>
<tr><th>AEC</th><th>Investigation location</th><th>COPCs reported</th></tr>
<tr><th colspan="3">Area 1 – Playford A & B Stations (Table 4A, Figure 3B)</th></tr>
<tr><td rowspan="3">AEC 1</td><td>Area1-MW101 2.9-3.1mbgs</td><td>• Minor concentrations of ethylbenzene, xylenes and naphthalene;
• Elevated concentrations of TRH >C_{10}-C_{16} (F2) and TRH >C_{34}-C_{40} below screening assessment criteria; and
• Elevated concentrations of TRH >C_{10}-C_{16} (4,200mg/kg) and TRH >C_{16}-C_{34} (10,000mg/kg) above the ASC NEPM (2013) Management Limits for TRH.</td></tr>
<tr><td>Area1-MW101 3.4-3.6mbgs</td><td>• Minor concentrations of ethylbenzene and naphthalene;
• Elevated concentrations of TRH >C_{10}-C_{16} (F2) and TRH >C_{34}-C_{40} below screening assessment criteria; and
• Elevated concentrations of TRH >C_{10}-C_{16} (3,100mg/kg) and TRH >C_{16}-C_{34} (5,000mg/kg) above the ASC NEPM (2013) Management Limits for TRH.</td></tr>
<tr><td>Area1-MW102 3.9-4.1mbgs</td><td>Minor concentrations of naphthalene, TRH >C_{10}-C_{16} and TRH >C_{16}-C_{34}.</td></tr>
<tr><td>AEC 2&5</td><td>Area1-SB101 0.4-0.5mbgs</td><td>Minor concentrations of TRH C_{29}-C_{36}.</td></tr>
<tr><td rowspan="2">AEC 3</td><td>Area1-MW105 0.4-0.5mbgs</td><td>Minor concentrations of TRH >C_{16}-C_{34}.</td></tr>
<tr><td>Area1-SB103 0.3-0.4mbgs</td><td rowspan="2">Minor concentrations of TRH >C_{16}-C_{34} and TRH >C_{34}-C_{40}.</td></tr>
<tr><td>AEC7A</td><td>Area1-MW107 0.7-0.8mbgs</td></tr>
</table>

AEC	Investigation location	COPCs reported
Area 3 – Playford Buildings (Table 6A, Figure 5B)		
AEC 11, 12, 13A, 13B 15, 16 & 17	Area3-SB112 0.4-0.5mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}.
	Area3-SB117 0.4-0.5mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}. It is noted that the TRH concentrations at Area3-SB117 increase from 150mg/kg at the sample analysed from 0.4-0.5mbgs to 250mg/kg at the sample analysed from 1.8-2.0mbgs. Given the concentrations present, and the lack of field observations and PID screening indicating a hydrocarbon source, it is considered unlikely that gross hydrocarbon impact is present at deeper depths.
	Area3-SB117 1.8-2.0mbgs	
	Area3-SB115 0.3-0.5mbgs	Minor concentrations of TRH C_{29}-C_{36}.
	Area3-SB115 1.8-2.0mbgs	Minor concentrations of TRH $>C_{10}$-C_{16}, TRH $>C_{16}$-C_{34} and TRH $>C_{34}$-C_{40}.
Area 5 – Steel Laydown Area (Table 7, Figure 7B)		
AEC 21	Area5-TP125 2.0mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}. TRH concentrations at TP125 2.0mbgs sample were reported at 110mg/kg. Given the concentrations present, and the lack of field observations and PID screening indicating a hydrocarbon source, it is considered unlikely that gross hydrocarbon impact is present at deeper depths. Monitoring wells located nearby do not report groundwater impacts.
	Area5-TP103 0.3-0.5mbgs	Minor concentrations of TRH C_{29}-C_{36}.
Area 8 – Storage and Maintenance Area (Tables 10A & 10B, Figure 10B)		
AEC 25	Area8-TP136 0.4-0.5mbgs	• Elevated concentrations of TRH $>C_{10}$-C_{16} (F2) and TRH $>C_{34}$-C_{40} below screening assessment criteria; and • Elevated concentrations of TRH $>C_{10}$-C_{16} (350mg/kg) and TRH $>C_{16}$-C_{34} (4,700mg/kg) above the ASC NEPM (2013) ESL for commercial/industrial land use.
	Area8-TP136 1.6-1.7mbgs	• Elevated concentrations of TRH $>C_{10}$-C_{16} and TRH $>C_{34}$-C_{40} below screening assessment criteria; and • Elevated concentrations of TRH $>C_{16}$-C_{34} (2,600mg/kg) above the ASC NEPM (2013) ESL for commercial/industrial land use.
	Area8-MW109 2.0-2.3mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}.
Area 9 – Recycling Area (Table 11, Figure 11B)		
AEC 28	Area9-TP141 0.4-0.5mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}.
Area 10 – Former Coal Loading Area (Table 12A, Figure 12B)		
AEC 29	Area10-TP161 0.4-0.5mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}.
	Area10-TP166 0.3-0.4mbgs	
	Area10-TP167 0.4-0.5mbgs	
	Area10-TP172 0.4-0.5mbgs	
	Area10-TP175 0.4-0.5mbgs	
	Area10-TP170 0.1-0.2mbgs	Minor concentrations of TRH $>C_{16}$-C_{34} and TRH $>C_{34}$-C_{40}.
Area 11 – Wastewater, Fuel Storage and Washdown Area (Tables 13A & 13B, Figure 13B)		
AEC 31A	Area11-TP184 0.4-0.5mbgs.	Minor concentrations of TRH $>C_{16}$-C_{34}.
AEC 31B	Area11-MW114 2.4-2.7mbgs	Minor concentrations of TRH $>C_{16}$-C_{34}.

AEC	Investigation location	COPCs reported
AEC 32	Area11-MW111 1.8-2.0mbgs	Minor concentrations of TRH >C_{16}-C_{34}.
Area 12 – Northern Station (Table 14A, Figure 14B)		
AEC 34	Area11-SB127 1.5-1.6mbgs	Minor concentrations of TRH C_{15}-C_{28} and TRH >C_{16}-C_{34}.
	Area12-SB127 2.8-3.0mbgs	
AEC 35	Area12-MW115 2.0mbgs	Minor concentrations of benzene, ethylbenzene, xylenes, naphthalene and TRH C_6-C_{10}.
Area 13 – Northern Station Infrastructure (Table 15A, Figure 15B)		
AEC 39	Area13-SB131 0.4-0.5mbgs	Minor concentrations of TRH >C_{10}-C_{16} and TRH >C_{16}-C_{34}.
AEC 42	Area13-SB138 0.5-0.6mbgs	Minor concentrations of TRH C_{29}-C_{36}.
Area 15 – Coal Loading Area (Tables 17A & 17B, Figure 17C)		
AEC 19	Area15-TP227	Elevated concentrations of TRH >C_{16}-C_{34} below screening assessment criteria.
	Area15-TP229	Elevated concentrations of TRH >C_{16}-C_{34} below screening assessment criteria.
	Area15-TP230	Elevated concentrations of TRH >C_{10}-C_{16} above screening criteria and elevated concentrations of TRH >C_{16}-C_{34} below screening assessment criteria.
	Area15-TP231	Minor concentrations of TRH C_{29}-C_{36}.
AEC 44	Area15-MW122 2mbgs	Elevated concentrations of TRH >C_{10}-C_{16} above screening criteria and elevated concentrations of TRH C_{16}-C_{34} below screening assessment criteria.
	Area 15-MW123 2.1-2.3mbgs	Minor concentrations of TRH >C_{16}-C_{34}.
Area 16 – Train Unloading Area (Tables 18A & 18B, Figure 18C)		
AEC 49B	Area16-TP245	Minor concentrations of TRH >C_{16}-C_{34}.
	Area 16-TP250	
Area 17 – Ash Pond (Table 19A, Figure 19B)		
AEC 50B	Area17-TP254 0-0.1mbgs	Minor concentrations of TRH C_{29}-C_{36}.
Area 18 – Rail Filling Area (Table 18, Figure 20B)		
AEC 52	Area18-TP257 0.1-0.2mbgs	Minor concentrations of TRH >C_{16}-C_{34}.
	Area18-TP260 0-0.1mbgs	Minor concentrations of TRH C_{15}-C_{28} and TRH C_{29}-C_{36}.
	Area18-TP261 0-0.1mbgs	Minor concentrations of TRH >C_{16}-C_{34}.

6.3.3. Sediment analytical results

The analytical results reported from the soils/sediment collected at each SPEL drain outlet (nine samples at each outlet) reported the following elevated results, presented in Table 8A and Figure 8B:

- Concentrations of TRH >C_{10}-C_{16} were reported in two samples collected from SPEL 1 between 74mg/kg and 140mg/kg;
- Concentrations of TRH >C_{16}-C_{34} were reported at all samples collected from SPEL 1 between 330mg/kg and 7,000mg/kg. The concentration of 7,000mg/kg was reported above the ASC NEPM (2013) Management Limits for TRH at sample SPEL 1-4 0.4-0.5mbgs;
- Concentrations of TRH >C_{16}-C_{40} were also reported in samples collected from SPEL 2 between 110 and 330mg/kg and from SPEL 3 between 100 and 290mg/kg;

- Concentrations of PCBs above the laboratory limit of reporting (LOR) were reported in samples collected from SPEL 3;
- Elevated concentrations of the following metals were reported above the sediment quality guidelines at all three SPELs:
  - Arsenic above the sediment quality guideline in samples SPEL 2-5 0.1-0.2mbgs, SPEL 3-4 0.4-0.5mbgs and SPEL 3-6 0.4-0.5mbgs;
  - Copper above the sediment quality guideline in six samples analysed from SPEL-1 with concentrations reported between 74 and 190mg/kg; in three samples analysed from SPEL-2 with concentrations reported between 74 and 89mg/kg; and in five samples analysed from SPEL-3 with concentrations reported between 66 and 1,400mg/kg;
  - Lead above the sediment quality guideline in six samples analysed from SPEL-1 with concentrations reported between 51 and 210mg/kg; in one sample analysed from SPEL-2 (61mg/kg); and in three samples analysed from SPEL-3 with concentrations reported between 55 and 210mg/kg;
  - Mercury above the sediment quality guideline in six samples analysed from SPEL-1 with concentrations reported between 0.2 and 0.3mg/kg; in two samples analysed from SPEL-2 with concentrations reported at 0.2mg/kg; and in five samples analysed from SPEL-3 with concentrations reported between 0.2 and 75mg/kg;
  - Nickel above the sediment quality guideline in five samples analysed from SPEL-1 with concentrations reported between 24 and 33mg/kg; in four samples analysed from SPEL-2 with concentrations reported between 22 and 35mg/kg; and in three samples analysed from SPEL-3 with concentrations reported between 27 and 120mg/kg; and
  - Zinc above the sediment quality guideline in all nine samples analysed from SPEL-1 with concentrations reported between 330 and 1,400mg/kg; in eight samples analysed from SPEL-2 with concentrations reported between 210 and 1,500mg/kg; and in eight samples analysed from SPEL-3 with concentrations reported between 420 and 2,800mg/kg.

The elevated concentration of mercury reported in sample SPEL 3-4 0.4-0.5mbgs at 75mg/kg is an order of magnitude higher than any other sample analysed. The sample result along with all mercury results reported was checked with the analytical laboratory and confirmed to be correct. The elevated concentrations found in this single sample are delineated laterally and not considered to be generally representative of the material in the area.

6.3.4. Comparison to background concentrations

Based on the background information available from the testing conducted by SARDI (2010) as well as background testing completed by Coffey during the current investigation, a comparison of the elevated metals results reported against the background concentrations is presented below along with the sediment quality guideline values.

Table 6.3: Comparison against background concentrations (sediment)

Analyte	Concentration range (mg/L)	Background concentration range (mg/L)	Sediment quality guideline (mg/L)
Arsenic	<2 to 44	<2 to 13	20
Barium	200 to 390	960	-
Beryllium	<2 to 4.7	<2 to 3.4	-
Boron	15 to 200	160 to 220	-
Cadmium	<0.4 to 1.4	<0.4 to 0.5	1.5
Chromium	13 to 60	5 to 26	80
Cobalt	5.1 to 85	7.7 to 17	-
Copper	9 to 210	4 to 43	65
Lead	<5 to 210	<5 to 32	50
Manganese	140 to 4,100	185 to 500	-
Mercury	<0.1 to 75	<0.1 to 0.07	0.15
Nickel	<5 to 120	<5 to 26	21
Vanadium	22 to 32	58	-
Zinc	45 to 2,800	11-300	200

Notes:
"-" no guideline value

The comparison of analytical results against the background concentrations indicate some sediment samples may contain concentrations of the metals arsenic, cadmium, cobalt, copper, lead, manganese, mercury, nickel and zinc above general background levels.

Concentrations of the metals barium, beryllium, boron, cadmium, chromium and vanadium report concentrations generally consistent with background concentrations.

FPP have historically sampled water from within the SPEL drains for a limited analytical suite on an annual basis from May 2007, results of which are presented in Table 8B. The results of this testing reported requested metals (arsenic, chromium, copper and lead), grease and suspended solids in all samples tested and TRH in samples tested primarily from SPEL-1.

An assessment of the chemicals reported in this area and the affect they may have had on the mangrove ecosystem and ultimately the Spencer Gulf is further discussed in Section 9. The Flora and Fauna Assessment is presented in Appendix I.

6.4. Groundwater screening assessment criteria

Based on the groundwater BUA undertaken in the PSI report (Coffey 2016a) marine water aquatic ecosystems, recreational and aesthetic use of the Spencer Gulf and the possibility of future aquaculture industries have been identified as the realistic potential beneficial uses of water in the site's vicinity.

The amended ASC NEPM (NEPC 2013) provides health-based groundwater investigation screening levels (GILs) for assessment of the marine ecosystem and recreational and aesthetic use and HSLs for various exposure settings for some of the chemicals tested.

In line with the ASC NEPM (2013), the NHMRC (2008) guidelines are adopted for assessment of recreational waters. The NHRMC (2008) guidelines do not specify actual guideline values which chemical concentrations can be compared against; however it is recommended that expected exposure in terms of dose and frequency are considered in developing GILs. A conservative assumption has been made that approximately 200ml/day of water is ingested undertaking recreational activities involving extracted groundwater. Therefore a factor of 10 has been applied to the Australian Drinking water Guidelines (ADWG) (NHMRC & NRMMC 2011) to assess risk to potential beneficial uses with the exception of some analytes with aesthetic guidelines where this value has been adopted as the appropriate guideline for direct contact.

The HSLs for vapour intrusion for further evaluation of potential risks to human health resulting from intrusion of hydrocarbon vapours emanating from groundwater impacts at the site has also been adopted for assessing the groundwater at the site. In addition, to assess vapour intrusion for intrusive maintenance workers, the CRC CARE (2011) HSLs have been adopted. HSLs have been adopted based on the potential receptors, sand lithology and depth of groundwater.

To assess the presence of PFCs within the groundwater where known firefighting activities were undertaken within Area 14 – AEC 43B, the interim guidance from WA Department of Environment and Regulation (DER) (2016) Interim Guideline on the Assessment and Management of PFAS and an enHealth statement of PFCs issued in June 2016 (enHealth 2016) have been adopted for screening for protection of non-potable and recreational uses and freshwater ecosystems. No criteria is available at this time for marine ecosystems.

The regulatory criteria adopted for assessing groundwater at the site is therefore based on the following guidelines:

- **ASC NEPM (NEPC 2013)** GILs marine water ecosystem;
- **NHMRC (2008)** Guidelines for managing risks in recreational water;
- **ANZECC & ARMCANZ (2000)** Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Primary Industries – Aquaculture;
- **ASC NEPM (NEPC 2013)** HSLs, petroleum hydrocarbons for vapour intrusion, Commercial/Industrial HSL D;
- **CRC CARE (2011)** HSLs for intrusive maintenance workers (shallow trench); and
- **WA DER (2017)** Interim Guideline on the Assessment and Management of PFAS and **enHealth (2016)** statement: Interim national guidance on human health reference values for per- and poly-fluoroalkyl substances for use in site investigations in Australia – Area 14 only.

It is noted that there are no criteria for the assessment of groundwater within the ANZECC & ARMCANZ (2000) primary industry guidance for aquaculture and human consumption of aquatic foods. The guidance is based around influent (i.e. water that is entering the aquaculture operation) and source water quality, and it also addresses the safety of aquatic foods for human consumers. As the GIL for protection of marine ecosystems has been adopted, protection of influent for any future aquaculture activities is protected. As such this guideline is noted, but not included in our analytical tables for screening assessment purposes.

In their publication *Implementation of the National Environment Protection (Assessment of Site Contamination) Measure 1999* (Updated July 2016), the EPA has stated that during the review of existing site contamination guidance which is currently being undertaken, the approach to the determination of harm to water remains as set out in their publication *Site contamination: How to determine actual or potential harm to water that is not trivial resulting from site contamination* (EPA 839/08), in that the EPA considers that actual harm to water that is not trivial has occurred if chemical substances are in excess of background concentrations and are:

- Above the water quality criteria for the appropriate protected environmental value; and

- Or where there is no value, above the laboratory limit of reporting using a laboratory method approved by the Authority.

The EPA states that this involves comparison of groundwater quality against the water quality criteria for the relevant protected environmental values included in Schedule 2 of the former *Environment Protection (Water Quality) Policy 2003* (the former Water Quality EPP 2003), notwithstanding that these criteria were removed from the Policy when it was amended in 2015. The marine quality investigation levels, where available, have therefore been compared against the groundwater data collected as part of this investigation and presented in a separate table, Table 21.

The groundwater screening assessment criteria are for comparative purposes only and should not be regarded as "clean-up" levels. The HSL checklist is provided in Appendix G. The screening assessment criteria are included in the groundwater analytical tables Table 4B, 5B, 6B, 9B, 10C, 12B, 13C, 14B, 15B, 16C, 17C, 18C and 19B.

6.5. Groundwater screening assessment

6.5.1. Data presentation

Groundwater analytical results are presented in the appended tables by sequence and figures as presented below. Chain of custody documentation and laboratory certificates of analysis are presented in Appendices J and K respectively.

6.5.2. Groundwater analytical results

Groundwater analytical results were reported across the site generally below background concentrations with the exception of known areas of historical groundwater impacts. The following results were noted:

<u>Area 1 – Playford A & B Stations</u> (Table 4B, Figure 3D)

- Minor concentrations of TRH C_6-C_{10} were reported at the groundwater sample collected from Area1-MW103 and TRH >C_{10}-C_{40} were reported at the groundwater sample collected from Area1-MW104 located on the sea wall targeting AEC 2&5 (storage and use of transformers); and
- Minor concentrations of TRH >C_{10}-C_{40} were reported at the groundwater sample collected from Area1-MW107 located adjacent to the SPEL tank and sump, north west of the Playford B Station (AEC 7A).

It is noted that concentrations of 1,1-dichloroethane was reported at the groundwater sample collected from Area1-MW102 (AEC 1) at 1µg/L

<u>Area 12 – Northern Station</u> (Table 14B, Figure 14D)

- Elevated concentrations of benzene and ethylbenzene above the screening criteria for recreational waters and minor concentrations of xylenes and TRH C_6-C_{10} were reported in the groundwater sample collected from GW16, existing well located adjacent to the northern store UST (AEC 35).

<u>Area 14 – Steel Laydown Area</u> (Table 16C, Figure 19B

- Minor concentration of perfluorooctanesulfonic acid (PFOS) was reported in the groundwater sample collected from Area14-MW121 (0.00001mg/L) within the firefighting area (AEC 43B).

Area 15 – Coal Loading Area (Table 17C, Figure 17E)

- Elevated concentrations ethylbenzene, xylenes, naphthalene and TRH C_6-C_{34} were reported in the groundwater sample collected from Area15-MW124 targeting the fuel pad (AEC 44); and
- A minor concentration of naphthalene was reported in the groundwater sample collected from existing well GW21A located in the vicinity of the fuel pad (AEC 44).

6.5.3. Comparison to background concentrations

Heavy metal and metalloid concentrations were reported across the site (where analysed), with some metals (arsenic, cobalt, copper, iron, manganese, mercury, selenium, zinc) in some groundwater samples from the June 2016 monitoring event reported above the screening assessment criteria for the protection of marine ecosystems and/or recreational waters.

In addition, sulphate, ammonia and TDS concentrations were also reported above the screening assessment criteria at some locations. Ammonia was not noted to be elevated in the vicinity of the SA Water sewage ponds when compared to other wells, and in addition, no other nutrients were reported to be elevated. It is considered that only well APS 35 is in close enough proximity to the sewage ponds to be influenced.

The concentrations detected as noted above, are shown below in comparison to background concentrations of metals, metalloids and organics/inorganics (as determined in Section 2.12.4).

Table 6.4: Comparison against background concentrations (groundwater)

Analyte	Concentration range (mg/L)	Background concentration range (mg/L)
Arsenic	<0.005 to 0.017	<0.003 to 0.386
Cobalt	<0.001 to 0.022	<0.001 to 0.082
Copper	<0.001 to 0.013	<0.010 to 0.441
Iron	<0.05 to 3.6	0.09 to 169
Manganese	0.015 to 3.8	<0.001 to 6
Mercury	<0.0001 to 0.0003	<0.0001 to 0.001
Selenium	<0.001 to 29	<0.001 to 29
Zinc	<0.001 to 0.53	<0.003 to 0.296
Ammonia	0.07 to 6.1	0.07 to 6.1
Sulphate	350 to 2,300	3,510 to 9,960
TDS	54,000 to 190,000	57,000 to 230,000

The concentrations reported in groundwater samples collected are generally consistent with background concentrations. As such, on the basis of the available information, the above metals, metalloids and organics/inorganics are not considered to represent site contamination within groundwater at these locations at the site.

6.5.4. Historical groundwater analytical results

Historical groundwater data available for existing wells is presented in Table 22A for TRH, BTEXN and 1,1-dichloroethane concentrations. A comparison of historical and current analytical data is summarised below:

- Dissolved phase petroleum hydrocarbon impacts reported over time within Area 1 have generally decreased where present to less than the laboratory LOR. It is noted that LNAPL present in this area has remained generally consistent in reported thickness;
- Dissolved phase petroleum hydrocarbon impacts reported over time within Area 12 in the vicinity of the northern store UST (GW16) have shown a decreasing trend in concentrations; and
- 1-1-dichloroethane reported at GW8 on the sea wall at Area 1 at 0.1µg/L concentration at the previous monitoring event in June 2015 was not reported during the current event.

In addition, available historical groundwater data collected by FPP from APS wells since 2008 is presented in Table 22B. The results of the testing conducted indicate generally consistent concentrations over time. It is noted on comparison of results from the wells sampled by Coffey and FPP in June 2016, discrepancies in concentrations are present with the results Coffey reported lower than the FPP results. It is suggested that a selection of the APS wells around the site are sampled at least once within the Phase 3 program of works to confirm results reported.

6.6. Natural attenuation of contaminants in groundwater

6.6.1. Overview

The primary lines of evidence for natural attenuation are provided by observed reductions in impacted area geometry and contaminant concentrations. A shrinking or stable plume is evidence of natural attenuation, while for an expanding plume, the mass loading rate of the contaminants exceeds the natural attenuation rate.

Geochemical indicators of naturally-occurring biodegradation provide for secondary lines of evidence for natural attenuation. These natural attenuation indicators are useful because the biological transformation of petroleum hydrocarbons is the single most important process contributing to the natural attenuation of petroleum constituents. Geochemical natural attenuation indicators were collected during the current monitoring event and are presented in appended Table 2 (dissolved oxygen and redox) and groundwater analytical results tables (sulphate, nitrate, iron, manganese and alkalinity).

In general, biodegradation follows an order of favourable electron acceptor availability (O_2 > NO_3^- > Mn^{4+} >Fe >SO_4^{2-} >CO_2) due to the decreasing amount of energy gained through the reduction of these compounds. Nitrate, manganese, iron and sulphate are all electron acceptors which may be utilised in contaminant oxidation in the absence of dissolved oxygen.

Natural attenuation indicators assessed in June 2016 in groundwater wells at the site included:

- Dissolved oxygen (DO);
- Redox potential;
- Nitrate;
- Dissolved iron;
- Dissolved manganese (Mn^{4+});
- Sulphate; and
- Alkalinity.

This site-specific assessment of natural attenuation of the site follows the ASTM (2004) guidance document. This document states that at a minimum, primary lines of evidence are required to demonstrate the effectiveness of natural attenuation. If the primary lines of evidence are inconclusive, it may be necessary to obtain secondary lines of evidence.

6.6.2. Primary lines of evidence

Natural attenuation processes, particularly biodegradation, are often well documented at petroleum release sites where the configuration of the area of impacted groundwater is controlled by the source mass-loading rate relative to the removal rate provided by natural attenuation processes. Typically, the area impacted will expand until it reaches steady state where the rate of petroleum constituents contributed from the source is balanced with the rate of natural attenuation (ASTM, 2004). At steady-state (i.e. where concentrations are invariant with time) the area of impact stabilises. When the source area is depleted to the point that the rate of natural attenuation exceeds the source input, the result will be a shrinking area of impact over time.

The body of groundwater data collected at the site since 1996 indicates decreasing and stable groundwater concentrations across the areas investigated, the primary lines of evidence indicate that natural attenuation processes are likely to have occurred over time.

6.6.3. Secondary lines of evidence

As there was limited geochemical data available for the site, this data was collected during the current event in historical areas of impact to indicate further if natural attenuation processes were occurring in the groundwater system. Secondary lines of evidence for natural attenuation can be established through evaluation of geochemical indicators of the biodegradation processes. These parameters are useful for evaluating the occurrence and extent of biodegradation processes.

Table 6.5: Geochemical data

Well	TRH (mg/L)	Dissolved Oxygen (mg/L)	Redox (mV)	Nitrate (mg/L)	Manganese (mg/L)	Iron (mg/L)	Sulphate (mg/L)	Alkalinity (mg/L)
Area 1 Playford A & B Stations – AEC 1 Playford fuel oil loss								
GW1 Up gradient well	<LOR	0.5	-261	0.03	0.33	0.44	1500	740
GW7 Cross gradient well	<LOR	3.6	-210	1.2	0.015	<LOR	56	520
GW8 Down gradient well	<LOR	4.7	-34	0.1	0.42	<LOR	350	1000
Area 2 Playford B Switch Yard – AEC 8 Switch yard								
GW27 North west well	<LOR	2.2	-7	0.5	0.68	<LOR	1300	410
GW25 South west well	<LOR	1.1	-140	0.27	2.5	3.6	1600	620
Area 7 Fuel Oil Storage Area – AEC 23A Storage and dispensing of diesel								
Area7-MW108	<LOR	0.2	-310	0.05	0.86	0.32	2300	1000
GW12 Down gradient well	<LOR	0.1	-368	<LOR	0.41	0.25	1800	860
Area 8 Storage and Maintenance Area – AEC 24 Former UST location								
GW26A	<LOR	0.1	-391	<LOR	0.18	<LOR	1800	1500

Area 12 Northern Station – AEC 35 Northern store UST								
GW16	40	4.6	-128	<LOR	<LOR	<LOR	660	1300
Area 15 Coal Loading Area – AEC 44 Fuel padArea15-MW123								
Area15-MW123	<LOR	2.9	-32	1.6	0.49	1.3	620	300
GW19	<LOR	1.0	-27	<LOR	0.38	<LOR	370	200

Notes:
<LOR = results reported less than the laboratory LOR

Oxygen

Decreased DO indicates that where oxygen is available it is being used for the aerobic degradation of petroleum hydrocarbons. Concentrations of dissolved oxygen (DO) in groundwater are low to moderate across the site, but frequently notably low within and hydraulically down gradient of known areas of petroleum hydrocarbon release and groundwater impact.

Nitrate

Nitrate is at full depletion within previously impacted areas Area 7 and 8 and impacted areas Area 12 and 15. The depletion of nitrate indicates that anaerobic degradation, utilising nitrate as an electron acceptor, is occurring in the groundwater in these areas where it is available.

Manganese

Under anaerobic conditions manganese (IV) (Mn^{4+}) may be utilised as an electron acceptor, typically following the depletion of oxygen and nitrate within the groundwater. Increased dissolved manganese (predominantly Mn^{2+}) therefore indicates that Mn^{4+} is being utilised for biodegradation. The data does not show clear evidence indicating that manganese has been used as an electron acceptor.

Iron

Under anaerobic conditions, ferric iron (Fe^{3+}) may be utilised as an electron acceptor, and reduced to ferrous iron (Fe^{2+}) typically following the depletion of oxygen, nitrate and manganese within the groundwater. Iron concentrations are reported either below the laboratory LOR or at low concentrations across the site indicating no clear evidence of ferrous iron being produced as a result of anaerobic biodegradation.

Sulphate

Utilisation of sulphate as an electron acceptor in the biodegradation process typically occurs under strongly reducing conditions following the depletion of oxygen, nitrate and ferric iron. Sulphate concentrations were generally consistent at all locations where it was measured and at levels indicating that this electron receptor is not generally being utilised for biodegradation. It is noted a low concentration of sulphate was reported at GW7 located on the plume fringe of the Playford fuel oil loss (AEC 1) which may indicate that sulphate is being used in this area for biodegradation of the fuel oil in this area.

Alkalinity

Alkalinity, measured as bicarbonate, can be used as an indication of carbon dioxide production where biodegradation is occurring. Alkalinity measured in the groundwater samples was generally consistent at all locations where it was measured and at moderate levels. Therefore not providing clear evidence of carbon dioxide production as a result of biodegradation of hydrocarbon impacts.

Future for hydrocarbon degradation

Based on the natural attenuation data, it appears that natural attenuation has and is occurring within Area 1 in the vicinity of the fuel oil loss plume (AEC 1), within the vicinity of the northern store UST at Area 12 (AEC 35) and in the vicinity of the fuel pad (AEC 44) in Area 15. Given the groundwater conditions, there is potential for natural attenuation to be occurring and occur into the future.

7. Quality of analytical data

Field and laboratory quality assurance and quality control (QA/QC) results have been reviewed and verified for this phase of work. Coffey considers the fieldwork undertaken and soil, sediment and groundwater laboratory analysis are acceptable for the purposes of confirming the reliability and repeatability of the sampling and laboratory analysis procedures. A comprehensive review of the QA/QC results is provided in Appendix H.

8. Summary of results

The investigation undertaken at the site was completed in general accordance with the SAQP (Coffey 2016b). The subsurface conditions encountered beneath the site have indicated deeper fill areas are present closer to the Spencer Gulf where reclamation of land was undertaken for the site construction, and at lesser extents where site surface build up for construction occurred. Where site surface has been build up outside of the Playford areas, ash material is present in the fill. The natural soil surface is encountered at shallower depths further from the Spencer Gulf which is consistent with the site construction with land reclamation activities occurring over time.

Unburnt coal remains at the site in a defined area west of the coal loading area and fuel pad (Area 15) and this area will be included in the future management plan for the site along with the known waste dumps investigated and defined as part of these works.

The DSI has identified that historical activities, as defined in the AECs have caused some impacts to the subsurface. The impacts reported are primarily in line with known historical impacts at the site as identified below. It is noted metals have been reported across the site in fill material and groundwater. The concentrations reported within groundwater are considered to be generally reflective of background levels based on information collected from background locations in the site vicinity over time.

Area 1 – Playford A & B stations

Petroleum hydrocarbon impacts as a result of the historic Playford fuel oil loss (AEC 1) were identified in soils at the depth of the shallow aquifer while installing the secondary aquifer wells. Some TRH chain lengths were reported above the management limits for TRH reflective of a ‘smear zone’ in the soil in the vicinity of the phreatic surface. Groundwater impacts in the form of LNAPL and TRH were also confirmed as expected in this area of the site. The impacts noted are considered to potentially cause an unacceptable dermal contact and ingestion risk to current workers if the ground surface in this area is disturbed and to future users and structures if the impacts remain following closure if strict management protocols are not implemented. The investigation of the secondary aquifer in this area did not find that vertical migration of the impacts down to this water body had occurred.

Soil and groundwater impacts in the form of heavy end TRH have been identified to the north west of Playford B Station, in the vicinity of the SPEL tank and sump (AEC 7A). It is considered likely that the impacts noted are a result of the waste water infrastructure leaks/spills over time and/or surface water seepage due to this area of the site being 2m below the basement grade and the primary aquifer being encountered at 0.4mbgs. The impacts noted are considered to be at concentrations that do not pose a potential unacceptable risk to current and future identified receptors unless the area is excavated.

Shallow heavy end TRH impacts were noted in soils in the areas of the former spoon drains and transformer bunds, likely a result of the storage of the historic transformer storage in these areas of the site (AECs 2, 3 and 5). The minor TRH impacts noted in shallow soils are considered to be isolated and are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Heavy end TRH impacts were also noted in groundwater at the wells on the sea wall installed around the transformer bund (AEC 2 and 5). The impacts to groundwater noted could be a result of transformer oil leaking over time or could be a result of other activities undertaken along the sea wall associated with the Playford B Station such as equipment storage and vehicular traffic. The impacts noted are considered to be at concentrations that do not pose a potential unacceptable risk to current and future identified receptors unless the area is excavated.

The petroleum hydrocarbon groundwater impacts in the vicinity of the SPEL tank and sump (AEC 7A), from the sample from well MW107 and adjacent to the transformers on the sea wall (AEC 2 and 5) were not previously known. As was the case with 1,1 dichloroethane detected in the deeper aquifer at well MW102 beneath the fuel oil plume. These impacts are considered to be of anthropogenic origin and above background concentrations. As there are no water quality criteria within the now withdrawn 2003 Water Quality EPP, in accordance with SA EPA publication *Implementation of the National Environment Protection (Assessment of Site Contamination) Measure 1999* (Updated July 2016) which references SA EPA publication, and the referenced publication *Site contamination: How to determine actual or potential harm to water that is not trivial resulting from site contamination* (EPA 839/08), it is apparent that the EPA would likely consider that actual harm to water that is not trivial has occurred. On this basis these impacts were included in a notification to SA EPA under Section 83A of the EP Act (1993) of site contamination to underground water on 7 February 2017.

Area 2 – Playford B switch yard

The investigation completed around the AECs at Area 2 did not report notable impacts to the subsurface.

Area 3 – Playford buildings

Minor impacts to shallow soils were noted as heavy end TRH across Area 3. The impacts noted could be a result of vehicular traffic through the area and/or activities associated with the maintenance and workshop areas and are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Given the area is primarily made up of maintenance and workshop buildings, the subsurface conditions are unknown beneath the building footprints and as such impacts to the subsurface may exist in areas that have not been investigated as part of this DSI. It is recommended to consider assessment in Phase 3 beneath the building footprints once demolition has occurred.

Area 5 – Steel laydown area

Limited minor TRH impacts in shallow soils were noted at two isolated areas across the steel laydown area, possibly due to the storage of material over time (AEC 21). Given the concentrations noted, the impacts reported are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Area 6 – SPEL drain outlets

Elevated impacts to the sediments have been reported at Area 6 as discussed in Section 6.3.3. Further discussion of these impacts and the potential risk they may pose has been undertaken in Section 9.

Area 7 – Bulk fuel oil storage

The investigation completed around the AECs at Area 7 did not report notable impacts to the subsurface. It is noted that this area will be validated in Phase 3 following the removal of the fuel infrastructure including the AST bund.

Area 8 – Vehicle storage and maintenance area

Elevated concentrations of TRH were noted in soils from one isolated area located to the south of the vehicle maintenance shed and wash down bay (AEC 25) where surface water pools from drainage from the wash down bay (refer Photograph 9). Some TRH chain lengths were reported above the ESLs and it is noted that the impacts reported were not vertically delineated past 1.7mbgs. A potential risk to ecological receptors in this area of the site has been identified on the basis of the Tier 1 assessment.

Minor TRH impacts to soils were also reported at the monitoring well installed to the west of the maintenance shed and wash down bay at the depth of the shallow aquifer. Groundwater impacts were not reported above background levels indicating the soil impacts at this well are not at levels considered to present an unacceptable risk to current and future receptors of the site.

Area 9 – Recycling area

Limited minor TRH impacts in shallow soils were noted in at one isolated area within the recycling area, possibly due to the storage of material over time (AEC 28). Given the isolated nature and low concentrations reported, the impacts are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Area 10 – Former coal loading area

Minor impacts to shallow soils in the form of TRH were noted at a number of locations around the former coal loading area (AEC 29). Given the historical activities undertaken in this area associated with coal loading activities included use of heavy machinery, the former coal conveyor and railway line, it is considered likely that the shallow impacts noted are from these historical activities. Given the concentrations reported it is considered unlikely that these impacts would present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Area 11 – Wastewater, fuel storage and washdown area

Limited minor TRH impacts in shallow soils were noted at one isolated area in the vicinity of the former diesel AST footprint and pumping station (AEC 31A). The impacts noted are possibly from the storage of diesel in this area over time, or could be associated with the transfer of diesel. Given the concentrations reported it is considered unlikely that these impacts would present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Minor TRH impacts to soils were reported at the monitoring well installed adjacent to the fuel transfer pipeline (AEC 31B) at the depth of the shallow aquifer as well as at the monitoring well installed adjacent to the wash down bay (AEC 32). It is considered likely that the former fuel transfer pipeline (AEC 31B) and wash down bay (AEC 32) have been sources of impact to the soils and groundwater historically and have been reported in the smear zone in the current investigation. Given impacts were not reported in the groundwater from these locations, it is considered that impacts may have existed historically that have since decreased and it is unlikely that gross hydrocarbon impacts beneath the subsurface exist that are considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Area 12 – Northern station

Adjacent to the intermediate oily skimmer pit (AEC 34), minor impacts to soils in the form of TRH were reported at the depth of the shallow aquifer. This soil bore was located to the north of the pit where transfer pipework extends and it is possible this infrastructure or releases into the pit have leaked over time. The soil impacts reported were not vertically delineated past 3.0mbgs, however the monitoring well installed on the southern side of the pit did not report any impacts to soils or groundwater indicating the soil impacts are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Soil and groundwater impacts were reported in the form of BTEX and light end TRH in the vicinity of the northern store UST (AEC 35). Historic groundwater impacts were known to exist in this area and were confirmed during the 2016 works to be present in the primary aquifer. On the basis of the available information it is considered unlikely that these impacts would present an unacceptable risk to current and future receptors, unless the subsurface is removed and contact with the impacted soils and groundwater occurs. During the installation of the secondary aquifer well in this area, soil impacts were reported in soils at the depth of the primary aquifer. Vertical migration of impacts to the secondary aquifer has not appeared to have occurred.

Area 13 – Northern station infrastructure

Limited minor TRH impacts in shallow soils were noted at two isolated areas adjacent to the backup diesel generator and shed (AEC 39) and the north eastern side of the main waste oil storage area (AEC 42). The impacts noted are considered likely due to surface spills or leaks rather than the infrastructure leaking given the depth to impacts is less than 0.5mbgs. They are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Area 14 – Steel laydown area

The monitoring well installed to target the area of historic firefighting activities (fire extinguisher training) (AEC 43B) reported a trace concentration of PFOS in the groundwater below interim guidance. The concentrations reported are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use, however soil testing to determine if these impacts are present within the soils is recommended to be completed in Phase 3.

Furthermore PFOS groundwater impacts in the sample from well MW121 were not previously known and are considered to be of anthropogenic origin and above background concentrations. As there are no water quality criteria within the now withdrawn 2003 Water Quality EPP, in accordance with SA EPA publication *Implementation of the National Environment Protection (Assessment of Site Contamination) Measure 1999* (Updated July 2016) which references SA EPA publication, and the referenced publication *Site contamination: How to determine actual or potential harm to water that is not trivial resulting from site contamination* (EPA 839/08), it is apparent that the EPA would likely consider that actual harm to water that is not trivial has occurred. On this basis these impacts were included in a notification to SA EPA under Section 83A of the EP Act (1993) of site contamination to underground water on 7 February 2017.

Area 15 – Coal loading area

Along the coal conveyor sediment area (AEC 19), TRH impacts were noted in shallow soils. This area was utilised as the runoff for the coal conveyor when it was emptied and as such is considered a result of this activity. The concentrations reported are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

During the installation of the secondary aquifer well to the north of the fuel pad (AEC 44), elevated soil impacts in the form of TRH were reported above the ESL and management limits at the depth of the primary aquifer. Minor TRH impacts were also reported at the depth of the primary aquifer from the primary aquifer well installed adjacent. Historic groundwater results indicate this area has been historically impacted by activities associated with the fuel pad. It is considered likely that impacts would have extended to include the area to the north (MW122, MW123 and GW19) historically and have been reported in the smear zone in the current investigation. Given impacts were not reported in the groundwater from these locations, it is considered that impacts may have existed previously that have since decreased and it is unlikely that gross hydrocarbon impacts beneath the subsurface exist. The secondary aquifer groundwater results did not indicate vertical migration of impacts had occurred.

The groundwater in the vicinity of the fuel pad was reported to be impacted with LNAPL and petroleum hydrocarbons to the south of the fuel pad, down gradient form historically reported LNAPL. The impacts noted are considered to potentially pose an unacceptable dermal contact and ingestion risk to current workers if the ground surface in this area is disturbed and to future users and structures if the impacts remain following closure and strict management protocols are not implemented. It is expected that this area will be addressed in Phase 3 following the fuel pad infrastructure removal and at that time the extent of the impacts can be further determined and replacement monitoring wells installed will be utilised to further delineate the known groundwater impacts (if required).

The petroleum hydrocarbon groundwater impacts down hydraulic gradient of the fuel pad (AEC 44), from the sample from well MW124 were not previously known. These impacts considered to be of anthropogenic origin and above background concentrations. As there are no water quality criteria within the now withdrawn 2003 Water Quality EPP, in accordance with SA EPA publication *Implementation of the National Environment Protection (Assessment of Site Contamination) Measure 1999* (Updated July 2016) which references SA EPA publication, and the referenced publication *Site contamination: How to determine actual or potential harm to water that is not trivial resulting from site contamination* (EPA 839/08), it is apparent that the EPA would likely consider that actual harm to water that is not trivial has occurred. On this basis these impacts were included in a notification to SA EPA under Section 83A of the EP Act (1993) of site contamination to underground water on 7 February 2017.

Area 16 – Train unloading area

Along the swale soil drain (AEC 49B) where surface water is drained from this area to the north, minor TRH impacts were noted at two isolated locations not considered to pose an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Area 17 – Ash storage area (Ash pond)

One of the locations undertaken adjacent to the ash pond stage 2 pumps (AEC 50B) reported surface impacts in the form of TRH which are likely associated with a surface spill or vehicular traffic rather than the stage 2 pumps given the sample tested at 0.5mbgs did not report any TRH concentrations. The impacts reported are not considered to present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

Groundwater testing completed in the vicinity of the ash pond at existing APS wells reported some metal concentrations which on the basis of available information, appear to be generally consistent with background concentrations. The presence of the SA Water Waste Water Treatment Ponds in the north west of the ash ponds do not appear to have had a notable influence on the groundwater system with nutrients tested in the wells not noted to be elevated in the vicinity of the sewage ponds when compared to samples from other well locations.

Previous testing of the ash material within the ash pond (Golder 2016 and Coffey 2016c) reported some metals in the material below relevant health guidance. The characteristics of the ash material were reported to be consistent with bottom ash and within the expected ranges for this type of material. It was considered the ash material may be suitable for reuse in a commercial/industrial land use setting, would not degrade concrete piles and may be suitable for reuse as a recycled material for transport infrastructure. It is considered unlikely that given the chemical concentrations reported in the ash material, dust migration to the residential occupants and commercial workers within Port Augusta Township to the north/north west is unlikely to cause potential risks to human health. It is also unlikely an inhalation risk from ash pond material is present to the nearby receptors given the ash pond has since been covered with a dust suppressant and revegetation is to commence in the near future. However it is noted that SA Health have expressed concern about the high overall dust level measured on 1 January 2017 at monitoring stations in Stirling North and at Lea Memorial Oval in the southern outskirts of Port Augusta Township immediately after the dust suppressant had been degraded due to a storm and heavy rain, with that they refer to as "*a high fraction of particulate matter less than 10 microns in diameter (PM10)*" (SA Health 2017a).

It is also considered unlikely, given the concentrations of chemicals reported, that chemicals from the ash material would have leached to the subsurface and the groundwater conditions reported around the ash pond support this conclusion. Engineering solutions to avoid saline seepage from the ash pond are understood to have been implemented in the 1980's following previous saline seepage from the ash pond to the subsurface, particularly down gradient to the west which affected mangroves nearby (refer Section 2.9).

Area 18 – Rail filling area

Some minor TRH impacts were noted along the rail filling area (AEC 52) outside of the HDPE liner at levels that are considered unlikely to pose an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

9. Ecological screening risk assessment – Area 6

9.1. Background

9.1.1. Initiation

Following a review of the analytical results reported from the sediment samples collected in the discharge areas of the three SPEL drains located in Area 6 in June 2016, additional works were undertaken in early November 2016 which included further sampling for supplementary data collection and a flora and fauna assessment of two mangrove areas (refer Sections 4.2 and 6.3.3).

The data collected has been used to undertake this Ecological Risk Assessment (ERA) to evaluate any potential ecological impacts of the discharge from the SPEL drains has had on the mangrove ecosystem located to the south of the Playford area between the Playford Stations and Northern Station. The mangrove ecosystem area under investigation (‘the mangrove’) is shown in Figure 9.1 below and presented in the overall site plan (Figure 8D).

Figure 9.1: Mangrove swamp - area of investigation

The Playford area referred to herein includes the Playford Stations, switch yards, maintenance and workshop sheds and equipment laydown areas, all located north of the mangrove swamp. The Playford area investigations undertaken as part of this DSI, which provide the information for this ERA, include Area 1 (Playford A and B stations), Area 3 (Playford buildings), Area 5 (steel laydown area) and Area 6 (SPEL drain outlets).

9.1.2. Objective

The purpose of the ERA was to assess the potential ecological risks to the mangrove adjacent to the Playford area, primarily relating to discharge waters from the three SPEL drain outlets located north of the mangrove. This information is required to support decisions regarding further remediation or management options that would potentially improve the overall health of the small mangrove swamp under assessment in this area.

Furthermore, this ERA is limited to contaminants previously identified within the swamp sediments and drain waters sampled and does not include an assessment of risks to ecological receptors due to potential impacts from other sources such as atmospheric deposition or the gulf.

9.1.3. Risk assessment approach

The assessment of potential environmental risks was undertaken using a tiered approach as outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000). The approach is outlined as follows:

- Tier 1 – Sediment/surface water contaminant characterisation and comparison to guideline values.
- Tier 2 – Comparison to background concentrations, examination of factors controlling bioavailability and ecological surveys.
- Tier 3 – Acute and chronic toxicity testing.

The scope of work for this investigation is a Tier 1 assessment of the mangrove swamp with some Tier 2 considerations, specifically a comparison to sediment quality in the swamp at a greater distance from the SPEL drains and in a background reference mangrove. In addition a visual evaluation of the ecosystem as provided in a Flora and Fauna Assessment undertaken in November 2016 (refer Appendix I). A more detailed Tier 2 or Tier 3 would only be considered where a potential environmental risk is indicated.

The ecological risk assessment approach adopted is also consistent with the ASC NEPM. The guideline on ERA methodology described in Schedule B5a of the ASC NEPM provides the framework for this preliminary assessment.

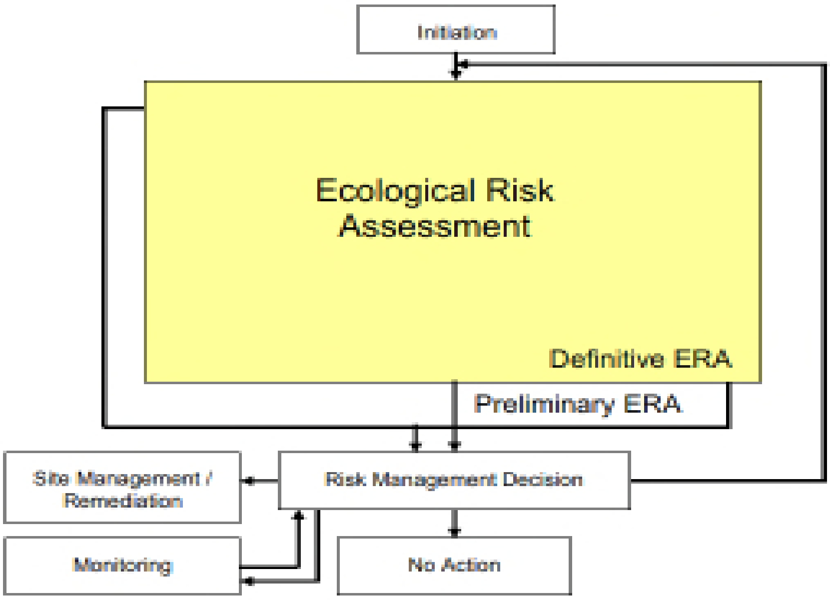


Figure 9.2: ERA framework. ASC NEPM Schedule B5a (2013)

9.2. Site details and surrounding environment

The site is located in the Northern Spencer Gulf which forms part of the South Australia coastal marine environment, located approximately 6km south of Port Augusta. The Northern Spencer Gulf is considered to be an inverse estuary (Baker, 2004) given the salinity increases toward the north resulting from increased evaporation, low rainfall and low surface water runoff. The sheltered shores of the Northern Spencer Gulf, the high salinity, tidal amplitude and warm water temperatures all contribute to conditions that are not found elsewhere in South Australia. The region provides temperate habitats such as coastal saltmarshes, mud flats, seagrass meadows and mangrove forests that contain both tropical and sub-tropical species as well as endemic species.

Although there are mangroves present along the eastern side of the Northern Spencer Gulf in this region, both to the north and south of the site, the Mangrove Area that is the focus of this ERA is surrounded by the power plant facilities (see Figure 9.1):

- Playford A & B Stations and buildings, steel laydown area and the switch yard directly to the north;
- Maintenance and storage area and the Northern Station facility to the east; and
- Process water inlet and outlet channels to the south.

The site has an extensive waste water network across the site, the majority of collected water drained to the ash pond (Area 17) or the contaminated drains pond (Area 11) (refer Section 2.6.4). There are three SPEL drainage outlets located along the south of South Coast Road, adjacent to the northern area of the mangrove swamp as indicated on Figure 8B. Surface water collected from the Playford area infrastructure, primarily the switch yards, maintenance and workshop sheds, equipment laydown areas is discharged to the north and north east of the mangrove swamp via the three SPEL drain outlets. The 'SPEL' system is believed to have been installed at the site in the year 2000. Prior to the SPEL system installation, the drainage system existed predominately in its current form. Outfalls were directed into the Spencer Gulf around the Playford Stations – this was redirected to the SPEL tank and sump following SPEL installation, and into the Spencer Gulf south of the Playford buildings and SAPN switch yard where SPEL drain outlets have since been installed.

The intertidal zone is approximately 470m wide in the vicinity of the site and mangroves occupy the upper region. During high tide, the mangrove trees can be flooded to 1.2m in the deeper area and less than 0.1m in the higher areas (Ecological Associates, 2016).

The mangrove is part of the Upper Spencer Gulf Marine Park and is zoned under the General Managed Use Zone. The zoning is intended to provide protection for habitats and biodiversity within the marine park, while allowing ecologically sustainable development and use. The management of marine parks in South Australia is currently regulated under the Marine Parks Act, 2007.

Seagrass monitoring has been undertaken by FPP as well as others in the area since the 1980’s and has determined no significant changes in the seagrass communities in and around the power station (refer Section 2.8 above).

An assessment of the Hospital Creek discharge to Spencer Gulf undertaken in 2010 by SARDI investigated four components of the ecosystem (sediment, mangroves, seagrasses and infauna) within three control mangrove sites in the area as well as the discharge area to the Spencer Gulf and did not conclude that the environment at Hospital Creek was affected by site activities (refer Section 2.6.2 above).

9.3. Mangrove assessment methodology

9.3.1. Investigations undertaken

Two sediment investigations were undertaken in the vicinity of the SPEL outlets in June 2016 and November 2016 and the results are presented in Table 8A. Two background locations (BS1 and BS2) to the south of the mangrove swamp were also sampled in the November 2016 investigation (refer Sections 2.12.3 and 4.2 and Figure 8B). Additional background samples (BGSS1 and BGSS2) were obtained from the mangrove located to the north east of the Playford B Station (refer Sections 4.2 and 6.3.3 and Figure 8C). It is noted that this mangrove area had die backs in the 1950’s and 1980’s and has had a number of replanting events over time.

In order to understand the potential impacts of the site’s activities on the mangrove swamp, a flora and fauna assessment was undertaken by Ecological Associates in November 2016 (Appendix I). The assessment included an evaluation of the mangrove swamps located north and south of the Playford infrastructure to determine whether the mangrove swamp area subject to this ERA had been significantly degraded as a result of the power station activities. The two swamp sites were of similar areas and classified into condition zones based on aerial photograph review and visual inspection of the sites. It is noted that these same two areas were assessed as part of the EIS for the construction of the Northern Station as described in Section 2.7 above.

A general visual inspection of the condition of the mangrove swamp under ERA and the background mangrove swamp was conducted based on the selected transects and quadrants (Ecological Associates, 2016). The visual assessment included:

- Number of trees;
- Height of each tree;
- Health of each tree based on 5 categories ranging from dead to very good;
- Overall canopy cover of the quadrant;
- Sediment texture;
- Abundance of pneumatophores (aerial roots);
- Abundance of barnacles;
- Presence of woody debris; and

- Presence of other plants such as filamentous algae and samphire which affect mangrove tree health.

Whilst other flora and fauna may have present at both mangrove sites assessed, it should be noted that a formal ecological survey was not conducted as part of the assessment.

9.3.2. Beneficial uses and guidelines

In order to decide on the appropriate guideline values to be applied to the mangrove swamp, the environmental values, or beneficial uses must be determined based on local environmental conditions.

Generally, mangrove swamps and forests are considered to be important coastal ecosystems as they stabilise mudflats, and offer ecological niches for important species such as crabs, fishes, molluscs spiders and birdlife. On the basis mangroves provide refuge and sources of food for a vast number of organism, they are often considered to have high ecological value. At present, the mangrove under ERA is considered to be part of the Upper Spencer Gulf Marine Park but is currently not within a habitat protection, sanctuary or restricted access zone.

The condition of the mangrove ecosystem under assessment is determined based on its location, condition and ecological value. Based on the following information, the mangrove is considered to be highly disturbed:

- Located in a marine park however is adjacent to a former power station facility;
- Outcomes of the flora and fauna assessment undertaken in November 2016 report the ecosystem of the mangrove swamp under ERA is considered to be degraded with some areas more severely disturbed than others; and
- Mangrove swamps are considered to have high ecological value however the mangrove under ERA is in the vicinity of larger mangrove swamps that are relatively un-impacted.

9.4. Mangrove area conceptual site model

9.4.1. Mangroves adjacent to APS

In South Australia mangrove distribution is limited given the climate. *Avicennia marina*, the white or grey mangrove, is the only mangrove species found in South Australia. Mangrove swamps are considered to be depositional environments where sediments are consistently deposited as a result of decomposing organic material from mangrove trees, detritus feeders and sediments transported via tidal flows. The ecology of mangroves is diverse as they support a wide variety of fauna.

As detailed in Section 2.7 above, the area of mangroves under ERA had a number of die backs in the 1950's from the sulphur dioxide emissions from the Playford chimneys. These chimneys were replaced by the one 80m chimney in 1961 and aerial photography up to 1984 showed recovery and stabilisation of the mangroves from this event (Kinhill Stearn, 1986).

The health of the mangrove swamp under ERA varies considerably and observations indicate a number of factors are likely to be contributing. A potential source of contaminants to the mangrove is via the three SPEL drains that have discharged surface water from the Playford area. The condition of the mangroves down gradient of SPEL 1, and along assumed drainage lines, were noted to be particularly degraded.

Run-off from roads adjacent to the eastern and southern boundaries of the mangrove are also likely to occur. Historical activities such as vehicle washing are understood to have occurred in the areas adjacent to the mangrove swamp and associated water run-off to the swamp.

The development of the Northern Station included the removal of mangrove habitat in the construction of the Northern Station infrastructure including the cooling water channels to direct water from the gulf into the plant for cooling purposes. The returned warm water was via the more southern channel outlet. The sand bars created to direct gulf water extends beyond the mangrove vegetated areas into the open water. The sand bars are likely to impact the movement of water flow and tidal flushing in the mangrove. The mangroves in this area were markedly changed in the 1980's by mechanical disruption and as such, the mangrove community within this area has been highly modified.

Groundwater flow direction beneath the former power station site is towards the west. The recent groundwater monitoring event indicated immediately up-gradient monitoring wells in Areas 8, 11 and 12 (refer to Figure 2B) reported all analyte concentrations below the laboratory LOR. Metals were not included in the analytical suite for these areas during the current investigation, however based on the soil analytical data known and activities undertaken in these areas, it is unlikely elevated concentrations of metals would be present in the groundwater system as a result of site contamination.

Mangroves ideally prefer a mix of fresh and marine waters however the ongoing discharge of freshwater to certain areas may impact the balance required for healthy tree growth. The vegetation at the SPEL 1 discharge area, and along associated drainage lines, are further up the shore line and potentially receive reduced tidal saline water exposure and hence may be more susceptible to exposure to excess freshwater as a result.

Sediments are important, particularly in a mangrove swamp or forest, as they act as both a source and as a sink of dissolved metals. As well as influencing surface water quality, sediments represent a source of bioavailable metals to benthic biota and hence potentially to the aquatic food chain.

9.4.2. Mangrove assessment observations

The flora and fauna assessment undertaken by Ecological Associates (2016) (included in Appendix I) classified the vegetation conditions of the mangrove under ERA and background mangrove site into three zones (refer to Figure 8F). The following summarises the findings of the assessment.

Figure 9.3: Vegetation condition mapping for the mangrove control site based on 2009 imagery (Ecological Associates, 2016)

The northern control site as shown in Figure 9.3 above, mangrove vegetation is in good condition, with the presence of barnacles and dense pneumatophores, and does not appear to show signs of environmental impact. The mangrove tree condition was generally considered be moderate to very good. The canopy cover ranged from 75% shade in the Shore Zone to 20% in other areas where the tree density was less but the trees were generally in good health. Tree height was more than 2m in most trees however tree density across the zones was considered low, attributable to presence of largely mature trees.

It is noted this area of mangroves has suffered die backs on numerous occasions due to the sulphur dioxide emissions from the Playford chimneys in the 1950's as well as a 'slug' of highly saline groundwater migrating through these mangroves from the ash pond in the 1980's (Kinhill Stearn, 1986).

Figure 9.4. Vegetation condition mapping for the mangroves based on 2009 imagery (Ecological Associates, 2016)

The mangrove under ERA as shown in Figure 9.4 above, was observed to be in poorer condition. For the purposes of this assessment the investigation area has been divided into three zones on the basis of vegetation mapping. Refer to Figure 9.4 for the location and extent of the designated zones. Tree condition in Zone C, located in the deepest waters, were in good condition however Zone B trees in the central area of the mangroves were mainly moderate or good condition with a significant portion in poor condition. Trees in Zone A were mostly dead. Zone A generally includes the discharge area related to SPEL 1 and the eastern portion of the mangrove. Canopy coverage ranged from 20-30% in Zones B and C due to low tree density and <1% in Zone A. Tree height in Zone A was mostly <1m and included dead seedlings and stumps of dead immature trees. Zone B also contained a large number of trees < 1m, including many juvenile trees. The majority of trees in Zone C were 2-3m tall. Tree density in Zone C was low however Zone A and B were considered high due to the high numbers of seedlings and immature trees in Zone B.

While the flora and fauna assessment indicated that degradation of this area appears to have occurred between 2002 and 2009, historical aerial photography between the 1950's and 2016 does not support this and indicates the area has recovered from the 1950's dieback, and stabilised following the Northern Station construction disruption. This area has also had a number of replanting events.

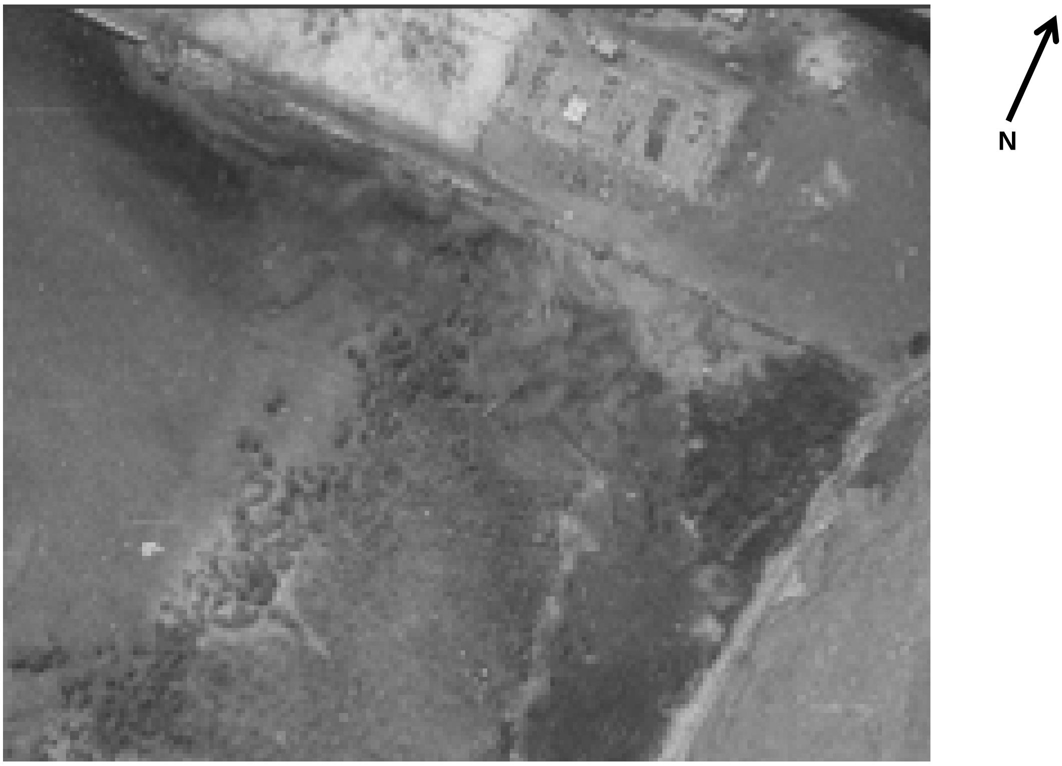


Figure 9.5: Historical aerial photography, 1963 (DEWNR, 2015)

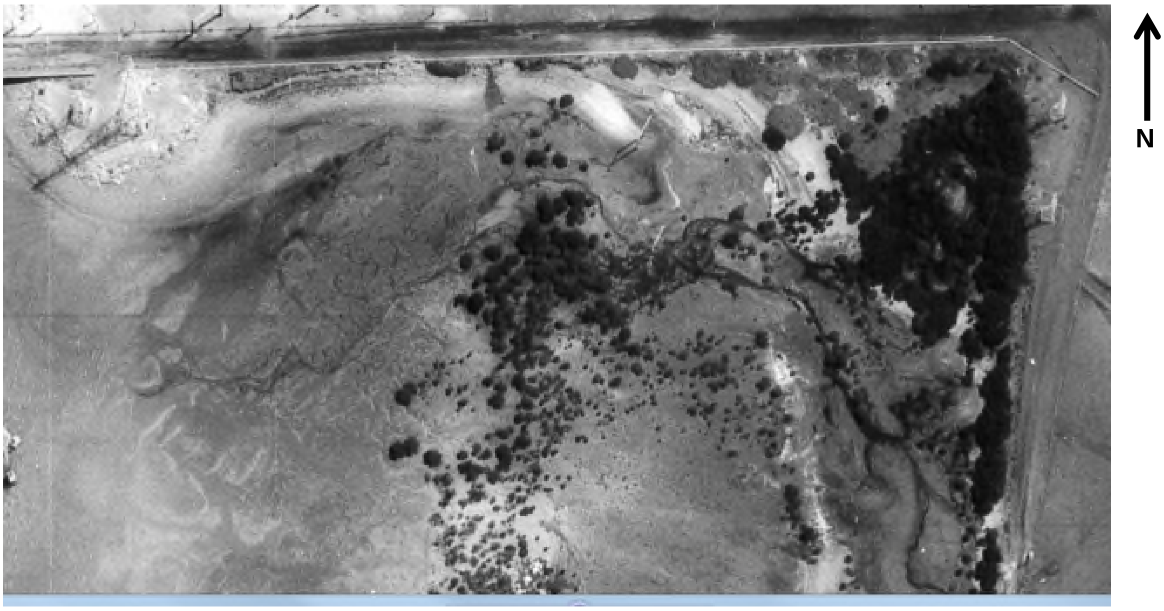


Figure 9.6: Historical aerial photography, 1972 (DEWNR, 2015)

Figure 9.7: Historical aerial photography, 1984 (DEWNR, 2015)

Figure 9.8: Historical aerial photography, 2016 (Google Earth, 2016)

9.4.3. Sediment results

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality –Interim Sediment Quality Guidelines (ISQG) (ANZECC/ARMCANZ, 2000) were adopted for the assessment of sediments (refer Section 6.3). The ISQG are adopted from international data given limited Australian information is available. The ISQG are applicable to both marine and fresh water environments.

A number of the screening criteria have a low trigger level value ($ISQG_{low}$) where detected concentrations below this value are considered to pose a low risk and require no further action. Where a measured concentration is in-between the low and high ISQG, the background concentrations are considered to ascertain local or regional natural levels of a chemical. Where background concentrations are similar, the risk of effects to the ecology are considered to be low. In the event both the background concentrations and the high ISQG criteria are exceeded, further evaluation of the contaminant's bioavailability is recommended.

Background sediment samples collected in the mangrove control site (BGSS1 and BGSS2) are considered to be more representative of background concentrations in this portion of the Northern Spencer Gulf as opposed to the samples obtained further south of the SPEL drains in the mangrove under ERA (BS1 and BS2). In addition, sediment results from the SARDI (2010) investigation are considered to be representative of background conditions in the area.

Sample locations relating to the mangrove area are presented in Figure 8A and 8B and background sample locations from the north are shown in Figure 8C. Full analytical results from both the June and November 2016 sediment investigations are presented in Table 8A. A summary of the analytes detected above the laboratory LOR in sediments are presented below in Table 9.1.

Table 9.1: Sediment screening assessment

Chemical	ISQG[1]		Alternative guideline	Maximum concentration (mg/kg)	Background concentration (mg/kg)		Samples that exceed guidelines
	Low	High			Mangrove control site (BGSS1 & BGSS2)	In the south of the mangrove under ERA (BS1 & BS2)	
TRH $C_6 – C_9$	NE		500 (5)	<20	<20	<20	Not applicable
TRH $C_{10} – C_{14}$	NE			110	<50	<50	-
TRH $C_{14} – C_{28}$	NE			3400	<50	68	SPEL1-1, 1-2,1-3, 1-4, 1-5, 1-6
TRH $C_{28} – C_{36}$	NE			3900	<50	<50	
Arsenic	20	70	-	44	2.5	9.8	-
Boron	NE		440 (4)	200	-	220	-
Beryllium	NE		6.8 (4)	4.7	-	3.4	-
Cadmium	1.5	10	-	1.4	0.5	<0.4	-
Chromium (III)	80	370		-	-	<1	-
Chromium (VI)				60	8.5	-	-
Cobalt	NE		34 (4)	85	-	17	SPEL1-5, SPEL3-4, 3-5, 3-6
Copper	65	270	-	1400	6.7	43	SPEL3-4
Lead	50	220	-	210	<5	30	-
Manganese	NE		1100 (6)	4100	-	500	SPEL1-5, SPEL3-4, 3-5
Mercury	0.15	1	-	75	<0.1	<0.1	SPEL3-4, 3-6
Nickel	21	52	-	120	<5	26	SPEL3-4, 3-6
Selenium	NE		2 (7)	<2	-	<2	-
Zinc	200	410	-	2800	26	300	SPEL1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 2-1, 2-2, 2-3, 2-5, 2-6, 3-1, 3-3, 3-4, 3-5, 3-6
Total PCB	23	-	-	10	<0.1	<0.1	-

NE = Not established

Shading indicates the adopted screening criteria is exceeded

1 ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Interim Sediment Quality Guidelines (ISQG).

2 Mangrove swamp located north of Playford facility.

3 Located in southern portion of mangrove swamp, furthest from SPEL outlets.

4 Based on 2 x background concentration (ANZECC/ARMCANZ, 2000)

5 Atlantic PIRI (2012)

6 Based on freshwater. OMOE (2008)

7 Based on freshwater. BC MOE (2006)

9.4.4. Annual SPEL drain water monitoring

Annual monitoring of the drain water collected at the three SPEL locations was undertaken by FPP staff from 2007 to 2016 as part of the site's environmental licence compliance. The analysis included arsenic, chromium, copper, lead, TRH fractions, grease and total suspended solids. Given the drain waters are assumed to be discharging to a marine environment, the marine water guidelines were adopted. Exceedances of the marine investigation levels relating to chromium, copper, lead and TRH were detected at various times. Lead and chromium exceedances were reported at all locations, with lead detected in every investigation at one or more locations. Copper exceedances reported at SPEL 1 and SPEL 2. Grease and suspended solids were detected at each location in most annual events however whilst no guidelines have been established for these parameters, both have potential to impact mangrove habitat.

Full analytical results as provided by FPP from the annual SPEL water sampling are presented in Table 8B.

9.4.5. Chemicals of potential concern

Historical site information indicates that the groundwater collected area north of the mangrove may have contained a number of chemicals that were associated with the power station activities including fuel oil loss, storage and use of transformers, maintenance and workshop and general dumping of waste. It is understood the waste dump in immediately north of the mangroves comprises construction waste from SAPN upgrades to the SAPN switch yard (Area 4).

Hazardous substances associated with the these activities could include petroleum hydrocarbons, chlorinated hydrocarbons, PCBs, PAHs, and metals, such as arsenic, barium, beryllium, cadmium, chromium, lead, mercury, nickel, selenium, zinc.

Concentrations of COPCs identified in the sediments associated with the SPEL 1, SPEL 2 and SPEL 3 outfalls above the ANZECC/ARMCANZ (2000) sediment investigation levels or adopted guideline values, during the June and November 2016 investigations include cobalt, copper, manganese, mercury, nickel, zinc and TRH. As these substances were detected above the high ISQG as well as the expected background levels, they were considered COPCs for the mangrove swamp.

Whilst TRH has been detected in the sediment in the mangrove and some uncertainty may be present as it is not known whether these concentrations may include hydrocarbons due to other sources, including natural organic matter, given the TRH measured in the un-impacted northern mangrove was not detected above the LOR, the TRH impacts noted are assumed to be due to petroleum hydrocarbons rather than natural organic matter.

The COPCs potentially associated with the SPEL drain discharges and other surface water runoff sources from adjacent roads, were therefore considered to be:

- Metals:
  - Cobalt
  - Copper
  - Manganese
  - Mercury
  - Nickel
  - Zinc
- Heavy TRH fractions $>C_{14}$; and
- Grease.

9.5. Exposure assessment

9.5.1. COPC toxicity and bioavailability

Mangroves are, however, particularly susceptible to heavy metal build up because of their particular habitat, for instance, sediments tend to be fine grained and rich in organic matter. The dissolved metals readily bind to organic carbon and for that reason mangrove sediments are considered to be a sink for heavy metals.

Sediment and water concentrations alone do not determine availability or uptake of metals by organisms. Metal bioavailability to ecological receptors is controlled by complex physical, chemical, and biological factors that affect exposure and uptake patterns. These factors include metal speciation, metal concentration in aqueous and particulate (food) phases, and ecological processes such as feeding strategies and the position in the food chain of exposed organisms (Chen et al, 2016).

Adverse ecological effects arising from exposure to hazardous substances are dependent on a large variety of factors. These factors include the intrinsic toxicity of the substance; the characteristics of the environment; the intensity and duration of the exposure; the biological and behaviour characteristics of the exposed species; and concurrent exposure to other hazardous substances with similar toxic effects.

Metals such as copper, manganese, mercury, nickel and zinc are known to bioaccumulate in organisms. All of these metals are considered to be toxic. They cannot be biologically degraded and become concentrated in sediments over time as a result of pollution and other industrial and urbanisation activities. Mercury can be methylated to form the more toxic methylmercury compound. Methylmercury has been shown to bioaccumulate in biota at higher concentrations than found in sediments.

Petroleum hydrocarbons are not considered to bioaccumulate as they are readily metabolised. Heavier TRH fractions readily adsorb to organic matter.

9.5.2. Receptors of potential concern

Mangroves produce large amounts of organic litter such as leaves, twigs, bark, flowers and seeds which are consumed by detritus feeders. Whilst some of the detritus is consumed by crabs, fungi and bacteria are vital in the process as these micro-organisms produce waste which provides food for molluscs, small crustaceans and fish.

In the mangrove areas where roots are permanently submerged, the organisms living there include algae, barnacles, oysters, sponges, and bryozoans. Shrimps and mud lobsters use the muddy bottoms as their home. Mangrove crabs mulch the mangrove leaves, adding nutrients to the mud for other bottom feeders.

Mangroves also provide safe nesting and feeding sites for herons, egrets and other birds and are also home to a variety of snakes and spiders.

The mangroves are used by spawning adult fish and post-larvae of Mud Cockles. They provide a nursery area for juvenile Blue Swimmer Crabs, Western King Prawns, juvenile baitworms and Mud Cockles. Juvenile of fish species that use these as a food source include School Whiting, King George Whiting, West Australia Salmon, Tommy Ruff, Southern Sea Garfish, Yellow-eye Mullet, flathead species and flounder species (Ecological Associates, 2016).

A detailed flora and fauna survey has not been conducted however based on general mangrove ecosystems and the information provided in the flora and fauna assessment (Ecological Associates, 2016) (Appendix I) the ecological receptors at the wetland include:

- Avicennia marina, the white or grey mangrove tree;
- Aquatic benthic macroinvertebrates (crabs, polychaetes, bivalves and barnacles);
- Aquatic microinvertebrates;
- Fish; and
- Avifauna.

9.5.3. Exposure evaluation

Adverse effects may be associated with chemical exposure to flora and fauna via ingestion, respiration and/or direct contact pathways. An exposure pathway consists of the following elements:

- A source and mechanism for release;
- A storage and/or transport medium (e.g. contaminants stored in soil, volatilise and are transported into the atmosphere);
- An exposure point, where the receptor comes in contact with the contamination; and
- An exposure route (e.g. respiration and dermal).

The physico-chemical characteristics of the COPC and the behaviour of the receptor of interest will determine the method of exposure and subsequent systemic absorption.

The potential exposure pathways are presented in Table 9.2, based on ecological receptors within the Mangrove.

Table 9.2: Exposure pathways checklist - sediment

<table>
<tr><th>Source</th><th>Transport</th><th>Exposure point</th><th>Exposure route</th><th>Potential receptors[1]</th><th>Complete pathway[2]</th></tr>
<tr><td rowspan="13">SPEL discharge water</td><td>Volatilisation</td><td>Outdoor air[3]</td><td>Respiration</td><td>• Flora
• Fauna</td><td>×</td></tr>
<tr><td colspan="2" rowspan="2">Plant Uptake</td><td>Plant uptake</td><td>• Flora</td><td>✓</td></tr>
<tr><td>Bioaccumulation</td><td>• Fauna</td><td>✓</td></tr>
<tr><td rowspan="10">Drainage lines</td><td rowspan="6">Surface water</td><td>Ingestion</td><td>• Flora
• Fauna</td><td>✓</td></tr>
<tr><td>Aerosol</td><td>• Flora
• Fauna</td><td>×</td></tr>
<tr><td>Respiration</td><td>• Flora
• Fauna</td><td>✓</td></tr>
<tr><td>Direct contact</td><td>• Flora
• Fauna</td><td>✓</td></tr>
<tr><td>Plant uptake</td><td>• Flora</td><td>✓</td></tr>
<tr><td>Bioaccumulation</td><td>• Fauna</td><td>✓</td></tr>
<tr><td rowspan="4">Sediment</td><td>Ingestion</td><td>• Flora
• Fauna</td><td>✓</td></tr>
<tr><td>Direct contact</td><td>• Flora
• Fauna</td><td>✓</td></tr>
<tr><td>Plant uptake</td><td>• Flora</td><td>✓</td></tr>
<tr><td>Bioaccumulation</td><td>• Fauna</td><td>✓</td></tr>
</table>

1 Assessment of human receptors was outside the scope of works.
2 Includes both current and future pathways.
3 Emissions from groundwater to outdoor are considered to be negligible.

Metals and TRH in sediment and pore-water are considered to be important routes of exposure in coastal food webs. Exposure is expected to be greatest for vegetation, aquatic microinvertebrates, benthic invertebrates and fish due to longer exposure durations to the COPC. Avifauna may potentially be exposed to COPC predominantly via direct contact and bioaccumulation of some COPC in plants and other fauna.

9.6. Risk characterisation

The detection of cobalt, copper, manganese, mercury, nickel, zinc and heavy chained TRH in sediments in the vicinity of the SPEL drain outlets, at concentrations exceeding the screening criteria, indicates ecological receptors in these areas are likely to be impacted. This is generally confirmed in the flora and fauna assessment which found the habitat in the vicinity of SPEL 1 to have dead vegetation and the absence of barnacles.

The extent of impacts in sediments beyond the area sampled is not known. Background samples collected from the southern extent of the mangrove (BS1 & BS2) suggest the impact is potentially concentrated in the north. The flora and fauna report found the poorest habitat at the mangrove (Zone A) extends approximately 130m south and south west of SPEL 1 (refer to Figure 9:4 above in Section 9.4.1 for Zone A extents).

Other factors are also likely to be impacting the mangrove and should be taken into consideration. Surface water run-off from adjacent roads is also likely to be contributing to the TRH and metal impact. In addition, the area immediately adjacent to the roads, SPEL drains and along drainage lines are likely to be exposed to more freshwater than other areas of the mangrove.

Whilst a detailed flora and fauna survey was not conducted as part of this assessment, it is possible that mangrove areas that are in poor health are more susceptible to plant disease such as phytophthora cinnamomi root rot fungus and excessive algal growth that would further impact the mangrove ecosystem.

Physical changes to the mangrove habitat as a result of the construction of the Playford Stations and Northern Station water channels have potentially altered tidal flushing and drainage patterns.

Metal impact in groundwater discharging to the mangrove is not expected to be occurring given the known soil conditions and activities undertaken in the vicinity of the mangroves. The contribution of TRH is considered to be negligible given groundwater results in up-gradient areas (Area 8 and 12) adjacent to mangrove are generally below the laboratory LOR.

Sediment sampling and flora and fauna assessment of the background mangrove located north of the Playford Stations suggest other potential sources of impact such as the gulf waters are unlikely to be contributing factors in the health of the mangrove.

9.7. ERA conclusions

A qualitative ecological risk assessment has been conducted to evaluate the potential impacts on ecological receptors within the small area of highly disturbed mangrove swamp situated to the south of the Playford Stations posed by the historical activities of the site. Based on available data, concentrations of cobalt, copper, manganese, mercury, nickel, zinc and heavy chained TRH fraction in sediment, as presented in this report, may present an unacceptable risk to ecological receptors within the mangrove swamp immediately south of the Playford Stations. The extent of metal and TRH impact in sediments is considered to be localised with samples collected in the south of the mangrove not exceeding screening criteria.

Annual water sampling of the SPEL water outlets collected by FPP staff only tested for a limited range of chemicals, however reported concentrations of copper, chromium and lead exceeded the marine ecological risk screening criteria. Grease and TRH were consistently detected in the highest concentrations at SPEL 1, located at the north eastern area of the mangrove swamp. It is possible surface runoff collected from the adjacent roads and washing areas have contributed to the TRH impacts in the drain water.

Suspended solid concentrations varied across the SPEL drains over the 10 year sampling period. Whilst there is no criteria for this parameter, excess suspended particulate matter may cause smothering of benthic organisms and carry chemicals such as metals. Grease and particulates may contribute to the suffocation of the mangrove trees' important oxygen obtaining pneumatophore roots, limiting the plants ability to obtain oxygen.

The flora and fauna assessment concluded the observed mangrove vegetation generally provided a poor habitat for marine fauna. The impacts were noted to be greatest in the east of the swamp and extended through the drainage lines toward the west. The dead vegetation in Zone A also represented a poor physical habitat. The upper vegetation in Zone B is considered poor however the understorey appeared to be more hospitable to fish and benthic invertebrates. The least impacted Zone C, located to the west of the mangrove area closest to the gulf waters, was healthy and compared favourably with the unaffected background mangrove swamp. It is noted that the mangrove area has suffered known die backs in the 1950's and aerial photography shows the recovery of the mangrove community since this point as well as following on from the disruption caused by the Northern Station construction. It is noted a number of replanting events of the mangroves to the south of the Playford Stations has occurred over time.

The quantity and frequency of discharge of waters from the SPEL outlets is not known however the impact of freshwater is also likely to affect the flora and fauna of the swamp. Mangrove trees are well adapted to a saline environment and ideally prefer a 50/50 mix of marine and freshwater. Trees, particularly located near the drain outlets or roadway runoff and along drainage lines that were subjected to higher levels of freshwater may have suffered a decline in health as a result.

The physical change to tidal flows as a result of the Northern Stations process water inlet and outlet channels, as well as the reclaimed land for the Playford areas, may also contribute to impact to sediment deposition in the swamp area and drainage of both tidal and surface waters.

Sediment sampling and flora and fauna assessment of the background mangrove located north of the Playford stations suggest other potential sources of impact such as the gulf waters are unlikely to be contributing factors in the health of the mangrove area under assessment. It must be noted that this area of mangroves has suffered die backs in the 1950's and 1980's.

Seagrass monitoring has been undertaken by FPP as well as others in the area since the 1980's and has determined no significant changes in the seagrass communities in and around the power station indicating any discharge from the mangroves to the Spencer Gulf is not having a detrimental effect on the marine ecosystem. On the basis the flora and fauna assessment concluded the mangrove vegetation in the area subject to this ERA was degraded and provided a poor habitat for marine fauna, the location and activities of the power station, particularly the construction of the Northern Station are considered to have contributed to the environmental degradation of the mangrove. Although waters discharging from the SPEL drains are potentially a source of the impact in north and east of the mangrove, other factors are also likely to be contributing to the deteriorating health of the mangrove habitat.

10. Conceptual site model update

10.1. Human health risk assessment

The ASC NEPM (NEPC, 2013) provides a framework for undertaking assessment of potential risk to human health caused by site contamination. The framework comprises the following components:

- Issues identification;
- Hazard assessment (often called toxicity assessment);
- Exposure assessment;
- Risk characterisation; and
- Risk communication and management.

The issues identification process was undertaken during the previous PSI which lead to the compilation of a preliminary CSM. Hazard assessment, exposure assessment and risk characterisation have been achieved through detailed site characterisation and a Tier 1 generic screening level assessment through comparison of site data with relevant ASC NEPM health risk screening criteria.

10.2. Ecological risk assessment

The ASC NEPM (NEPC, 2013) provides a framework for undertaking assessment of potential risk to the environment which is essentially similar to that adopted for human health risk assessment.

The current investigation has identified localised TRH concentrations that could potentially result in an unacceptable risk to ecological receptors. It should be noted that the ASC NEPM states that ESLs presented for hydrocarbon fractions $>C_{16}$ are regarded as being of low reliability.

The impacts noted above the ESLs in Area 8 can be addressed by remediation of the impacted soils or through additional tiers of risk assessment following the ASC NEPM framework. The impacts noted above ESLs in Area 15 around the fuel pad were revealed during installation of a monitoring well and as such are unable to be addressed at this time by remediation but could be subject to additional tiers of risk assessment following the ASC NEPM framework. It is noted the fuel pad area will be further evaluated in Phase 3 works following fuel infrastructure removal.

Refer to Section 9 on the site-specific ecological risk assessment undertaken for Area 6.

10.3. Aesthetics and other potential risks

In accordance with Section 3.6 of ASC NEPM (NEPC 2013) (Schedule B1), observations on the aesthetics of the site were noted, however given the site is currently being demolished, any aesthetic issues that may be present will be assessed following the completion of the site demolition works. It is noted that remaining coal was removed from the coal loading area prior to the DSI fieldworks to the extent practicable with this area since revegetated and remaining coal was being removed from the coal conveyor prior to demolition during the DSI fieldworks. An area of unburnt coal remains at the site and is defined for inclusion in the future management plan for the site.

The extent of the ash storage area is well defined with a detailed survey plan available. The area has been covered with a dust suppressant to avoid any future dust events towards the Port Augusta Township and rehabilitation through revegetation of the area will be undertaken in the near future to further limit airborne ash material migrating to nearby receptors.

Historical waste dumps were investigated with the extents defined and these areas can be managed through implementation of a site management plan for the site following completion of Phase 3 works.

Within Area 1 around the Playford fuel oil loss, and Area 15 around the fuel pad, soil impacts were reported above the ASC NEPM Management Limits. As indicated in Section 6.2, the purpose of management limits is to “avoid or minimise” potential effects of petroleum hydrocarbons and the ASC NEPM Schedule B (1) identifies these effects as:

- Formation of observable LNAPL;
- Fire and explosive hazards; and
- Effects on buried infrastructure.

Given the areas these impacts have been reported have had historical LNAPL impacts reported, the impacts noted above management limits are expected to represent the formation of observed LNAPL within the subsurface. As both of these areas will be addressed within Phase 3 works, it is not considered that these impacts will present a potential risk of fire and explosives hazards or degradation of buried infrastructure in the future.

10.4. Summary of evaluation of exposure pathways

The plausible potentially complete exposure pathways identified from the preliminary CSM set out in Section 3, Table 3.1 have been re-evaluated on the basis of the findings of the current investigation. The findings of this re-evaluation are presented in Table 10.1 below.

Table 10.1: Re-evaluation of exposure pathways identified from preliminary CSM

Hazard/source of contamination	Key areas affected	Potential transport mechanisms and exposure routes	Key potential receptors
Hydrocarbon impacted soils/sediments and groundwater	• Playford stations – Playford fuel oil loss, sea wall around the transformer storage area and adjacent to the SPEL sump and tank • Northern station – in the vicinity of the unleaded UST at the Northern station store • Fuel pad within the coal loading area • SPEL drain outlets at Area 6 • Possibly beneath existing fuel infrastructure including the bulk fuel oil storage areas, fuel transfer pipelines and diesel ASTs • Possibly beneath wash down areas, maintenance and workshop sheds across the site	• Dermal contact & ingestion • Surface water infiltration • Lateral and vertical migration through permeable strata and groundwater	• Current and future workers of the site • Future users of the site • The flora and fauna within the mangrove ecosystem • Marine ecosystems within Spencer Gulf • Users of Spencer Gulf
Metals impacted soils/sediments	• SPEL drain outlets at Area 6	• Surface water infiltration	• The flora and fauna within the mangrove ecosystem

11. Conclusions

The objective of the DSI reported herein was to assess if site historical activities as defined in the AECs have caused site impacts and if these impacts present a potential risk to identified site receptors under the proposed continued commercial/industrial land use.

The subsurface conditions encountered beneath the site have indicated deeper fill areas are present closer to the Spencer Gulf where reclamation of land was undertaken for the site construction, and at lesser extents where site surface build up for construction occurred. Where the site surface has been built up outside of the Playford areas, ash material is present in the fill. The natural soil surface is encountered at shallower depths further from the Spencer Gulf which is consistent with the site construction through land reclamation over time.

Unburnt coal remains at the site in a defined area west of the coal loading area and fuel pad (Area 15) and this area will be included in the future management plan for the site.

With the exception of previously known areas of historical fuel losses, gross soil and groundwater impacts have not been identified from the DSI works completed in relation to the previously defined AECs. The minor hydrocarbon impacts not previously identified have been noted in shallow soils in various areas within the site but are generally considered to be isolated and unlikely to present an unacceptable dermal contact or inhalation risk to current and future identified receptors with respect to ongoing commercial/industrial land use.

Localised previously identified hydrocarbon impacts to the primary aquifer have been confirmed, however given the groundwater conditions, there is potential for natural attenuation to be occurring and occur into the future which will continue to reduce the severity and extent of these impacts.

The secondary aquifer was investigated in areas of historical petroleum hydrocarbon impacts (Area 1, Area 12 and Area 15). Vertical migration of impacts into the secondary aquifer was not apparent in these areas.

Known historical impacts associated with the Playford fuel oil loss (AEC 1) have been confirmed within the unsaturated zone and within the primary aquifer during the investigation as LNAPL and dissolved phase petroleum hydrocarbons. The impacts identified are considered to potentially pose an unacceptable dermal contact and ingestion risk to current workers if the ground surface in this area is disturbed and to future users and structures, if the impacts remain following closure and if strict management protocols are not implemented. The previous DRA completed for the Playford fuel oil loss (EP 2014) indicated that the plume is stable and shrinking and unlikely to expand to reach the marine ecosystem. Information obtained from the DSI support these findings.

The Playford area is currently being demolished with demolition of the area expected to be completed in 2018, no ground disturbance in the vicinity of the fuel oil loss plume is expected during demolition as the plume is located between the Playford A and B Stations. Following the demolition works, the impacts noted are to be further assessed as part of Phase 3 of the site contamination assessment and appropriate mitigation measures will be implemented to manage identified potential risks to human health.

Petroleum hydrocarbons are also present in soils and dissolved in groundwater in the vicinity of the sea wall adjacent to Playford B Station (AEC 5) and adjacent to the SPEL tank and sump to the north west of Playford B Station (AEC 7A). The impacts noted are considered to be at concentrations that are unlikely to pose a potential risk to current and future identified receptors unless the area is excavated and appropriate management protocols are not implemented.

TRH impacts were noted at concentrations above generic ASC NEPM ESLs locally at the vehicle storage and maintenance area (Area 8, AEC 25) which potentially pose a risk to ecological receptors.

The soils in the vicinity of the fuel transfer pipeline (AEC 31B) and wash down bay (AEC 32) (Area 11) reported some minor TRH impacts at the depth of groundwater. It is considered likely that these sources have been sources of impact to the soils and groundwater historically and have been reported in the smear zone in the current investigation. Given impacts were not reported in the groundwater from these locations, it is considered that impacts may have existed historically that have since attenuated and it is considered unlikely that gross hydrocarbon impacts beneath the subsurface exist that present an unacceptable risk to current and future receptors at the site with respect to ongoing commercial/industrial land use.

The soils and groundwater in the vicinity of the northern store UST located at the Northern Station (Area 12, AEC 35) are confirmed to be impacted in line with historical data and confirm an unleaded petrol source based on the composition of chemicals reported. It is likely the impacts reported are from surface spills/leaks from the dispensing pump associated with the UST leaching into the soil and shallow groundwater from surface water infiltration rather than a breach in the UST given the up and down gradient monitoring wells do not report impacts to groundwater. The impacts noted are considered unlikely to present an unacceptable risk to current and future receptors, unless the subsurface is removed and contact with the impacted soils and groundwater occurs.

A trace concentration of PFOS was reported in the groundwater in the vicinity of the firefighting training area (fire extinguisher training) (AEC 43B, Area 14).

Around the fuel pad (AEC 44) at the coal loading area (Area 15), soil and groundwater impacts have been reported that could pose a potentially unacceptable risk to current workers if the ground is disturbed and to future users and structures if the impacts remain following closure and if strict management protocols are not implemented. The groundwater impacts reported to the south of the fuel pad remain undelineated down gradient to the south west. It is understood that this area is to be revegetated and the fuel pad will be removed.

Groundwater testing completed in June 2016 in the vicinity of the ash pond (AEC 50A) did not report chemicals above likely background concentrations. The presence of the SA Water Waste Water Treatment Ponds in the north west of the ash ponds do not appear to have had a notable influence on the groundwater system with nutrients tested in the wells not noted to be elevated in the vicinity of the sewage ponds when compared to other well locations. It is noted there are discrepancies in the results of testing conducted by FPP and Coffey in June 2016 from wells around the ash pond and it is recommended that groundwater sampling of the identified background well locations (at least) is undertaken to confirm the chemical concentrations.

Previous testing of the ash material within the ash storage area reported the material to be consistent with bottom ash and within the expected ranges for this type of material. The ash pond is well defined with an up to date survey plan which will be included in the future management plan for the site. It is considered unlikely that given the chemicals reported in the ash material, dust migration to the residential occupants and commercial workers within Port Augusta Township to the north/north west is unlikely to cause potential risks to human health. It is also unlikely an inhalation risk from ash pond material is present to the nearby receptors given the ash pond has since been covered with a dust suppressant and revegetation is to commence in the near future. However it is noted that SA Health have expressed concern about the high overall dust level measured on 1 January 2017 at monitoring stations in Stirling North and at Lea Memorial Oval in the southern outskirts of Port Augusta Township immediately after the dust suppressant had been degraded due to a storm and heavy rain, with that they refer to as "*a high fraction of particulate matter less than 10 microns in diameter (PM10)*" (SA Health 2017a).

It is also considered unlikely, given the testing results of the ash material, that chemicals from the ash pond would have leached to the subsurface and the groundwater conditions reported around the ash pond support this conclusion. Engineering solutions to avoid seepage from the ash pond are understood to have been implemented in the 1980's following seepage from the ash pond to the subsurface.

.

The ecological risk assessment undertaken for the small highly modified mangrove swamp at Area 6, within the man-made inlet immediately south of the Playford Stations has identified that sediments from site drainage water may have impacted the mangrove area with concentrations of some metals and heavy end TRH reported at levels that may present an unacceptable risk to ecological receptors within the mangrove swamp. The extent of metal and TRH impact in sediments appear to be localised. The flora and fauna assessment completed determined that the mangrove area consisted of a poor habitat for marine fauna, however this area is highly disturbed from known diebacks in the 1950’s and construction of the Northern Station and infrastructure including the water inlet/outlet channel in the 1980’s. It is also noted that this area has been replanted on a number of occasions. The influx of freshwater from the SPEL drains along with the change to tidal flows as a result of the construction of the Northern Station process water inlet/outlet channel may have also had an effect on the mangrove health. It is possible surface runoff collected from the adjacent roads and washing areas have also contributed to the TRH impacts in the SPEL water along with the surface water drainage. Historical aerial photography between 1963 and 2016 shows the mangroves recovered from the 1950’s dieback, and stabilised following the Northern Station construction disruption. Seagrass monitoring has been undertaken by FPP as well as others in the area since the 1980’s has determined no significant changes in the seagrass communities in and around the power station indicating any discharge from the mangroves to the Spencer Gulf is not having a detrimental effect on the marine ecosystem.

12. Recommendations

Based on the results of this investigation as described in the Sections above, the following recommendations will be considered for the next phase of contamination assessment, Phase 3 remediation.

Table 12.1: Phase 3 recommendations

Area/AEC	Recommendations
Area 1 – AEC 1 Playford fuel oil loss Petroleum hydrocarbon impacts to soils and shallow groundwater may potentially pose an unacceptable dermal contact and ingestion risk to current workers if the ground surface in this area is disturbed and to future users and structures, if the impacts remain following closure and if strict management protocols are not implemented	Following the demolition works, the impacts noted are to be further assessed and appropriate mitigation measures will be implemented to manage identified potential risks to human health, likely to comprise removal of gross impacted soils
Area 1 – AEC 5 Transformers and AEC 7A SPEL sump and tank Minor petroleum hydrocarbon impacts to groundwater are unlikely to pose a potential risk to current and future identified receptors unless the area is excavated and appropriate management protocols are not implemented	Future potential risk associated with excavation works can be managed through the implementation of a site management plan following completion of Phase 3 works
Area 3 – Playford buildings Limited assessment to date due to access constraints	Following demolition, soil validation beneath the building footprints
Area 6 – AEC 7B SPEL drain outlets Discharge to mangroves may be contributing to the overall health of the mangrove ecosystem, however a number of factors are considered to be affecting the highly disturbed ecosystem	Inclusion in the future management plan to continue discharge monitoring as well as monitoring of the mangrove ecosystem health
Area 7 – AEC 23A & 23B Fuel storage area Limited assessment to date due to access constraints	Validation following removal of fuel infrastructure
Area 8 – AEC 25 Maintenance shed and wash down bay Petroleum hydrocarbon impacts to soils potentially pose a risk to ecological receptors	Additional tiers of risk assessment to further evaluate potential risks or potential risk mitigation by remediation of the impacted soils
Area 11 – AEC 31B fuel transfer pipeline Limited assessment to date due to access constraints	Validation following removal of fuel infrastructure
Area 12 – AEC 35 Northern store UST Petroleum hydrocarbon impacts to groundwater unlikely to present an unacceptable risk to current and future receptors, unless the subsurface is removed and contact with the impacted soils and groundwater occurs	Validation following the excavation and removal of the UST, dispensing pump, and any other fuel related infrastructure in the area and the impacted soils.
Area 14 – AEC 43B Firefighting area PFOS reported in groundwater at the laboratory LOR	Soil testing to determine if gross impacts to the soils are present from firefighting activities
Area 15 – AEC 44 Fuel pad Petroleum hydrocarbon impacts to soils and groundwater that may pose a potentially unacceptable risk to current workers if the ground is disturbed and to future users and structures if the impacts remain following closure and if strict management protocols are not implemented	Further assessment and/or risk mitigation following removal of the fuel pad and associated infrastructure

Area/AEC	Recommendations
Area 15 – AEC 45 Diesel ASTs Limited assessment to date due to access constraints	Validation following removal of fuel infrastructure
Area 17 – AEC 50A Ash pond Discrepancies in the results of testing conducted by FPP and Coffey in June 2016 from wells around the ash pond	Groundwater sampling to confirm the chemical concentrations
Area 17 – AEC 51E Acid clean pit dump Known material deposited in this dump comprises hydrochloric acid and stabilised cyanide (<1kg)	Further investigation of the acid clean pit

Monitoring wells within areas to be subject to excavation during Phase 3 works are likely to be destroyed through this process. It is recommended that prior to any excavation works commencing, wells likely to be destroyed are decommissioned by a licensed driller and following excavation works, replacement monitoring wells are installed to determine the success of remediation activities undertaken. Any additional delineation wells required can also be installed at this time.

Historical waste dumps were investigated with the extents defined and it is considered that potential risks associated with these areas can be managed through implementation of a site management plan.

Bulk fuel storage areas are to be removed including any bunds as part of the site closure and following removal will be required to be validated along with any building footprints, wash down bays, sumps, tanks etc. if they are removed.

All conclusions and findings presented in this report must be read in accordance with ‘Important information about your Coffey environmental report’ provided in Section 13.

13. Important information about your Coffey Environmental Report

1. Introduction

This report has been prepared by Coffey for you, as Coffey's client, in accordance with our agreed purpose, scope, schedule and budget.

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

The report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. Assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, including budget and timing. The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice,

This interpretation is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment. Coffey may have also relied on data and other information provided by you and other qualified individuals in preparing this report. Coffey has not verified the accuracy or completeness of such data or information except as otherwise stated in the report. For these reasons the report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.

2. Your report has been written for a specific purpose

Your report has been developed for a specific purpose as agreed by us and applies only to the site or area investigated. Unless otherwise stated in the report, this report cannot be applied to an adjacent site or area, nor can it be used when the nature of the specific purpose changes from that which we agreed.

For each purpose, a tailored approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible quantify, risks that both recognised and potential contamination posed in the context of the agreed purpose. Such risks may be financial (for example, clean up costs or constraints on site use) and/or physical (for example, potential health risks to users of the site or the general public).

3. Limitations of the Report

The work was conducted, and the report has been prepared, in response to an agreed purpose and scope, within time and budgetary constraints, and in reliance on certain data and information made available to Coffey.

The analyses, evaluations, opinions and conclusions presented in this report are based on that purpose and scope, requirements, data or information, and they could change if such requirements or data are inaccurate or incomplete.

This report is valid as of the date of preparation. The condition of the site (including subsurface conditions) and extent or nature of contamination or other environmental hazards can change over time, as a result of either natural processes or human influence. Coffey should be kept appraised of any such events and should be consulted for further investigations if any changes are noted, particularly during construction activities where excavations often reveal subsurface conditions.

In addition, advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in this report should be verified if you propose to use this report more than 6 months after its date of issue.

The report does not include the evaluation or assessment of potential geotechnical engineering constraints of the site.

4. Interpretation of factual data

Environmental site assessments identify actual conditions only at those points where samples are taken and on the date collected. Data derived from indirect field measurements, and sometimes other reports on the site, are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions.

Variations in soil and groundwater conditions may occur between test or sample locations and actual conditions may differ from those inferred to exist. No environmental assessment program, no matter how comprehensive, can reveal all subsurface details and anomalies. Similarly, no professional, no matter how well qualified, can reveal what is hidden by earth, rock or changed through time.

The actual interface between different materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of a suitably qualified and experienced environmental consultant through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other unrecognised features encountered on site. Coffey would be pleased to assist with any investigation or advice in such circumstances.

5. Recommendations in this report

This report assumes, in accordance with industry practice, that the site conditions recognised through discrete sampling are representative of actual conditions throughout the investigation area. Recommendations are based on the resulting interpretation.

Should further data be obtained that differs from the data on which the report recommendations are based (such as through excavation or other additional assessment), then the recommendations would need to be reviewed and may need to be revised.

6. Report for benefit of client

Unless otherwise agreed between us, the report has been prepared for your benefit and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendation and should make their own enquiries and obtain independent advice in relation to such matters.

Coffey assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report.

To avoid misuse of the information presented in your report, we recommend that Coffey be consulted before the report is provided to another party who may not be familiar with the background and the purpose of the report. In particular, an environmental disclosure report for a property vendor may not be suitable for satisfying the needs of that property's purchaser. This report should not be applied for any purpose other than that stated in the report.

7. Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, a suitably qualified and experienced environmental consultant should be retained to explain the implications of the report to other professionals referring to the report and then review plans and specifications produced to see how other professionals have incorporated the report findings.

Given Coffey prepared the report and has familiarity with the site, Coffey is well placed to provide such assistance. If another party is engaged to interpret the recommendations of the report, there is a risk that the contents of the report may be misinterpreted and Coffey disowns any responsibility for such misinterpretation.

8. Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists or engineers based on their interpretation of field logs, field testing and laboratory evaluation of samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

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

9. Responsibility

Environmental reporting relies on interpretation of factual information using professional judgement and opinion and has a level of uncertainty attached to it, which is much less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. As noted earlier, the recommendations and findings set out in this report should only be regarded as interpretive and should not be taken as accurate and complete information about all environmental media at all depths and locations across the site.

14. References

Ainslie, R.C, Johnston, D. A, and Offler, E. W. (1994) Growth of seagrass *Posidonia sinuosa* Cambridge *et* Kuo at locations near to, and remote from, a power station thermal outfall in Northern Spencer Gulf, South Australia. Transactions of the Royal Society of SA, Volume 118 (3), pages 197-206

Alinta Energy (2015) Augusta Power Stations, Seagrass Aerial Monitoring, 2002 – 2014, Dated 23 April 2015

ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 3, Primary Industries — Rationale and Background Information (Chapter 3 and Chapter 9), October 2000

ASTM (2004) Standard Guide for Remediation of Groundwater by Natural Attenuation at Petroleum Release Sites: E-1943-98. West Conshohocken, Pennsylvania

Atlantic PIRI (2012). Risk-Based Corrective Action, User Guidance. Reference Documentation for Petroleum Impacted Sites in Atlantic Canada. Version 3.0.

Australian Radiation Protection and Nuclear Safety Agency (2012) A Survey of Naturally Occurring Radioactive Material Associated with Mining. Technical Report Series No. 161, August 2012

Baker, J. L. (2004) *Towards a System of Ecologically Representative Marine Protected Areas in South Australian Marine Bioregions - Technical Report.* Prepared for Coast and Marine Conservation Branch, Department for Environment and Heritage, South Australia

BC MOE (2006). A Compendium of Working Water Quality Guidelines for British Columbia. Science and Information Branch, Ministry of Environment

BRW (2000) Flinders Power Land Contamination Issues, Independent Review. Ref: 024-9247-01, dated June 2000

Bureau Veritas (2017) Results of Quantitative Identification of Asbestos and Other Fibres. Report No. 17AA0080_00034.0, dated 13 January 2017

Chen et al (2016) Celia Y. Chen 1,*, Darren M. Ward 2, Jason J. Williams 3 and Nicholas S. Fisher. Metal Bioaccumulation by Estuarine Food Webs in New England, USA. Journal Marine Science and Engineering. 2016, 4, 41

Coffey (2016a) Preliminary Site Investigation, Version 1, Augusta Power Stations. Ref: ENAUKESW01445AA-R03 Version 1, dated 20 April 2016

Coffey (2016b) Sampling, Analysis and Quality Plan, Version 2, Augusta Power Stations. Ref: ENAUKESW01445AA-R06 Version 2, dated 22 April 2016

Coffey (2016c) Chemical assessment of ash for use as backfill material, Augusta Power Stations. Ref: ENAUKESW01445AD-L03, dated 17 June 2016

Coffey (2016d) Tidal Logging Results, Augusta Power Stations. Ref: ENAUKESW01445AD-L05, dated 29 July 2016

CRC CARE (2011) *Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater* (technical paper No.10) Guidelines, CRC for Contamination Assessment and Remediation of the Environment (CRC CARE)

DPTI (2012) Port Augusta (City) Development Plan, consolidated 15 November 2012

Department of Mines (1968) Geological Survey of South Australia, Port Augusta Sheet 53-4 Zone 5, scale 1:250,000

DEWNR (2015) Historical aerial photographs

Domenico, P.A. & Schwartz, F.W. (1990) Physical and Chemical Hydrogeology, Wiley, New York

Diomides, C.J (2005) An Investigation of Inorganic Background Soil Constituents with a Focus on Arsenic Species. A Thesis submitted for the degree of Doctor of Philosophy. Victoria University. School of Molecular Sciences. September 2005

Ecological Associates (2016) Flora and Fauna Assessment – Augusta Power Stations. November 2016

enHealth (2016) enHealth statement: Interim national guidance on human health reference values for per- and poly-fluoroalkyl substances for use in site investigations in Australia

EnviroManagement (2014) Verification of the Marine Monitoring Programme (2013/2014), dated November 2014

Environmental Projects (2014) Playford Power Stations Detailed Risk Assessment, Port Augusta Power Stations, Port Augusta SA. Dated 16 December 2014

Flinders Power (2000) Contaminated Lands Identification, Management and Liability Assessment, dated 17 February 2000

Golder (2016) Geotechnical and chemical assessment of ash for reuse as waste derived fill, ash storage area, Port Augusta. Ref: 1539676-003-L-Rev0, dated 4 March 2016

Google Earth (2016) Aerial imagery

Kinhill Stearns (1985) Draft Environmental Impact Statement, Northern Power Station Unit 3, dated August 1985

Kinhill Stearns (1986) Supplement to the Draft Environmental Impact Statement, Northern Power Station Unit 3, dated August 1986

NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended in 2013,* National Environment Protection Council, Canberra

NHMRC (2008) Guidelines for managing risks in recreational water

NHMRC & NRMMC (2011) Australian Drinking Water Guidelines

OMOE (2008) Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An Integrated Approach. Ontario Ministry of the Environment. December 22, 2009

PB (2015) Groundwater Assessment of Port Augusta Power Stations, Power Station Road, Port Augusta, SA. Ref: 15-0103-00-2201721A, dated 17 July 2015

SA EPA (1994) Environment Protection (Marine) Policy

SA EPA (2003) Environment Protection Policy (Water Quality EPP)

SA EPA (2008) Guideline Site Contamination: Determination of background concentrations

SA EPA (2009) Site Contamination: Guidelines for the Assessment and Remediation of Groundwater Contamination

SA EPA (2013) Standard for the production and use of Waste Derived Fill

SA EPA (2015) Environment Protection Policy (Water Quality EPP)

SA EPA (2017) Flinders Power Ash Dam Frequently asked questions – UPDATED. Issued 3 February 2017. Available on SA EPA website.

SA Government (1993) Environment Protection Act

SA Health (2017a) SA Health risk assessment of airborne dust collected on 1 January 2017. Available on SA EPA website.

SA Health (2017b) Fact Sheet – Dust and your health January 2017. Available on SA EPA website.

SARDI (2010) Assessment of potential impacts of Alinta Energy discharges into Hospital Creek, Upper Spencer Gulf, SA. Marine Environment and Ecology. Karen Wiltshire and Jason Tanner. SARDI publication number F2010/000810-1. SARDI Research Report Series No. 506. Dated October 2010

Standards Australia (2005) Guide to the Sampling and Investigation of Potentially Contaminated Soil. Part 1: Non-volatile and semi-volatile compounds, AS 4482.1-2005

WA DER (2017) Interim Guideline on the Assessment and Management of PFAS. Contaminated Sites Guidelines (January 2017)

Woodward-Clyde (1994) Assessment of the groundwater characteristics and flow patterns in the vicinity of Northern Power Station ash disposal areas. Report ref 5200, dated 18 January 1994