REPORT

Preliminary Site Investigation, Weipa

Submitted by:

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Executive Summary

Golder Associates have been commissioned to undertake a Preliminary Site Investigation (PSI) in support of the assessment of potential per-and polyfluoroalkyl substances (PFAS) contamination within and surrounding the RTAW mining areas, Weipa. The Project Area comprises the Andoom and East Weipa mining areas, the adjoining land areas and the receiving environment that includes the Pine, Mission and Embley River catchments. This report presents detailed desk study information, interviews and site inspections along with preliminary site investigation data.

Six Primary Source areas have been identified with PFAS concentrations in excess of the adopted guideline values. Future Detailed Site Investigation (DSI) is proposed to confirm the extent and magnitude of PFAS impacts and assess the potential risk to human health and the environment from the AHEQ within the Mission River catchment and Evans Landing, Railway Workshop, Lorim Point, Weipa Airport and EWHEQ within the Embley River catchment.

Eight Secondary Source Areas have been identified with PFAS concentrations predominantly below the adopted guideline values. The secondary source Areas comprise Andoom Service Bay, Herring Oil Slot, Civil Workshop, Lorim Point Fuel Depot, East Weipa Bioremediation Pad, landfills, release of AFFF in mining areas and release of AFFF outside of mine areas.

Three Potential Source Areas have been identified but have not been characterised by PFAS contamination assessment. The Potential Source Areas include sewage treatment plants, former and current landfills, and tailings stockpile facilities.

Four monitoring rounds from the potable water network recorded concentrations consistently below the guideline values for drinking water. monitoring of potable water is planned to confirm this finding.

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1.0 INTRODUCTION

Golder Associates Pty Ltd (Golder) have been commissioned to undertake a Preliminary Site Investigation (PSI) in support of the assessment of potential per-and polyfluoroalkyl substances (PFAS) contamination within and surrounding the Weipa and Andoom mining areas, Cape York, Queensland. A regional locality map (including mining lease areas) is presented as Figure 1. Figure 2 illustrates the local features of the region. The land area subject to the PSI has been defined as outlined in Section 5.0 and is illustrated in Figure 3.

This PSI report presents a combined desk study and preliminary contamination assessment including laboratory testing of soil, sediment, groundwater, surface water and potable water.

2.0 BACKGROUND

In 2017, RTA Weipa Pty Ltd (RTAW) commissioned Golder to conduct preliminary investigation works at 4 locations to consider the potential for PFAS contamination relating to the use and storage of legacy Aqueous Film Forming Foam (AFFF). The 4 locations are identified on Figure 2 as East Weipa Heavy Equipment Workshop (EWHEQ), Weipa Airport, Fire and Rescue (F&R) at Lorim Point and the Andoom Heavy Equipment Workshop (AHEQ). PFAS was identified in soil and groundwater and the findings from 2017 are integrated into this report. Golder was subsequently instructed to investigate potential impact to potable abstraction wells and groundwater monitoring wells (2017c).

Rio Tinto is responsible for drinking water supply within their mining areas and for the drinking water supply within the township of Weipa via the Weipa Town Authority (WTA). The recorded PFAS concentrations were less than the adopted drinking water screening values at all potable water supply locations (Golder, 2017c). These findings were reported to the Queensland Government Department of Environment and Science (DES) by RTAW in November 2017.

Given the presence of sensitive human health and environmental receptors within the area, further investigation of potential PFAS contamination was undertaken. To guide the investigation a PFAS Assessment Strategy was prepared by Golder (Golder 2018) and submitted to DES by RTAW.

3.0 INVESTIGATION OBJECTIVES AND SCOPE OF WORKS

The overarching objective is to manage potential risk to the environment and human health posed by the legacy PFAS environmental contamination (where identified) from RTAW operations. To achieve this objective, the foundation step to guide subsequent management actions has been the completion of a NEPM compliant PFAS Preliminary Site Investigation (PSI).

The PSI will include developing a preliminary conceptual site model (pCSM) across the identified Project Area by developing an understanding of potential PFAS contamination risks both within RTAW operational areas and the surrounding environment. Possible exposure pathways between PFAS contamination in the environment and humans and ecology are also considered.

The aim of this report is to present the findings of a preliminary site investigation (PSI). The PSI scope includes:

- Confirmation of the investigation footprint or Project Area based on potential PFAS source sites and broad source-pathway-receptor linkages. These tasks consider both “on-site” areas being operational activities of the RTAW mining lease plus Weipa Town Authority and “off-site” areas;
- Review and incorporation of initial PFAS site investigation work completed by Golder for RTAW at 4 locations;
- AFFF/PFAS source identification;

- Sampling of the potable water supply network, surface water and groundwater monitoring wells.
- Pathway and receptor identification; and
- Preparation of a preliminary conceptual site model.

The findings of the PSI will be used to prepare a separate Sampling and Analysis Quality Plan (SAQP) for a Detailed Site Investigation (DSI).

The PSI follows the principles of the National Environmental Protection (Assessment of Site Contamination) Measure (NEPM) 1999, as amended 2013 (NEPM 1999) and the PFAS National Environmental Management Plan 2018 (NEMP 2018) which are both endorsed by the Queensland DES.

The investigation documented in this report is based on the scope of work outlined in a proposal prepared by Golder (ref. P1780475-008-P-RevE dated 19 March) and subsequently amended by proposals 18100235-004-P-Rev1 dated 16 May 2018 and 18100235-011-P-Rev0 dated 29 June 2018.

Sampling and assessment of aquatic biota is reported separately (Golder, 2018c)

3.1 Information Received from RTAW

The following information has been received from RTAW and reviewed as part of the PSI assessment:

- Spatial Information displaying water supply and monitoring well locations;
- Locations and survey information for groundwater monitoring wells;
- Borehole logs for RTAW wells;
- Internal register of site histories;
- Third party reports of site investigations and monitoring;
- Management documents provided by RTAW including:
  - RTA Weipa Operations Site Water Management Plan 2014 to 2018, dated 14 April 2014;
  - AFFF Management Plan, Weipa Classic HSEC Management System, dated 30 June 2017;
  - Weipa Green Banner, Subject: Ban of AFFF Fire Fighting Foam, dated 30 June 2017;
  - Receiving Environment Monitoring Program – North of Embley, dated February 2018; and
  - Routine Environmental Water Monitoring Program, dated March 2018.
- Training presentation, Firefighting Foam, Recommended Practice, not dated;
- Procurement records of RTAW fire fighting foams from 2006 to 21 June 2018;
- Safety Data Sheets for CHUBB PEFS F3 Foam Concentrate, CHUBB AFFF 6% and CHUBB AEROWATER 3%;
- Vehicle Fire Suppression System Fluorine Free Foam Maintenance Manual;
- Rio Tinto Weipa fire extinguisher purchases in 2015 and 2016;
- Results of PFAS sampling carried out at Napranum;
- Laboratory PFAS results of CHUBB 6% foam concentrate conducted by RTAW;

- Records of Fire Suppression Activation by heavy mobile equipment from 30 June 2017 to 2018; and
- Potable water network information and abstraction rates.

3.2 Data Quality Objectives

The NEPM specifies that Data Quality Objectives (DQO) are developed, *"when site contamination data is being relied on to make a risk-based decision as part of a detailed site investigation"*. It further outlines that a, *"simplified planning process may be appropriate for straightforward screening assessment".* In this instance a screening assessment is being completed and qualitative DQO have been developed.

The seven steps in the DQO process are listed in Table 1 along with a summary of the planning approach.

Table 1: Data Quality Objectives

Step	DQO Statement	DQO Approach
1 - State the Problem	The historic storage use and disposal of AFFF has potentially released PFAS to the environment within and around mining areas at Weipa. Due to the mobility and persistence of PFAS, potential receptors could be impacted.	A preliminary review by RTAW indicated use of PFAS containing AFFF at the following primary locations (Figure 2): ■ East Weipa Heavy Equipment Workshop (EWHEQ); ■ Weipa Airport; ■ Weipa Fire & Rescue; and ■ Andoom Heavy Equipment Workshop (AHEQ).
2 - Identify the decision or goal of the investigation	The goals of the investigation are to develop an understanding of the potential release of PFAS to the environment and to prepare a preliminary conceptual site model (CSM) to identify potential linkages between PFAS sources, pathways and receptors.	The preliminary CSM will be used to identify data gaps and potential risk to human health and the environment that require further assessment.
3. Identify the Information Inputs	Information will be collected from numerous available sources.	Information sources include: ■ Local and national regulations and guideline documentation; ■ Environmental values and assessment criteria; ■ Past information such as previous investigation reports and historical aerial photographs; ■ Publicly available information for the region including topographical, soil and geological maps and registered groundwater wells; ■ Information gathered through interviews, procurement records and site inspections; and ■ Preliminary site investigation with collection and analysis of samples of potable water, surface water and groundwater.
4. Define the Boundaries	Spatially, the legacy use of AFFF and the mobile nature of PFAS in the environment may result in widespread	The rationale for the Project Area definition is outlined in Section 5.0

Step	DQO Statement	DQO Approach
	receptors on a catchment scale. A precautionary approach will be adopted to define the Project Area. Temporally, investigation will be conducted over different seasonal conditions.	The temporal sampling involves data collection in both wet and dry season conditions.
5. Develop the analytical approach / decision rules	The laboratory testing methods and screening values will be defined.	The key decision rules will be: 1. Is the analytical data collected suitable for interpretation for the project objectives as outlined in Section 3. If the answer is 'yes' then the data can be used to answer the decision rules below, and the statements developed in Step 1. If the answer is 'no', then an assessment of the need to collect supplementary data will be required. 2. Do investigation data collected form an adequate basis for an appropriate level of preliminary risk assessment? If the answer is 'yes' then the data can be used to assess the magnitude of risk. If the answer is 'no', then additional investigation data will be required. 3. Do PFAS concentrations exceed the screening values? If the answer is 'no' then risks are considered acceptable. Where the answer is 'yes' and results exceed the adopted screening values (defined in Section 10.0), this may not necessarily indicate an unacceptable level of risk, however, mitigation may need to be considered or further investigation will be required to confirm if risks are unacceptable. 4. Does the investigation data form an adequate basis for preparation of an SAQP for DSI?
6. Specify performance or acceptance limits	This step should assist in specifying the acceptable decision error rates, based on a consideration of the consequences of making an incorrect decision.	Potential incorrect decisions and consequences include: ■ Deciding that the risks to a receptor posed by PFAS are acceptable when these risks are not acceptable (i.e. a false negative). The consequence of this error may be unacceptable impact to human health or the environment; or ■ Deciding that the risks to a receptor posed by PFAS are unacceptable when the risks are acceptable (i.e. a false positive). The consequence of this error may be

Step	DQO Statement	DQO Approach
		unnecessary or unwarranted additional investigation and/or mitigation.
7. Develop the plan for obtaining data (optimise the design)	This step includes identification of an efficient sampling and analysis design	Sample locations have been selected based on their location relative to the identified areas where PFAS-containing AFFF have previously been stored, used or disposed. Furthermore, some samples have been collected from monitoring wells or surface water locations associated with the RTAW routine monitoring program.

4.0 PROJECT AREA DESCRIPTION AND OPERATIONS

RTAW extracts bauxite from mining lease ML 7024 on the Weipa Peninsula and lease ML 7031 north of Weipa on the west coast of Cape York, Queensland (Figure 1). Mined bauxite is shipped off site to produce alumina and subsequently aluminium. There are two continuous operations at East Weipa and Andoom, located south and north of the Mission River respectively. In addition, a new mining area ("Amrun") is currently in the process of being established on land south of the Embley River with operations expected to commence in December 2018.

Heavy Mobile Equipment (HME) used at Amrun have fire suppression systems that utilise AFFF. No information has been made available regarding testing of the AFFF and it is not known if it contains PFAS. However, there are mandatory procedures for recording discharge of the systems and the contractor operating the HME has reported no incidents of AFFF use or discharge at Amrun as of late August 2018. There are no other sources of PFAS identified for Amrun and this area has not been considered as part of the Project Area geographic definition.

In 1961 bauxite mining began in Weipa and the first year of commercial production by Commonwealth Aluminium Corporation (Comalco) was in 1963. The Weipa township was built by Comalco between 1964 and 1967. The Weipa town boundary was extended in 1994 by the Queensland Government to include the Evans Landing area. In 2006, Comalco was renamed Rio Tinto Aluminium and in 2007 Rio Tinto purchased Canadian aluminium company, Alcan Inc, and then renamed the newly integrated company Rio Tinto Alcan (WTA 2014).

Residential communities in the area include the township of Weipa, the village of Napranum (northern bank of Embley River) and outstations identified as Redbeach (northern bank of Mission River), Wathyn and Pappan (south east and east of the mining area at Weipa respectively) (Figure 2).

The general mining process has generally not changed with time and includes:

- Vegetation clearance, top soil removal and mining of bauxite material.
- Transport of bauxite by haul trucks from the East Weipa mine area to the Lorim Point beneficiation plant and stockpiling of ore in an adjacent area.
- Mining at Andoom includes subsequent transport of bauxite by haul trucks from the Andoom mine area to the Andoom beneficiation plant. Trains are used to transport the processed bauxite to the Lorim Point ore stockpiles;
- Ship loading of approximately 30 million tonnes of bauxite per year onto ships at Lorim Point for transport to refineries; and

- Rehabilitation of mined areas.

Additional RTAW operations that currently support the mining process include:

- Two diesel power stations supplying the mine, the Weipa town and neighbouring community of Napranum. The power station located at Lorim Point is reported to generate 26 megawatts while the Andoom Station generates 10 megawatts;
- Workshops at Andoom, East Weipa and Lorim Point associated with servicing of HME including dozers, scrapers, loaders, haul trucks and railway locomotives;
- Light industrial activities and businesses associated with maintenance of light vehicles, civil works, a chemical laboratory and stores at Lorim Point and Evans Landing;
- Unloading of bulk fuel and oil by Viva Energy at Evans Landing and storage at Evans Landing, Lorim Point and Weipa airport;
- Administration of the township of Weipa and Single Persons Quarters, which Rio Tinto operates through the Weipa Town Authority (WTA) and a Contractor (Sodexo) respectively; and
- Operation of the Weipa airport via Aerodrome Management Services.

5.0 PROJECT AREA DEFINITION

A Project Area has been defined to establish the footprint of proposed assessment activities, as recommended in the NEPM (1999). The Project Area includes potential PFAS sources and broad source-pathway-receptor linkages. The following items were considered in defining the Project Area to account for how PFAS may migrate thought the natural and engineered environment:

- Sources of PFAS;
- Topography and surface water drainage;
- General groundwater flow direction; and
- Potential sensitive receptors.

The Project Area is defined in Figure 3 and includes:

- Preliminary potential source areas that include ‘on-site’ activities operated directly by RTAW and indirectly by management companies within the Andoom and East Weipa Areas, and the adjoining ‘off-site’ land areas; and
- Preliminary receiving environment that includes the Embley River, Mission River, Jackson Channel, Bagley Channel and Pine River Bay.

This section outlines the environmental setting of the Project Area. The objective is to outline potential pathways for the transport and distribution of PFAS.

6.0 ENVIRONMENTAL SETTING

6.1 Topographic Setting

The Project Area is situated in the western portion of Cape York Peninsula. This area is defined by an essentially flat coastal plain incised by meandering rivers and floodplains, with hills up to 800m above sea level at the McIlwraith Range or northern Great Dividing Range to the east. The topography of the Project Area and surrounds (Figure 4) indicates that the:

- Andoom area rises to the north east from the coast to approximately 55 m AHD approximately 20 km inland. The area is incised by the Pine River to the north west and Mission River to the south. The catchment divide with the Wenlock River defines the northern boundary of the Project Area; and
- Weipa area rises to the east from the coast to approximately 40m AHD approximately 15 km inland. The area is characterised by relatively shallow incised creeks with Mission River to the north and Embley River to the south.

6.2 Surrounding Land Uses

The land use surrounding the Project Area is as follows:

- North and north west – undisturbed land of the Mission River and Wenlock River catchments. The community of Mapoon is located on the estuarine inlet of the Wenlock River 36 km north of the Project Area.
- East - Royal Australian Air Force (RAAF) Base Scherger is located to the east of the Weipa mining area. The RAAF facility is identified as a non-operational “bare base”, is managed by caretaker staff and includes an aircraft runway with associated buildings over an area of 3,907 hectares;
- South – Embley River and undisturbed land of the Embley River catchment. Development activities have commenced south of the Embley River for bauxite mining as part of the Amrun Project; and
- West – coastal waters of Albatross Bay and the Gulf of Carpentaria.

6.3 Climate

The Western Cape York Peninsula has a tropical monsoonal climate with distinct wet and dry seasons. The wet season occurs from December through to March with average annual rainfall at Weipa of near 2 m. The dry season from May to September has very little rain (BOM, 2018). Plate 1 below displays the monthly average rainfall for Weipa Airport.

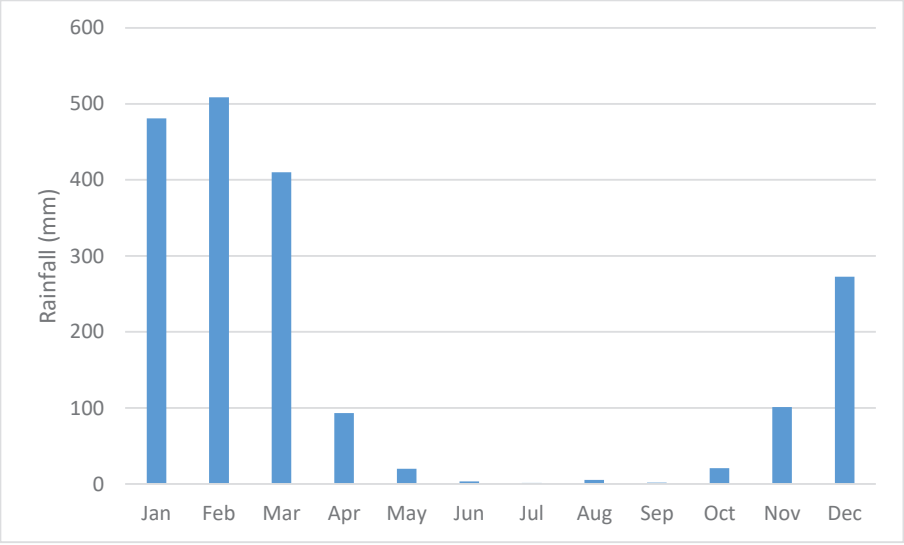


Plate 1: Weipa Airport Monthly Average Rainfall (BOM, 2018).

6.4 Surface Water Drainage Systems

The Project Area surface water drainage is located within the Pine, Mission and Embley River catchments as displayed in Figure 5. The Andoom area is divided into the Pine River catchment to the north west and the

Mission River catchment to the south east. The largest tributary within this area is Andoom Creek that extends north from Mission River. The Wenlock catchment is north of Andoom and outside of the Project Area.

The Weipa Peninsula is bisected in an east to west direction into the Embley River catchment to the north and the Mission River catchment to the south. Pappan Creek and Mission River Creek define the eastern boundary of the Project Area.

A series of sub-catchments including local creeks, tributaries and swamps have been identified by RTAW and are shown on Figure 5. These sub-catchments are sourced from following documents:

- Receiving Environment Monitoring Program – North of Embley, (Rio Tinto Weipa 2018a); and
- Routine Environmental Water Monitoring Program, (Rio Tino Weipa 2018b).

6.5 Regional Geology

A surficial geological map of the study area is shown in Figure 6. This map is based on the Carpentaria-Karumba Basins Regional Mapping of 1:1,000,000 scale published geological information on Queensland Globe, an online interactive tool provided by the Queensland Government (QLD Gov 2018).

The indicated geology of the project area generally comprises:

- Qc: Quaternary age mud, silt and sand along the coastal flats associated with the Embley River, Mission River, Pine River and Andoom Creek;
- TQd\a: Late Tertiary to Quaternary aluminous laterite, including bauxite with sandy “A” horizon and deeply weathered Aurunkun surface over the majority of the Andoom and Weipa mining areas; and
- Ti: Eocene age Bulimba Formation including sandstone, pebble conglomerate and sandy claystone along incised sections of Pappan Creek and Mission River Creek to the east of the Weipa mining area and to the west and east of the Andoom mining area.

6.6 Regional Hydrogeology

The Project Area is located on the Cape York Peninsula within the Mesozoic Carpentaria Basin, which underlies an area of about 560,000 km^2 of northern Queensland, and consists of a 1,200m thick sequence of sedimentary rocks (Smart et al., 1980). The Carpentaria Basin makes up the northernmost portion of the Great Artesian Basin.

Numerous time-contiguous formations have been recognized across the vast extent of the Carpentaria Basin. In the project area, the following units are present:

- Middle Jurassic fluvial sedimentary rocks of the Garraway Beds
- Early Cretaceous fluvial and estuarine rocks of the Rollings Downs Group

The Rollings Downs Group includes late Cretaceous shallow marine rocks of the Normanton Formation that are recognized as a regional aquifer. The rocks of the Rollings Downs Group outcrop east and south of the Weipa Peninsula. In the Weipa and Andoom areas, they are overlain by younger rocks of the Karumba Basin, which was initiated in the Late Cretaceous and developed as a series of cyclic erosion and deposition cycles of continental sand with some silt and clay, up to a thickness of about 300m (Smart et al., 1980).

The initial depositional cycle of the Karumba Basin resulted in deposition of the fluvial Bulimba Formation, which underlies the study area. Geologic maps of the project area (Smart et al., 1980) do not differentiate the local subunits of the Karumba Basin above the Bulimba Formation, and indicate that Tertiary and Quaternary sediments in the Weipa and Andoom areas are products of weathering and residual material, described as ‘aluminous laterite include bauxite, with sandy “A” horizon’.

A study by Halcrow (2012) described individual depositional units of the Karumba Basin, and conceptualised the shallow subsurface as follows:

- Ironstone, mottled clay, and bauxite (Wyaaba beds);
- Silt/Clay layer (semi-confining Trunding clay);
- Napranum sand layer (shallow aquifer); and
- low permeability Bulimba formation siltstone /sandstone.

Halcrow (2012) cites various sources and describes the Napranum sand as the shallow aquifer with the Bulimba formation siltstone / sandstone identified as relatively impermeable.

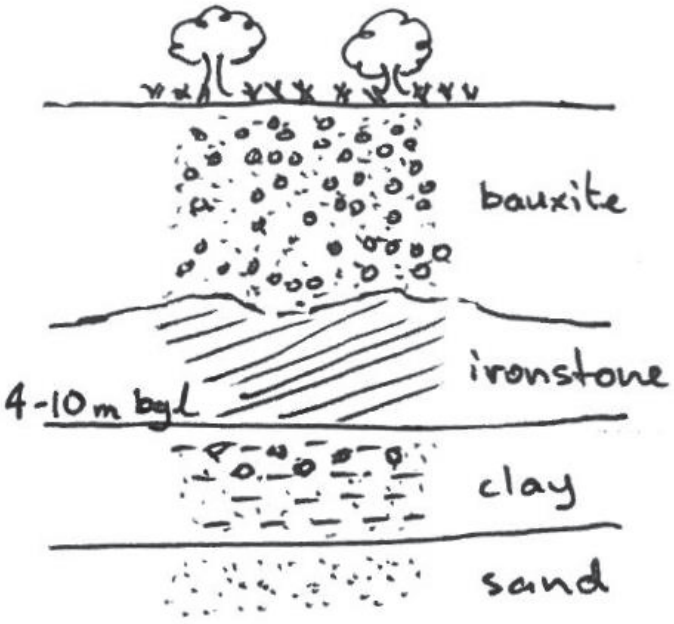


Plate 2: Diagrammatic Sketch of the Shallow Hydrogeological Units, East Weipa.

Hydrogeological investigations by Golder (2017b) do not recognize Napranum sand and divide the shallow subsurface into a superficial Kaolinite Unit and the shallow sandstone aquifer of the Bulimba Formation. The superficial 'Kaolinite Unit' comprises topsoil, alluvium, Red Soil, Bauxite and lateritic duricrust (Golder, 2017c). Studies of the unconfined Kaolinite Unit have indicated that the formation is mainly unsaturated and discontinuous (RTA, 2013). The upper zone of the Kaolinite Unit is considered moderately permeable and varies between unsaturated and saturated during the dry and wet seasons. The middle zone of the Kaolinite Unit is considered to range from moderate to low permeability and is generally saturated. This portion of the Unit may represent a poor aquifer unit or an aquitard depending on the local hydraulic characteristics. The lower zone of the Kaolinite Unit has low permeability and is characterised as an aquitard.

The sandstone of the Bulimba Formation generally represents a high yielding shallow aquifer, which is an important resource over the Weipa Peninsula. Recorded values for hydraulic conductivity of the Bulimba Formation range between 140 to 3,305 m/day and specific yield has been recorded between 0.08 and 0.1 (Smerdon et al., 2012). The potentiometric surface of the shallow aquifer generally follows surface topography and groundwater flow is predominantly east to west, although at the margins of the Weipa Peninsula flow is radially outward towards the surrounding bays. Recharge to the sandstone of the Bulimba Formation occurs via rainfall infiltration along outcropping sandstone and by leakage from overlying surficial aquifers.

Groundwater quality in the shallow aquifer is relatively fresh due to the high annual rainfall and recharge to the Karumba Basin.

Hydrochemical studies of groundwater in the regional aquifer system suggests a vertical connection between the Karumba Basin and the underlying aquifer.

6.7 Registered Groundwater Wells

Registered groundwater wells within the Project Areas have been reviewed based on an online interactive tool called Queensland Globe that is provided by the Queensland Government (QLD Gov, 2018). Queensland Globe's records indicate that within the Project Area there are 304 registered groundwater wells including 13 artesian and 291 sub-artesian (shallow, up to approximately 15 m depth) wells. Few details regarding the owner, construction or usage of the registered wells are available.

Review of the Queensland Globe registered groundwater well database and RTAW documents is summarised in Table 2 and the location of relevant wells shown on Figure 7.

Table 2: Purpose of Registered Groundwater Borehole within the Project Area

Type of Groundwater Well	Information Source	Comments	No. Shallow Aquifer Registered Groundwater Boreholes	No. Artesian Aquifer Registered Groundwater Boreholes
WTA/RTAW potable water supply wells	Review of RTAW Documents	23 sub-artesian wells	23	0
RTAW abstraction wells for mining processes		28 sub-artesian wells and 13 artesian wells	40	13
RTAW abstraction well for irrigation at the Weipa Golf Course		1 well used for irrigation	1	0
RTAW Monitoring		Approximately 80 of the registered groundwater boreholes are used for monitoring of mine sites and the receiving environment	80	0
Community Areas	Review of registered groundwater wells in community areas.	A single registered well is located at both Pappan (RN109173) and Wathyn outstations (RN109171)	2	0
		Redbeach outstation does not have a registered groundwater well	0	0
		Napranum community has 5 registered groundwater well	5	0

Type of Groundwater Well	Information Source	Comments	No. Shallow Aquifer Registered Groundwater Boreholes	No. Artesian Aquifer Registered Groundwater Boreholes
		(RN45070, RN92867, RN45072, RN45071 and RN14711)		
		50 sub-artesian wells are identified in the Weipa township area. Eight of these are WTA/RTAW potable water supply wells	42	0
Unknown Use	QLD Globe	The remainder of the registered groundwater wells are within the mine areas and are inferred exploration boreholes that have been subsequently removed following mining for bauxite.	98	0
Total Count of Registered Groundwater Boreholes within the Proiect Area			291	13

Testing was completed in November 2017 by the Queensland Government of 3 potable water abstraction wells and an accumulation point at Napranum, located south of the Weipa airport. Results indicated detectable concentrations of PFAS with most results below the laboratory reporting limit and all results below human health guideline values for drinking water (NEMP, 2018). The results were provided to RTAW, however, the sample locations were not included in the information.

7.0 AFFF AND PFAS SOURCE IDENTIFICATION

7.1 Historical Aerial Photograph Review

Aerial photographs obtained from QImagery (an online aerial photograph library provided by the Queensland Government) and Google Earth were reviewed. Table 3 presents a summary of the historical aerial photograph review and copies of the images are presented in Appendix A.

Table 3: Summary of Historical Aerial Photograph Review

Year	Comment
1969	**Andoom:** The Andoom area appears to be largely undisturbed apart from what appears to be a small airfield runway to the north west of Andoom Creek. **Weipa**: Development of the Weipa area is evident and initial development must have preceded 1969. Rocky Point has been cleared and residential buildings have been developed in this area. Large areas within the eastern portion of the Weipa Peninsula have been cleared. Further west, the peninsula is predominantly vegetated with narrow transects cleared. Some buildings are present at Lorim Point and Evans Landing, and material has been stockpiled adjacent to the shoreline at Lorim Point. Runways for the Weipa airport have been cleared and appear to be in use. Vegetation along the shoreline of Napranum has been cleared although no buildings are evident.

Year	Comment
1979	**Andoom:** Development of the Andoom area is evident and initial development must have occurred during the period 1969 to 1979. Large areas of Andoom have been cleared of vegetation with access roads and mining earthworks being undertaken. Buildings at the AHEQ and Andoom Service Bay are present. A stockpile of material is present to the north east of Andoom Service Bay. Andoom mine centre is present. **Weipa:** Further residential suburbs have been constructed west and south of Rocky Point. The Mission River bridge is present. A rectangular pond is present at Awonga Point near the site of the current sewage treatment works. Large areas of cleared vegetation and mining earthworks are present across the western and central portions of Weipa Peninsula. Lake Patricia is present and several smaller water bodies are evident west of Evans Landing. Tailings stockpiles are evident to the north and east of Lorim Point. Commercial buildings and above ground storage tanks are evident at Evans Landing and Lorim Point. In addition, jetties have been developed at Evans Landing and Lorim Point. A small wharf may also be present at the location of the current Humbug Wharf. Residential development is evident at Napranum and 3 rectangular ponds are present to the north.
1983	**Andoom:** Small areas of land cleared to the west of the AHEQ building. Remaining area of photograph appears unchanged.
1984	**Andoom:** The Andoom mining area has expanded to the north and south. **Weipa:** The East Weipa mining area has expanded to the west.
1988	**Andoom:** The area to the south of the AHEQ has been cleared in transect strips. Vehicle tracks have also been cleared to the west of the AHEQ.
1989	**Andoom:** There has been continued expansion of the mining areas south of Andoom and revegetation of older mining areas. Aerial imagery for northern Andoom is not available. **Weipa:** There appears to have been continued expansion of the mining areas and revegetation of older mining areas. Lake McLeod is evident with an apparent drainage connection to Lake Patricia. Additional buildings are present at Evans Landing and Lorim Point and the tailings stockpile to the east has expanded in size. There has been continued residential development at Napranum.
1990	**Andoom:** Some areas to the south and west of the AHEQ have been revegetated.
1994	There appears to have been continued expansion of the mining areas to the north and south at Andoom and to the east at Weipa, however, the aerial image from this date is not detailed. RAAF Base Scherger is evident.
1995	Imagery only available for the South Weipa Peninsula along the Embley River. There appears to have been continued mining, commercial and residential expansion. In addition, older mining areas have been revegetated.
2004	There appears to have been continued expansion of the mining areas to the north and south at Andoom and to the east at Weipa, however, the aerial image from this date is not detailed. Linear features are present from the Andoom mining area to water bodies in the north.

Year	Comment
2014 and 2016	There appears to have been continued expansion of the mining and revegetation areas at Andoom and Weipa, however, the aerial image from this date is not detailed.

The findings of the historical aerial photograph review support information gathered from other sources (ie interview and records review) completed as part of this PSI.

7.2 Site Inspection and Interview Information

7.2.1 Inspection and Interview Approach

Site-based interviews were conducted by Golder in June 2018. Key personnel, previous staff and contractors with knowledge of current and historic AFFF storage, use and waste disposal were identified by RTAW. Inspections of areas with known storage and use of AFFF were also conducted. Eighteen interviews were completed, involving 22 RTAW staff members and 2 Chubb employees. The staff included group leaders or superintendents with responsibility for firefighting, bulk fuel storage, water supply, environmental services, mining operations, civil works and procurement. The people interviewed typically had in the order of 10 years' experience, however, one long term employee with 30 years' experience was included. The interviews and inspections focused on the following items:

- Source of information and knowledge of the area;
- Current land use and history of the relevant location;
- AFFF product usage, type, volume and location;
- Surface drainage and other pathways; and
- Waste management.

Information from the interviews has been summarised below in terms of general comments that apply across the Project Area. Information relevant to a specific area is included in Section 7.3. Photographs taken during the inspections are included in Appendix B.

7.2.2 Inspection and Interview Findings

7.2.2.1 Potable Water Use

RTAW and WTA fulfil the function of the water service provider in accordance with the Queensland *Water Supply (Safety and Reliability) Act 2008*. RTAW supply drinking water to the airport and both the Andoom and East Weipa mining areas. The WTA operates two domestic water supply schemes, supplying approximately 1500 connections from: Weipa township including Rocky Point, Golf Link Estate, Trunding and Nanum; and the Evans Landing and Lorim Point areas including the industrial estates and single person quarters (SPQ) accommodation facility.

Previous sampling of potable wells and nearby groundwater monitoring wells was conducted as two separate monitoring events in October and November 2017 (Golder 2017c). The reported PFAS concentrations were less than the adopted drinking water screening values at all locations (Golder, 2017c). These findings were reported to the Queensland Government Department of Environment and Science (DES) by RTAW in November 2017.

It was confirmed by the head of HS&E and the superintendent for Environmental Services that all residential houses, accommodation facilities, the primary school and recreational areas in Weipa are connected to the

potable water supply and that residents have a generous usage allowance. It was reported during this interview that there are some unregistered private boreholes used for groundwater abstraction for watering gardens and filling swimming pools. It was also indicated that there are no large residential plots, allotments or market gardens that could supply fruit and vegetables on a large scale, however that mains water and/or (unregistered private bores) would be used for small scale home produce (herbs, vegetables, fruit) and watering chickens.

7.2.2.2 RTAW Approach to AFFF Use

All of the staff interviewed indicated or confirmed that AFFF was only available and considered for use at “high risk facilities”. High risk facilities were considered by the staff to include those that used or stored highly flammable fuels (jet fuel and petrol) and during specific training events.

More specifically, the high-risk facilities were identified by the staff and included:

- bulk fuel unloading facilities at Evans Landing;
- the bulk fuel tanks at Evans Landing and the Weipa airport; and
- the HME used for development, production and rehabilitation of mine areas.

Training events that used AFFF were routinely conducted adjacent to the F&R building and once every 2 years at the airport. Further details regarding these events are provided below. There were no records or anecdotal reports of training events using AFFF at other areas.

Interviews indicated that all training events and testing of equipment at the bulk fuel facilities used water only. No staff reported fires or use of AFFF at the bulk fuel facilities over the last 20 years when they had direct knowledge. In addition, there were no anecdotal reports of historic fires or training events using firefighting foam at the bulk fuel facilities.

Most of the staff interviewed had detailed knowledge of the various facilities present across the Project Area. These facilities include the beneficiation plants, waste oil plant, Calcination plant, power stations, railway workshop and HME workshops. It was confirmed that the firefighting equipment at these plants used water only and did not include AFFF. Small, hand held foam fire extinguishers may be kept at these facilities, but there was no reported records or knowledge of their use and regular inspections included visual checks only with no release or physical testing of AFFF.

In June 2017 RTAW issued the following documents to control and phase out the use of fluorinated AFFF, copies of which are provided in Appendix C:

- AFFF Management Plan, Weipa Classic HSEC Management System (RT Weipa, 2017a); and
- Weipa Green Banner, Subject: Ban of AFFF Fire Fighting Foam (RT Weipa, 2017b).

These documents provided information regarding the QLD Government policy to ban AFFF products with specified concentrations by 2019 (QLD Gov, 2016). It identified that CHUBB 3% and 6% were required to be phased out and that 3M Light Water (FC-203CE) 3% could no longer be procured. The AFFF management plan requires:

- All new AFFF concentrates must be clearly labelled and stored in an impermeable bund;
- All spillages or release of firefighting foams, including release from HME, must be recorded as an environmental incident and the location of the spill must be recorded. For large spillages the Environmental Operations Team and Fire & Rescue must be contacted for assistance;

- All waste AFFF, from HME servicing etc. must be stored in appropriately labelled containers and within an impermeable bund; and
- Remondis the waste management contractor must be contacted for collection and disposal of the waste AFFF products.

7.2.2.3 AFFF Product Use

AFFF concentrate in bulk containers and foam fire extinguishers are delivered to the Main Stores in Lorim Point before dispatch for operational activities. Internal procurement records available from 2006 were reviewed for AFFF products and these are summarised in Table 4.

Table 4: AFFF Product Procurement Records

Product Name	Product Size	Total Usage Since 2006	PFAS Content
CHUBB Foam extinguishers Product 1011/01	9 litres	456	Unconfirmed
CHUBB Aerowater 3% (alternate name based on site inspections and SDS provided by site staff is AFFF 3%)	20 litres	13	Noted on Chubb website to contain PFOA.
Solberg RF3	20 litres	54	Solberg report this product as flourosurfactant and fluoropolymer-free
Solberg RF3	200 litres	No procurement records since 2006. However, what appeared to be a relatively new 200 L drum of this product was observed at F&R during the site inspections.	
Solberg RF6	20 litres	188	
Solberg – with label on drums stating *"DoD 3155 Defence Training Foam"*	20 litres	No procurement records since 2006. However, 3 x 20L drums of this product dated "1 MAR 12" were observed at F&R during the site inspections.	Solberg report this product as low toxicity, biodegradable and containing no organohalides or persistent chemicals.

Chubb also provide AFFF during servicing of fire suppression systems on mobile plant. Chubb indicated that they provided 678 litres of AFFF to RTAW in 2017. This volume did not include AFFF used by Fire and Rescue, and recharge of fire suppression systems by RTAW staff outside of regular servicing by Chubb.

7.2.2.4 AFFF Concentrate

Golder collected a sample of CHUBB AFFF 3% product from a drum at the AHEQ during the 2017 investigation. This sample was analysed "as is" and after oxidation using the total oxidisable precursor assay (TOPA) method with the laboratory results reported in mg/kg included in Appendix D. It is noted that the analytical reporting limit for the TOPA method were raised by 3 or more orders of magnitude, due to the dilution required. The Total PFAS concentration was 14.16 mg/kg using the standard method and 4,364 mg/kg

using the TOPA method. No PFOS or PFHxS was reported by either analysis method at the reported detection limits. Concentrations of compounds from the perfluoroalkyl carboxylic acid “family” (PFBA, PFPeA, PFHxA and PFHpA) increased following the TOPA oxidation, likely as a result of oxidation of compounds from the Fluorotelomer family. The concentration of 6:2 FtS (Fluorotelomer family) also increased by an order of magnitude.

RTAW collected and commissioned testing of a sample of CHUBB AFFF 6% concentrate in March 2017. The origin of the sample was not detailed; however, it is understood that the testing was completed to help understand the PFAS content of AFFF used for firefighting. A copy of the laboratory certificate of analysis was provided by RTAW and is presented in Appendix D. The laboratory testing was completed for a suite of 33 PFAS analytes with the sample analysed “as is” and the results are reported in mg/kg. The PFAS compound 6-2 fluorotelomer sulfonate was detected at 3 mg/kg. All remaining PFAS compounds were detected below the laboratory limit of reporting (LOR) of 0.5 mg/kg.

7.3 Initial PFAS Source Areas

Information from the interviews has been summarised in terms of specific comments that apply to individual source areas. Seven initial AFFF source areas and one group of sources are identified comprising:

1) Andoom Heavy Equipment (AHEQ) workshop;
2) Evans Landing;
3) Railway Workshop (RWW);
4) Civil Workshop;
5) F&R building at Lorim Point;
6) Weipa airport;
7) East Weipa Heavy Equipment workshop (EWHEQ); and
8) Other possible PFAS sources including firefighting events, accidental discharge of fire suppression systems on HME, landfill materials and waste water treatment plants.

7.3.1 Andoom Heavy Equipment Workshop (AHEQ)

Mining commenced in the Andoom area in 1972 and the AHEQ is located to the south of the Andoom tailings stockpile facility (TSF, Figure 2). The AHEQ has been used for servicing of HME since 1979 (Plate 3). Before this, the Andoom HME were serviced at Lorim Point in a building currently known as the Civil Workshop (Figure 2).

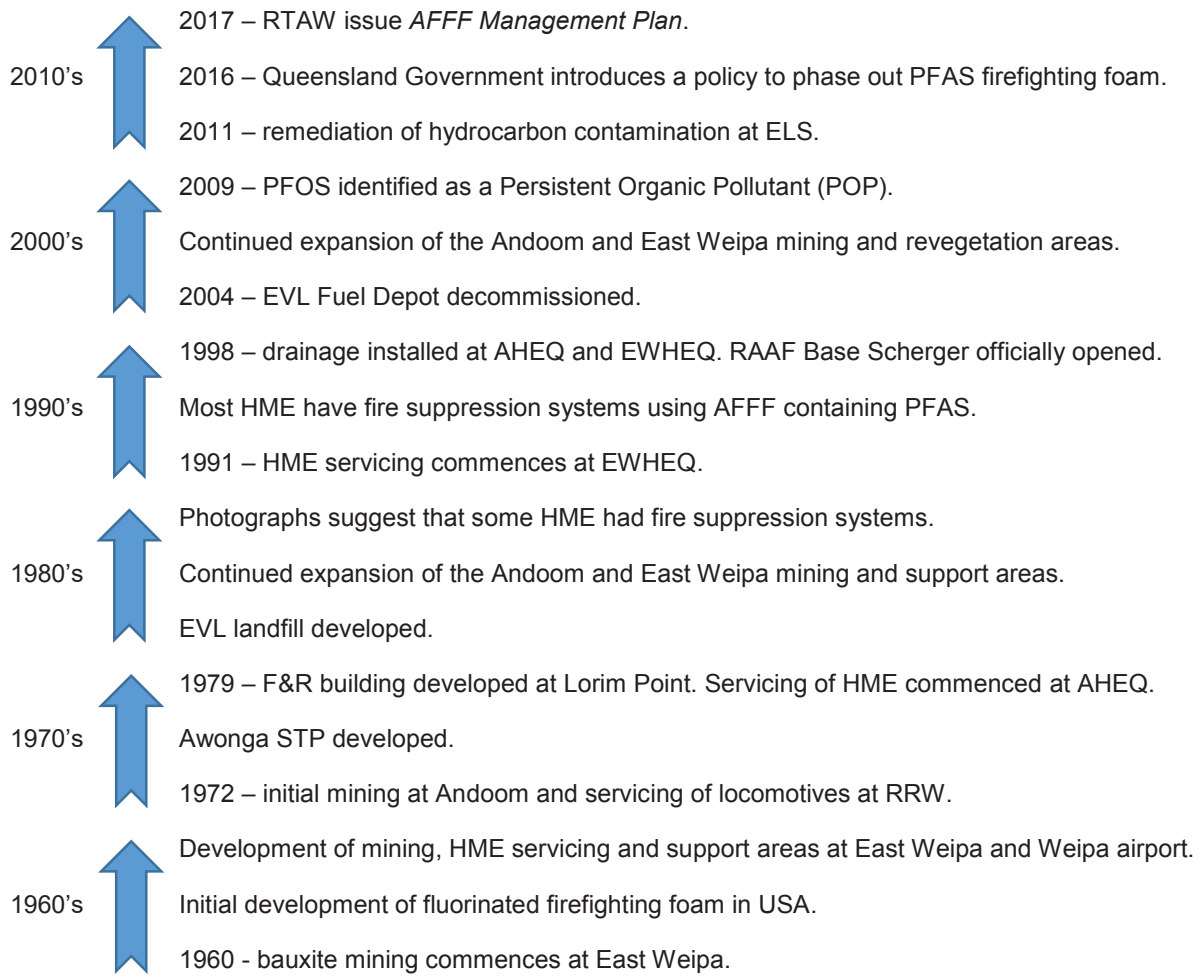


Plate 3: Timeline of Milestones and Events

Interviews were conducted with the crew leader at Andoom mine with 28 years' experience, a crew leader at AHEQ with 12 years' experience, with a senior staff member and with two Chubb employees with knowledge of site activities since 2003. No fire training or emergency response is known to have occurred at the AHEQ. There were reports of emergency response to fires on HME and rail plant outside of the AHEQ area, and these are summarised below.

During the last 10 year period there has been approximately 50 HME serviced at the AHEQ. All HME have fire suppression systems containing AFFF with the majority connected to a 106 L cylinder. Loaders and dozers have two 106 L cylinders (refer to Plate 12 of Appendix B).

It was reported that since the 1990's the HME fire suppression systems predominantly utilised 106 L red cylinders containing approximately 5 L of AFFF (reported to be a 6% product), 80 L of water and compressed nitrogen. A small number of HME had 65 L cylinders containing 3 L of AFFF. The proportion of AFFF was reported to have changed slightly with different AFFF products. For example, from 2010 the 106 L cylinders were reported to contain 6 L of AFFF (reported to be a 3% product). Staff were unable to recall the specific brand of AFFF used, but indicated that CHUBB products have been used since at least 2003 and some anecdotal reports suggest that CHUBB products were used before the 1990's.

The HME fire suppression systems are serviced annually by CHUBB at the AHEQ. It was reported by site staff that until June 2017 the AFFF systems were discharged to the floor of the building and hosed with water to

remove product from the working area. More recently the waste contents of the fire suppression systems have been collected and disposed off site by Remondis. Based on the indicated number of HME serviced and the product in their fire suppression systems, it is inferred that approximately 300 L of AFFF may have been released to the environment each year during the period 2000 to June 2017. Prior to this, the volume released would have been less as there were fewer HME in operation.

Two water carts used for dust suppression have water monitors at the rear (refer to Plate 13 of Appendix B) that can be used with an external AFFF source. It was reported that the monitors have not been used for either training or incident response and no foam product was observed on the HME at the time of inspection.

Surface water drainage from within the AHEQ is currently collected by spoon drains installed in 1996/7 that discharge to a sediment pit (refer to Plate 14 of Appendix B). Water from the sediment pit is pumped to a humiceptor and then on to the vehicle wash pad oil/water separator (refer to Plate 15 of Appendix B). The final discharge point is a drainage ditch south east of the building. Sediment is removed from the system as required, allowed to dewater in a stockpile adjacent to the wash pad and then moved to the East Weipa Bioremediation Pad for disposal.

Prior to installation of the spoon drains, surface water from the AHEQ was discharged to ground. During the wet season, surface water runoff surrounding the AHEQ was reported to drain to the south and south west towards Tea Tree Swamp (alternatively known as Saleng Tea Tree Swamp).

There were reports of fire suppression systems being inadvertently discharged within the Andoom mine area. Anecdotal reports suggest that discharge outside of the workshops occurs 3 to 6 times per year, predominantly along haul roads and on the clay floor in active mining areas. The locations for these discharge events have been recorded since June 2017. There is typically impact to the ground from engine fluids during these incidents and a backhoe is used to excavate the impacted material for disposal to the East Weipa Bio Pad.

7.3.1.1 Andoom Service Bay

The Andoom Service Bay (ASB) is located to the north of the AHEQ and is used for daily fuel, oil and grease maintenance with no recorded use or storage of AFFF by RTAW staff. In addition, no fire training or emergency response is known to have occurred at the ASB.

During the last 10 year period there has been approximately 10 hire plant serviced at the ASB by subcontractors. The plant is required to have fire suppression systems to comply with RTAW policies, but details regarding these systems were not readily available for review. For the purposes of this investigation it has been assumed that the content of the fire suppression system and the annual servicing is similar to that completed at AHEQ.

7.3.1.2 Andoom Mine Centre

The Andoom Mine Centre is located to the north of the Andoom Service Bay and adjacent to the tailings stockpile. The area is used for staff parking, messing and support facilities. Two 20 L blue drums of AFFF (Solberg RF3) are stored at the Andoom Mine Centre for use by F&R to support their emergency response. There was no recorded use of AFFF and no fire training or emergency response is known to have occurred in the area.

7.3.2 Evans Landing

The Evans Landing (EVL) area has been operational since the earliest mining activities (Plate 3) and includes:

- an active land fill to the west;
- an active bulk fuel depot in the north (ELN);

- a decommissioned bulk fuel depot in the south (ELS);
- a commercial/industrial precinct;
- single person accommodation quarters;
- a commercial jetty along with a recreational boat ramp and jetty;
- a closed TSF is located 600m north of EVL; and
- two landfills are present to the east.

RTAW documents indicate that the landfills were used between 1980 and 1984 for domestic and industrial waste. To the north east of the ELS tank farm is the old Evans Landing Beneficiation Plant that was operational in the 1960s.

Interviews were conducted with the crew leader for fuel infrastructure with 10 years' experience and with a senior staff member with 12 years' experience. No fire training or emergency response using AFFF is known to have occurred at the ELN or anecdotally for ELS.

The current fire suppression system at the ELN Tank Farm was reportedly installed approximately 3 years ago and utilises fluorine free AFFF stored in two 200 L drums within a small yellow shed next to the admin building (refer to Plate 19 of Appendix B). Before this infrastructure was installed, the firefighting system comprised 2 gantry water cannons that could be connected to drums of AFFF (containing PFAS) stored on site. Storage over the past *circa* 20 years included 2 pallets loaded with three 44-gallon drums of AFFF that was reported as a 3% product of unknown origin. The drums of foam concentrate were set up to be speared or lanced and mixed with water using a venturi system from the water cannons. Several people interviewed confirmed that only water has released from the cannons for training and testing. One instance of fire training, potentially using AFFF, may have been completed to the east of the tank farm. However, there were conflicting anecdotal reports and practices could not be confirmed.

The fuel farm of Evans Landing south operated from 1961 to 2004 when it was decommissioned. A hydrocarbon plume was identified beneath the site and in 2011 remediation of the plume was carried out using multi-phase extraction. A proprietary surfactant was injected at "strategic wells" prior to remediation to assist removal of hydrocarbon contaminants from the soil matrix (OTEX, 2011). No description was provided of the surfactant type, volume used or injection locations.

A site investigation report of the ELS area indicates that there was a "Fire Rescue" building 50m west of the ELS fuel tank farm (Figure 2 of OTEK, 2011). The presence of a "Fire Rescue" building in this area was not verified during interviews, however, it is considered likely that training exercises using AFFF may have occurred in the tank farm areas of Evans Landing.

7.3.3 Railway Workshop

The railway workshop area (RWW) is used for the servicing of locomotives and wagons since 1972 (Plate 3). The workshop is located to the south west of the East Weipa TSF between Evans Landing and Lorim Point (Figure 2). The interviews included two railway workshop employees with up to 15 years' experience and two Chubb staff with knowledge of site activities since 2003.

There are no records or reports of AFFF storage or use around the RWW other than within the fire suppression systems of locomotives operated by RTAW and rail grinding plant operated by a subcontractor. No AFFF is stored at the RWW and track machines including compressor trucks use Dry Chemical Powder (DCP) extinguishers.

There are currently 2 locomotives in use, each with fire suppression systems connected to two 106 L cylinders. It was reported that fire suppression systems with AFFF have been used in 4 of the 5 locomotives since the 1980's. The AFFF products and volumes were reported to be the same as for HME with 5 to 6 L of AFFF in each cylinder. The AFFF product was recently upgraded in both locomotives and was reported to be fluorine free.

The fire suppression systems are serviced every 6 months by CHUBB. It was reported that since 2015, the contents of the cylinders have been collected and disposed off site by Remondis. It was reported by site staff that prior to 2015, the cylinders were discharged to the floor of the workshop and hosed away from the working area. Based on the number of locomotives serviced and the product in their fire suppression systems, it is inferred that approximately 50 L of AFFF may have been released to the environment each year during the period 2000 to 2015. Prior to this, the volume released may have been less as one or more of the locomotives did not have a fire suppression system.

Surface water from the RWW currently flows through an oil/water separator (refer to Plate 17 of Appendix B) and is discharged to a drainage ditch to the north of the building. The drainage ditch is understood to flow in a westerly direction. Prior to upgrade works on the drainage system, surface water from the RWW was reported to drain directly to the ditch at the north of the building. Staff did not know when the drainage works were completed.

Anecdotal reports suggest that there have been 3 incidents involving application of the railway fire suppression systems discharging outside of the RWW. The first incident occurred on Christmas Day approximately 14 years ago at the 17km mark of the railway track to Andoom as displayed on Figure 2. The 2 subsequent incidents were in the last approximately 5 years and involved fires on rail grinding plant on the railway line north of Mission River bridge. The F&R team responded to these incidents, but it is not clear if additional AFFF was applied from the fire truck.

7.3.4 Civil Workshop

Prior to construction of the AHEQ and EWHEQ, servicing and maintenance of HME was conducted at what is currently known as the Civil Workshop in Lorim Point (Figure 2 and Plate 3). Two staff members from the Civil Workshop with up to 30 years' experience were interviewed. A photograph of the workshop *circa* 1988 with HME parked adjacent to the building is shown in Plate 18 of Appendix B.

It was reported that drainage from the workshop area is currently pumped through an oil/water separator that discharges to the north west of the building. It was not known when the drainage system was installed.

7.3.5 Fire and Rescue Building

The F&R team respond to emergencies within mining areas, support facilities, in the Weipa township and in Napranum. The F&R facility is situated in the northern portion of Lorim Point (Figure 2), has been present since at least 1979 (Plate 3) and is the primary location for fire training activities. Five current or previous employees of the F&R team and two members of the auxiliary emergency response team where interviewed. Their knowledge of firefighting activities primarily relates to the last 10 years, however, 3 staff members had knowledge of activities from the early 2000's.

At the F&R Facility, AFFF has been dispensed in training events from:

- a fire truck containing 200 L of concentrated product,
- a fire trailer containing 1,000 L of concentrated product; and
- foam extinguishers ranging from 9 kg to 50 kg.

It was reported that the AFFF product currently used is Solberg RF3 and that the F&R team previously used concentrate supplied by 3M. It was also reported that the AFFF product RF6 was used from 2001 to 2007.

Drums of AFFF are stored outside the F&R building on pallets resting on bare ground. No bunding or containment was evident. At the time of the inspection the storage included four 20 L drums and one 200 L drum of Solberg RF3 3% (refer to Plate 3 and 4 of Appendix B) along with three 20 L drums of Solberg labelled *'Defence training foam (DoD3155)'* (refer to Plate 2 of Appendix B).

Training exercises using AFFF have been undertaken on bare ground to the north, west and south of the F&R building as shown in Figure 9A. It is understood that the majority of the training has been to the north of the building around the fire training structures (refer to Plate 5 of Appendix B). The number of training exercises was reported to vary from 2 to 6 times per year with an average of 3 training events per year that used AFFF. The fire truck used for training events has a 200 L tank for AFFF and it was reported that the tank was replenished with 1 to 2 drums or 20 to 40 L of AFFF after each training event. Based on the number of training events and volume of product used, it is inferred that approximately 100 L of AFFF may have been released to the environment each year during the period 2000 to *circa.* 2017. There is little information on AFFF use prior to this period.

The fire trailer (refer to Plate 6 of Appendix B) is stored at F&R and was reported to be moved to the Lorim Point and Evans Landing wharves during fuel offloading. The fire trailer is also moved to the airport during training events. However, there have been no records or anecdotal reports of the fire trailer being actively used at the F&R building, the wharves or fuel storage facilities. The trailer may have been used for training exercises at the airport, but there are conflicting reports on this issue.

Fire extinguisher training for site personnel is conducted at the F&R building. The training involved discharging the extinguishers within training events or to the concrete structure to the north east of the F&R building (refer to Figure 9A). Based on the interviews it is likely that most and possibly all of the extinguishers were CO2 and dry chemical powder (DCP). One staff member who was part of the emergency response team suggested that foam extinguishers may have been used for training. This has not been corroborated by other interviews and further details regarding the foam type, size or colour of the extinguishers could not be established.

Out of date AFFF product and most empty containers where reportedly placed in general waste bins for disposal to landfill located at Evans Landing. Some of the empty 20 L drums and most of the empty 200 L drums were recycled by residents from Weipa township.

The land surrounding the F&R building is raised slightly to the north east while the remaining area is essentially flat. There is a slight fall to a drainage ditch along the unnamed road to the west of the building. Surface water was reported to infiltrate or flow overland to the western drain and from there to the south and the Embley River.

7.3.6 Weipa Airport

The Weipa airport is located to the north east of Napranum (Figure 2). It is understood that the Airport is the responsibility of RTAW who sub-contract its operation to Aerodrome Management Services with fuel supply provided by Viva Energy and emergency response provided by RTAW. Interviews were completed with 7 RTAW staff members with knowledge of AFFF use in the airport area. Two of the staff members had up to 12 years' experience with fuel infrastructure maintenance and five staff members had up to 17 years' experience with F&R activities at the airport.

No fire incidents are known to have occurred at the airport.

The Airport Fuel Depot contained AFFF extinguishers of 50 kg and 9 kg size on bare ground within the fenced compound. The AFFF product in the extinguishers was not confirmed. A blue trolley was noted inside the

fenced area during a site inspection and this is likely to be the 50 kg extinguisher referred to during interviews (refer to Plate 7 of Appendix B). In addition, it was reported that 20 L drums of AFFF are stored at the Airport Fuel Depot for use by F&R. These drums were not visible during an inspection from outside of the fenced area and it is not known how many drums are present. The fire trailer may also have also been stored at the fuel depot for relatively short periods.

Emergency response training is undertaken every two years at the airport. These events involve numerous staff members acting as casualties and there is general knowledge of the location, dates and general procedures. The fire truck was used as the first response during training with subsequent support including the fire trailer. It was reported that the AFFF tanks on the fire truck and trailer were replenished with a total of 2 to 3 drums or 40 to 60 L of AFFF after each training event. Based on the number of training events and volume of product used, it is inferred that approximately 50 L of AFFF may have been released to the environment every 2 years during the period 2008 to 2017. There is little information on AFFF use prior to this period.

The training events were reported to have been conducted at four areas surrounding the runway since 2008. The approximate location and year for the last 6 training events are shown on Figure 9B. It is understood that Solberg RF3 was used for the most recent training event. Previous AFFF usage was most likely a 3M product, however, simulation foam was anecdotally used for some training exercises and may have been used at the airport.

Weipa airport landfill is located 400m west of the airport terminal. The site was used as a landfill from early 1990's to circa 2000's. Previously a sand quarry that was approximately 3m deep, the void was infilled with waste including conveyor belts, tires, cars, batteries, cables, concrete and uncontrolled public waste (OTEK 2010a).

7.3.7 East Weipa Heavy Equipment Workshop

The EWHEQ is located approximately 2 km north east of the airport (Figure 2). It has been used for servicing of HME since 1991. Before this time the HME were serviced at Lorim Point in a building currently identified as the Civil Workshop. Interviews were conducted with two crew leaders at EWHEQ with up to 20 years' experience, with one staff member who specialised in HME maintenance who had 15 years' experience and with two Chubb employees with knowledge of site activities since 2003. These staff reported that small quantities of AFFF are stored at EWHEQ for use by F&R to support their emergency response. The site inspection identified one 20 L blue drum of Solberg RF3 and one 20 L black drum of CHUBB AFFF 3% (refer to Plate 9 of Appendix B). No fire training or emergency response is known to have occurred at EWHEQ or in the surrounding laydown area.

AFFF is used in fire suppression systems on HME. The systems were first installed on new HME *circa* 1985 and then added incrementally. By the year 2000 most HME were installed with fire suppression systems and by 2005 their use was mandatory. Based on historic photographs of HME, the early fire suppression systems appeared to host 60 L blue cylinders possibly containing 5 L of AFFF. Dry chemical powder was tested, but the systems suffered from compaction and were not continued.

The installation of fire suppression systems on HME and use of AFFF at Weipa Peninsula is understood to follow the same pattern recorded for Andoom.

There are currently about 40 RTAW HME serviced at the EWHEQ and 5 to 10 contractor HME serviced at the Lorim Point Mine Centre. The number of HME was previously lower and between 1991 to 2001 about 30 HME were serviced at EWHEQ. Before 1991 it is estimated that 10 HME were serviced at Lorim Point in the current Civil Workshop building. Based on the number of HME serviced and the product in their fire suppression systems, it is inferred that approximately 300 L of AFFF may have been released to the environment each

year during the period 2001 to June 2017. Prior to this, the volume released would have been considerably less.

The HME fire suppression systems are serviced annually by CHUBB at the EWHEQ. It was reported by site staff that until June 2017 the systems were discharged to the floor of the building and hosed with water to remove product from the working area. More recently, the contents of the fire suppression systems have been collected and disposed off site by Remondis. There is a rolling programme in place for all HME fire suppression systems to be upgraded by mid-2018 to allow use of fluorine free AFFF.

In 1996 or 1997 spoon drains were installed around the perimeter of the EWHEQ. These drains transport surface water from the workshop, but not roof water, to a sediment pit to the west of the building. The waste water then passes through a humiceptor before being discharged to the vehicle wash pad, an oil/water separator and a final sedimentation pond. Water from the pond is released to the environment at a drainage ditch or discharge point to the south west of the building and accumulated sediment in the pond has been taken to the East Weipa Bioremediation Pad for disposal.

It was reported that “several years ago” a large volume of waste water from the EWHEQ workshop that contained degreaser was discharged to the vehicle wash pad and through the oil/water separator. As part of the clean-up works from this incident, soil down gradient of the discharge point and potentially containing PFAS was removed and taken to the East Weipa Bioremediation Pad. Following this incident, waste water from the humiceptor was diverted directly to the discharge point south-west of the building for approximately one year.

In addition to release of AFFF during servicing of HME, there were reports of fire suppression systems being discharged within active mine areas due to fires, suspected fires and system malfunctions. Maintenance records indicate 30 incidents of discharge outside of the workshops in the last 8 years. Anecdotal reports support this and suggest that discharge outside of the workshops occurs 3 to 6 times per year. The locations for these discharge events have only been recorded since June 2017.

7.3.8 Other Potential AFFF Sources in the Project Area

In contrast to the buildings and plant described above, it was reported that all other buildings and plant across the Weipa and Andoom areas used water, carbon dioxide and dry compressed powder extinguishers. A potential exception is the current power stations that were reported by a member of the F&R team to have four 106 L cylinders containing AFFF. These cylinders were reported by RTAW as “never used” and only visually inspected every 6 months with no testing. Other potential AFFF sources are detailed in the following sections.

7.3.8.1 Herring Oil Slot

The Herring Oil Slot comprises a series of former open excavations or slots within a previously mined area that were used for the disposal of waste oil. The site is located in the north Weipa Peninsula within the Mission River Catchment as displayed in Figure 2. Waste oil was historically placed in three separate areas between 1983 and 1991. Investigations and some remedial works were conducted at the site through the 1990s, however, some residual soil and groundwater contamination remains in the area. RTAW has indicated that this site has undergone periods of remediation whereby phase separated hydrocarbon is removed from impacted wells with bailers and taken off-site for disposal in accordance with the Draft Site Management Plan for this site. The site has been revegetated by RTAW and ongoing groundwater monitoring has been undertaken since the early 1990s (Golder 2018a). Herring oil slot is considered a potential source area as it may have received PFAS containing products.

7.3.8.2 Landfills

Evans Landing Landfill is currently the only licensed landfill in the Project Area. This landfill is considered to be a source area for PFAS due to reported disposal of AFFF products and containers and use of AFFF to extinguish fires within the landfill. Further details are provided in Table 5.

Uncontrolled landfilling has historically taken place at within the Project Area. PFAS containing materials may have been received at these locations and as the landfills are unlined there is a potential transport pathway to the surrounding environment. Landfills considered to represent potential source areas have been identified from review of information provided by RTAW and including third party reports. These are summarised in Table 5 and the locations are displayed in Figure 8.

Table 5: Summary of Landfills considered Potential Source Areas

Landfill Name	Approximate Year of Operation	Operation
Current Operating Landfill		
Evans Landing	1980s to current	Waste originally placed directly onto the exposed floor of completed mining excavations over an area of approximately 13 ha. A perimeter leachate interception system was retrofitted in 2011. Subsequent stages of the landfill have been lined and have leachate management systems (Golder 2015b). Currently the landfill receives domestic and commercial waste. It was reported during interviews that empty drums of AFFF product were placed in general waste for disposal at the Evans Landing Landfill. This practice was consistently reported by users of AFFF product and the practice is likely to have been carried out for greater than 10 years.
Former Uncontrolled and Unlined Landfills		
AHEQ landfill	Not known	Anecdotal information suggests that there was an old landfill to the south west of AHEQ. The exact location is unconfirmed, and no formal documentation exists on the material placed in the landfill. It is inferred that the landfill is located near a cleared area to the south-south east of the site (approx. 350 m from AHEQ). This cleared area may have also been utilised as a bioremediation pad for material from the wash down bay, however no formal documentation of this exists (Golder 2015a). The AHEQ building has been used for servicing of HME from 1979 and possible landfilling activities may have commenced following its construction.
Mission River Bridge landfill	1977 – 1983	Domestic and industrial waste disposal. Anecdotal information suggests that when the Comalco Warehouse was relocated to its current position at Lorim Point at an unknown timeframe a large quantity of stock was placed in this landfill. An oil slot operated in conjunction with this landfill from 1977 to 1986. The disposal of waste oil was transferred to Herring Oil Slot when the landfill closed.

Landfill Name	Approximate Year of Operation	Operation
Tonkin Road Landfill	1969 and 1977	This unlined landfill initially received waste from construction of housing within the Rocky Point area and subsequently received domestic waste (Golder 2013).
Trunding Landfill	1969 - 1970	Anecdotal evidence suggests that the site at the north end of Wattle Terrace may have been used as a landfill in 1969 and 1970. The site encompasses an area of approximately 1,765m^2. No information could be located on the volume or type of refuse placed in the landfill during a preliminary site investigation (OTEK 2008).
Denman's Domestic landfill	1978 -1983	Anecdotal information suggests that this landfill was approximately the size of two football fields. No details are available regarding the type of waste received at this landfill.
Landfill near Trunding Creek	1977 - 1978	Disposal of domestic waste in two deep trenches or borrow pits adjacent to the north east corner of the current East Weipa TSF.
Area G & X and Area Y Landfills	1980 - 1984	Domestic and industrial waste landfills formed on the mine floor in the Evans Landing area. The area has been subsequently rehabilitated with vegetation.
C South Industrial Waste Landfill	1988 - 1991	Industrial landfill including waste from an old Sand Blasting Yard, steel, rubber, electrical cables, spilt bauxite, batteries and paint. A stormwater drains cuts across the area to a discharge point on Embley River.
C North Extension Landfill	1972/73 - 1978	Landfill for predominantly industrial and some domestic waste located approximately 2.5 km north east of Lorim Point.
Weipa Airport landfill	Early 1990's – circa 2000	Previously a sand quarry approx. 3m deep that was infilled with waste including conveyor belts, tires, cars, batteries, cables, concrete and uncontrolled public waste (OTEK 2010 b).
Napranum Landfill	1980/82 - 2000 (potentially ongoing to present).	Unlined domestic landfill east of Napranum.
Area Q Landfill	1968 - 1978	Domestic and industrial waste landfill 2.5km south of the Weipa airport.

7.3.8.3 East Weipa Bioremediation Pad

Sediment from the vehicle wash pads at AHEQ and EWHEQ were reported to be taken to the hydrocarbon bioremediation pad located in East Weipa (Figure 2). This sediment may have been impacted by AFFF from

servicing of HME. Soil contaminated by degreaser, oils and potentially PFAS from the discharge point at EWHEQ was also removed and taken to the East Weipa Bioremediation Pad.

7.3.8.4 Weipa Army Reserves Depot

The Weipa Army Reserves Depot is located at Evans Landing. The Australian Government Department of Defence has published a short description of the Weipa Army Reserves Depot (Commonwealth of Australia, 2017). Base includes accommodation, mess facilities, stores and fuel/oil in above ground storage tanks. There are no available public records indicating use of AFFF at the depot.

7.3.8.5 Release of AFFF in Non-Mining Areas

Response to Fires

The RTAW F&R team respond to fire incidents in the Weipa Township, Napranum and on the mine. The first response typically involves use of the fire truck. The foam fire trailer was not reported to have been used as part of incident response. The following incidents were noted by five current or previous staff members:

- The F&R team reported responding to at least three car fires reported on the Lake Road near Lake Patricia and several car fires at Napranum and Weipa. There were conflicting reports regarding the use or otherwise of AFFF during the response. It was reported that the accepted best practice for car fires involved treatment with water only, but some staff members noted the potential use of “foam”;
- Most staff members reported that water has been used as the main response for house fires in Napranum and Weipa. However, one employee recalled that there was a house fire on Casuarina Crescent, Weipa in around 2005 that may have been extinguished with approximately 400 L of water mixed with AFFF. This incident was not confirmed and does not follow the accepted best practice for house fires;
- It was reported that in *circa* 2005, AFFF was potentially used for a conveyor belt fire at the western edge of the Lorim Point Salvage Yard; and
- Based on anecdotal reports, several fires at the Evans Landing Landfill may have been extinguished with AFFF.

Sewage Treatment Plants

There are sewage treatment plants at Awonga Point and Lorim Point operated by WTA and RTAW. Treated effluent from these plants is discharged at the coast adjacent to the facilities. In addition, there is a sewage treatment plant north of Napranum operated by the Napranum Aboriginal Shire Council. Treated effluent from this plant is reported to infiltrate to ground. These facilities could potentially receive PFAS from impacted residential and commercial waste water and discharge these compounds to groundwater and the environment as by-products of treatment (for example biosolids).

7.4 Potential AFFF Sources Outside of the Project Area

RAAF Base Scherger is located to the east of the Weipa mining area and PFAS containing AFFF products was used as part of their site practices (Golder 2017b, accessed via internet August 2018). No other off-site sources of AFFF have been identified.

The PSI completed for Defence involved review of historical use, storage, and disposal of AFFF and included sampling to identify potential PFAS contamination. The PSI report at RAAF Scherger indicated:

- AFFF was used at the Base in a single training exercise in 2005 or discharged to ground during extinguisher maintenance;

- Testing of soil, surface water, sediment and groundwater found that PFAS was not widespread within the Base;
- Surface water and groundwater from the Base flows into Mission River, to the north and west, through an engineered drainage network and surface water tributaries. The maximum groundwater concentration recorded for the PFAS compounds perfluorooctane sulfonic acid and perfluorohexane sulfonic acid (PFOS+PFHxS) was 0.179 µg/L from a location in the centre of the base. Groundwater elsewhere on the base contained lower concentrations of PFOS+PFHxS with most samples below the LOR of 0.002 µg/L; and
- Surface water testing from Mission River Creek and its tributaries to the west of the Base identified concentrations of PFOS+PFHxS below the LOR of 0.002 µg/L. One surface water concentration of 0.003 µg/L PFOS+PFHxS (marginally greater than the LOR) was recorded from the north east corner of the Base in a tributary draining north to Mission River.

8.0 PRELIMINARY CONCEPTUAL SITE MODEL

A preliminary Conceptual Site Model (pCSM) has been developed based on the:

- Known and potential sources of PFAS contamination;
- Potential transport pathways for contaminated soil, sediment, groundwater, surface water and potable water;
- Potential receptors including residents, commercial workers, recreational water use and sensitive ecosytems; and
- Potential and complete exposure pathways.

The above elements have been summarised in Plate 2 based on the recorded site history and continued residential and industrial land use.

Only complete pathways or linkages between a contamination source and a receptor result in potential risk. If a contaminant pathway is incomplete or not linked, there is considered to be no exposure and, therefore, no risk via that pathway. These elements are developed in this report and a revised Conceptual Site Model based on available data is presented in Section 11.

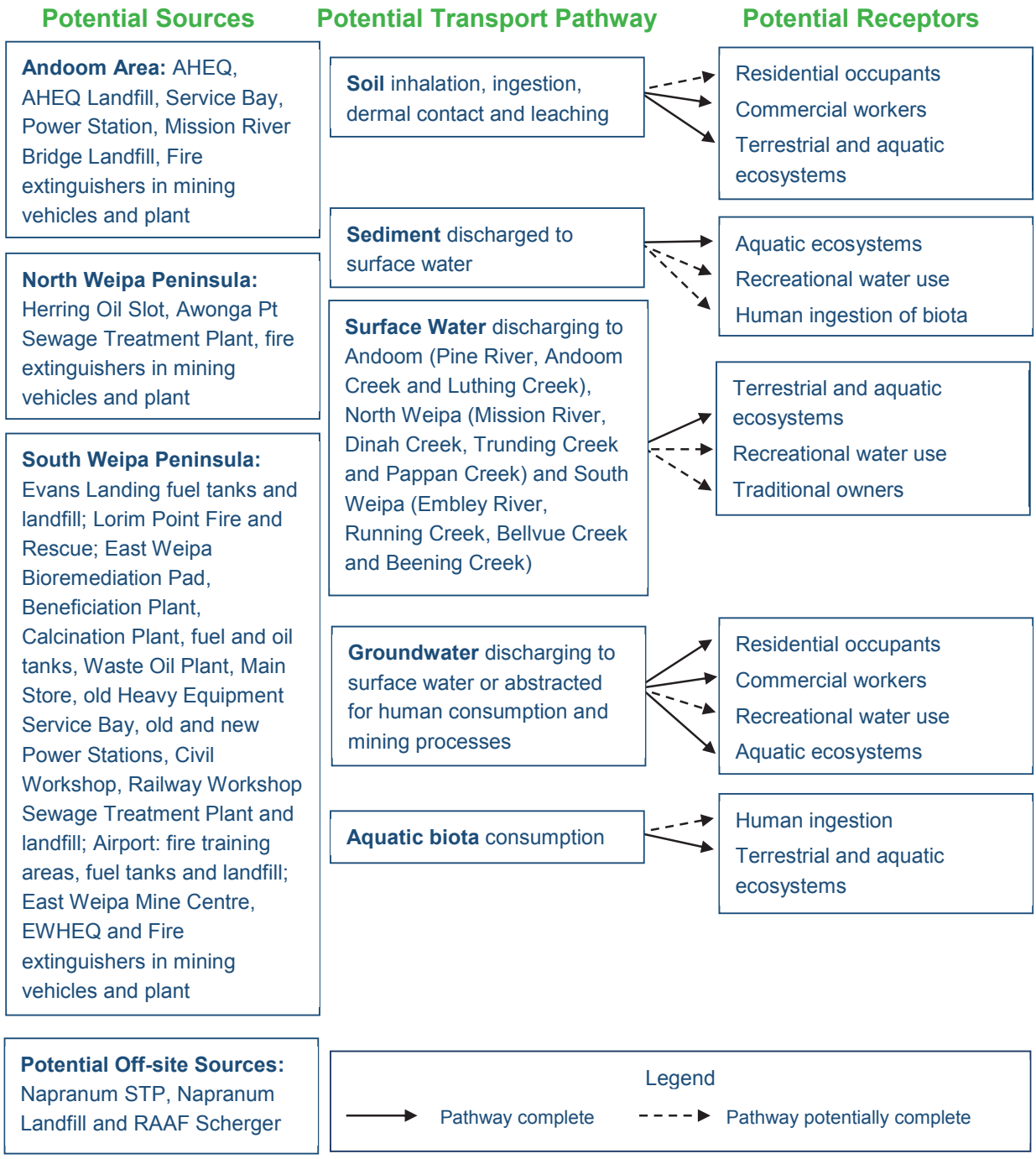


Plate 4: Project Area Preliminary Conceptual Site Model.

9.0 FIELD INVESTIGATION DATA

9.1 Introduction

Field investigation for PFAS undertaken by Golder includes:

- Site investigations in October 2017 being a preliminary assessment of PFAS in soil and groundwater at F&R building, Weipa Airport, EWHEQ and AHEQ. A sample of CHUBB AFFF product was also analysed for PFAS as part of this investigation;
- Sampling and testing of the potable water network in October 2017, November 2017, April 2018 and July 2018
- Sampling and testing of groundwater wells in October 2017 and June 2018;
- Sampling and testing of surface water locations in April and July 2018; and
- Separate to this PSI report, PFAS field investigation including sampling of aquatic biota and co-located sampling of surface water and sediment is documented in a biota SAQP and an assessment report produced by Golder (ref. 18100235-006 and 18100235-018).

The field investigations in 2017 and 2018 were undertaken by Environmental Scientists from Golder. Representative photographs of the 2018 sampling locations are included in Appendix B. All samples were analysed for an extended PFAS suite as follows:

- 51 soil samples from AHEQ, EWHEQ, F&R and the Airport were tested for 28 PFAS compounds with a typical laboratory LOR of 0.0002 mg/kg. This included PFAS TOPA analysis being conducted on 5 soil samples for total concentrations using the total oxidisable precursor assay (TOPA) and leachable testing using with deionised water using the Australian Standard Leaching Procedure (ASLP) on 5 samples.
- 17 groundwater monitoring wells in October/November 2017 and 66 wells in June/July 2018 from across the Project Area and including repeat sampling of 4 wells. Samples were tested for 28 PFAS compounds with a typical laboratory LOR of 0.0003 µg/L.
- Up to 24 potable water supply wells and accumulation points were sampled in October and November 2017 respectively. In addition, 21 potable water supply wells and 3 accumulation points were sampled in April and July 2018, and 6 wells and 1 accumulation point were resampled in July 2018 to confirm laboratory results. Samples were tested for 28 PFAS compounds with a typical laboratory LOR of 0.002 µg/L.
- 24 surface water locations were sampled in April 2018 and 10 surface water locations were sampled in July 2018. Samples were tested for 28 PFAS compounds with a typical laboratory LOR of 0.0003 µg/L.

The field monitoring records for all soil and water samples are summarised in Appendix E and the laboratory test certificates and chain of custody documentation for samples are included in Appendix F. Comparison of the analytical results to the adopted assessment criteria is discussed in Section 11.0.

9.2 Quality Assurance / Quality Control

Quality assurance and quality control was undertaken for the total 155 primary water samples collected for the field investigations of this PSI. Field quality control samples for the matrix of water included 17 primary laboratory blind duplicates, 15 secondary laboratory triplicate samples, 11 rinsate samples and 9 trip blanks. Internal laboratory control samples completed included duplicates, blanks, matrix spikes duplicates and surrogates.

A data validation summary of the QAQC assessment with tabulated field quality control sample results is presented in Appendix G. A summary of the investigation data quality assessment is presented in the below sections.

9.2.1 Fieldwork

Components of field work relevant to quality control are as follows:

- Golder internal fieldwork procedures as outlined in the SAQP were complied with and are considered appropriate for the purposes of sampling;
- Several QA/QC samples have minor inconsistencies with the labelling protocol outlined in the SAQP. Where these samples are presented, the sample type is detailed to avoid misunderstanding; and
- Two samples noted on a COC were received at the laboratory without sample labels and analysed as “No ID sample”. Results for both samples were less than the laboratory LOR for all analytes. Therefore, the samples were assessed as those stated on the COC.

9.2.2 Samples

Field and laboratory quality control samples were analysed with the following noted:

- Standard Golder internal sample collection, handling and storage procedures as outlined in the SAQP were complied with.
- Primary laboratory blind duplicates were analysed at a rate of 11% compared to primary samples, which meets the requirements of NEMP 2018.
- Secondary laboratory triplicate samples were analysed at a rate of 9% of primary samples, which is slightly below the 10% rate recommended in NEMP 2018.
- Rinsate blanks and trip blanks were submitted for each sampling event undertaken. All field blanks results were below the laboratory limit of detection. Two rinsate samples detected PFOS at the limit of reporting and all remaining rinsate blanks recorded results below the limit of reporting. Given these rinsate results, cross contamination is not considered to be an issue for sampling equipment that was reused between sample locations.

9.2.3 Analysis

Items regarding laboratory analysis of primary and quality control samples are summarised as follows:

- Laboratory analysis of samples was undertaken by facilities accredited by NATA for the selected tests.
- Relative percentage differences (RPD) between the primary samples and the primary laboratory blind duplicates exceeded the acceptance criteria for 9 of the 476 comparisons. The remaining RPD were below the acceptance criteria or were not calculated as all results were reported below the laboratory LOR. This indicates that approximately 98% of the analysis conducted by ALS is reproducible.
- RPD between the primary samples and the secondary laboratory triplicate samples exceeded the acceptance criteria for 14 of the 420 comparisons. The remaining RPD were below the acceptance criteria or were not calculated as all results were reported below the laboratory LOR. This indicates that approximately 97% of analysis conducted by ALS is reproducible at Eurofins.
- Laboratory QA/QC included laboratory control samples, matrix spikes, laboratory duplicates and surrogates. There were no outliers of laboratory data quality objectives for laboratory control samples, laboratory duplicates and surrogates. One matrix spike analysis for a PFAS analyte was lower than the laboratory data quality objective due to sample matrix interferences. All remaining matrix spike

recoveries were within the laboratory data quality objectives. Laboratory QA/QC samples were analysed at the appropriate frequency.

- All samples were chilled to 4ºC in airtight containers and transported with ice in appropriate storage containers. Due to the transport time from Weipa to the laboratories, the samples where received at greater than 4ºC. This is not considered significant for analysis of PFAS due to its stability in the environment and resistance to chemical change at elevated temperatures.

Based upon the QA/QC assessment it was concluded that the results are valid and suitable for use in this assessment.

10.0 ADOPTED GUIDELINE VALUES

No specific Environmental Values (EV) or water quality objectives have been published by the Queensland government for the western Cape York area. However, the Environmental Protection (Water) Policy 2009 (EPP Water) lists 8 broad environmental values that can be impacted by contamination, including:

- Aquatic ecosystem health;
- Aquaculture and human consumption of aquatic foods;
- Agricultural uses (e.g. stock watering and irrigation);
- Recreational uses (e.g. swimming, wading, boating, fishing and aesthetic);
- Drinking water (raw water supply);
- Industrial Uses; and
- Cultural and spiritual values.

The following 4 environmental values (EV) are considered relevant to the Project Area, may be impacted by PFAS contamination and are considered as part of this report:

- Aquatic Ecosystem Health;
- Recreational Use or the suitability of the water for primary or secondary recreational use, or visual recreational use;
- Drinking Water or the suitability of the water for supply as drinking water; and
- Industrial Use or the suitability of the water for industrial use.

The EV relating to the suitability of water for producing aquatic foods and for aquaculture for human consumption is being assessed separately in an aquatic biota assessment report (18100235-018-R-RevA). The EV relating to agriculture is not considered relevant as the Project Area is predominantly an active mining lease with supporting infrastructure and residential housing and these activities have not been identified within the Project Area.

The cultural or spiritual values of the water are being considered by review of the suitability of the water for fishing, recreation and for the production of aquatic foods for human consumption. The analytical results collected in 2017 and 2018 have been screened against published guideline values as part of a Tier 1 screening assessment.

The adopted assessment criteria are adopted from the PFAS NEMP 2018 and listed in Table 6. All soil samples have been collected from operational areas considered to have an industrial/commercial land use, as such only guideline values with this land use have been adopted.

Table 6: Adopted Guidelines Values for Soil

Exposure Scenario	PFOS/PFHxS	PFOA	PFOS
Human Health			
Industrial/commercial Land Use [a]	20 mg/kg	50 mg/kg	NA
Ecological			
Interim soil - ecological indirect exposure, Industrial/commercial land use [a]	NA	No guidance value	0.140 mg/kg

Notes: [a] Guideline value from PFAS NEMP 2018. PFOS/PFHxS: Sum of perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonic acid (PFOS). PFOA: perfluorooctanoic acid (PFOA)

Concentrations of PFAS reported in water samples have been screened against criteria adopted from the PFAS NEMP 2018 and listed in Table 7.

Table 7: Adopted Guidelines Values for Water

Exposure Scenario	PFOS/PFHxS	PFOA	PFOS
Human Health			
Drinking water, [a]	0.07 µg/L	0.56 µg/L	NA
Recreational water [a]	0.7 µg/L	5.6 µg/L	NA
Aquatic Ecosystem			
Freshwater and Interim Marine- 99% species protection – high conservation value systems [a]	NA	19 µg/L	0.00023 µg/L or >LOR of 0.0003 µg/L

Notes: [a] Guideline value from PFAS NEMP 2018. PFOS/PFHxS: sum of perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonic acid (PFOS). PFOA: perfluorooctanoic acid (PFOA)

The guideline value for aquatic ecosystems assumes 99% species protection for high conservation value systems. This follows guidance provided in the PFAS NEMP (2018) that recommends adoption of a precautionary approach for chemicals that bioaccumulate and biomagnify in wildlife.

11.0 RESULTS SUMMARY AND REVISED CONCEPTUAL SITE MODELS

11.1 Results Introduction

The Project Area comprises three consolidated drainage catchments which include the Pine River, Mission River and Embley River. This section presents a summary of available information for each of the drainage catchments including a revised CSM identifying the known and potential source areas.

PFAS results for soil and water from investigations conducted by Golder in 2017 and 2018 have been considered with information presented as follows:

- Tabulated results of samples analysed for PFAS are presented in Appendix H and screened against adopted guideline values for:
  - Soil (Table 1);
  - Soil Leachate (Table 2);
  - Potable Water (Table 3);
  - Groundwater Monitoring Wells (Table 4); and
  - Surface Water (Table 5).
- The location of samples are displayed as follows:
  - PFAS concentrations in soil compared to human health and ecological guideline values (Figures 10 and 11 respectively) for industrial/commercial land use; and
  - PFAS concentrations in water compared to human health and ecological guideline values (Figures 12 and 13 respectively).

The LOR for PFOS analysis is greater than the aquatic ecosystem guidance value for 99% species protection of 0.00023 ug/L. As it is not currently feasible to test samples with a LOR below the aquatic ecosystem guidance value, concentrations of PFOS reported as <LOR will not be considered to exceed this guidance value. This follows the NEMP guidance that the analytical limit of reporting can be used as a trigger value.

11.2 Source categorisation

Based on the findings of this PSI, PFAS sources have been categorised into three broad categories to represent the scale and significance, or the level of uncertainty associated with each identified source. The rationale used to define each source category is described below.

Primary Source Areas are considered the most significant based on the information available and multiple lines of evidence including:

- interviews with staff members from several business areas indicating consistent information on the magnitude and application practices for AFFF use;
- a high likelihood for release to the environment; and
- PFAS concentrations in soil and/or groundwater that exceed the adopted guideline values for human health and the environment.

The **Primary Source Areas** are those considered the priority for DSI.

Secondary Source Areas represent a second tier of significance based on:

- reduced detail in the information available on the source or conflicting reports from staff members interviewed;
- relatively low volumes of AFFF stored and used in these areas;
- application practises for AFFF indicating a reduced likelihood for release to the environment; and
- low to moderate PFAS concentrations that are less than the adopted human health guideline values, but typically exceeding the adopted ecological guideline value (i.e. >LOR).

Potential Source Areas have been identified as part of the PSI, but these could not be confirmed due to the limited information available. There is a degree of uncertainty regarding their significance based on:

- limited or no information available on the site history;
- no testing of soil or groundwater samples in the vicinity; and/or

- identification of the general site activity as a potential source by industry guidance (NEMP, 2018).

Secondary and Potential Source Areas are considered a lower priority to the Primary Source Areas. The location of the source areas are displayed on Figure 14 and further details are discussed below.

11.3 Pine River Catchment

11.3.1.1 PFAS Results Summary

The Pine River Catchment forms the north western portion of both the Project Area and the Andoom mining area. No Primary Source Areas have been identified within the catchment. There is potential impact to the catchment from irregular or infrequent discharge of the fire suppression systems in HME, however, this source is expected to be localised and to represent a relatively minor contribution. Two surface water samples have been collected from the catchment and these are summarised in Table 8. Neither samples contain concentrations of PFAS that exceed the laboratory LOR or adopted guideline values for human health or the environment. There are currently no confirmed source-pathway-receptor linkages and therefore a CSM has not been prepared for the Pine River Catchment. In addition, the Pine River catchment has been excluded from PFAS focussed DSI.

Table 8: PFAS Laboratory Results for Samples collected within the Pine River Catchment

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
Andoom Mine Area	*surface water*	2	0	<LOR	0	<LOR	2 samples from Ely Creek and Botchet Creek.

Note: the recorded concentrations of PFOA are consistently below the adopted guideline values and have not been included in the summary table.

11.4 Mission River Catchment

11.4.1 PFAS Results Summary

The Mission River Catchment forms the central section of the Project Area and includes the south eastern portion of the Andoom mining area and the northern portion of the Weipa Peninsula. One Primary Source Area, 4 Secondary Source Areas and 3 Potential Source Areas are identified within the catchment. These sources are described below in Section 11.4.2. Samples collected within the Mission River Catchment and results that exceed the adopted guideline values are summarised in Table 9.

The soil leachate and groundwater results summarised in Table 9 have been compared to the guideline values for drinking water and recreational water. This approach has been taken as an initial screen of the data and does not imply that the groundwater is consumed or used for recreational purposes.

Table 9: PFAS Laboratory Results for Samples collected within the Mission River Catchment

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
Andoom Mine Area	*ground water*	6	0	0.0026	6	0.0019	6 locations around Andoom Service Bay.
	surface water	7	0	0.0316	3	0.0217	6 locations across the mining area. Repeat sampling at 1 location
	potable water	10	0	0.006	1	0.002	Repeat sampling at 3 abstraction wells and the accumulation point.
AHEQ	*soil*	*4*	0	0.0072 mg/kg	5	0.0054	4 locations adjacent to the AHEQ, vehicle wash pad and within the drain that discharges to the south east. One sample analysed for TOPA.
	soil leachate	*1*	1[DW]	0.096	1	0.093	1 sample from the discharge point south east of AHEQ.
	ground water	*8*	2[DW]	0.099	8	0.069	6 locations around the AHEQ. Repeat sampling at 2 locations.
	surface water	*2*	0	0.0094	1	0.03	2 locations downstream of the discharge point to the south east of AHEQ.
North Weipa Peninsul	*ground water*	*2*	0	0.007	1	0.003	2 locations in Weipa township.

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
	surface water	*1*	0	0.0015	1	0.0006	1 downstream location at Trunding Creek.
	potable water	*39*	0	0.032	13	0.019	Repeat sampling from 9 abstraction wells and the accumulation point.
Herring Oil Slot	*ground water*	*4*	0	0.0239	2	0.0149	4 locations around the HOS.
Northern East Weipa Mine Area	*surface water*	*6*	0	0.0032	5	0.0015	5 widespread river locations. Repeat sampling at 1 location.

Note: the recorded concentrations of PFOA are consistently below the adopted guideline values and have not been included in the summary table; concentrations that exceed one or more of the guideline values are highlighted; DW = samples exceeding the drinking water guideline value; and RW = samples exceeding the recreational water guideline value.

11.4.2 Primary Source Area

11.4.2.1 AHEQ

The AHEQ has been operational since 1979 and HME with fire suppression systems containing AFFF have been serviced annually at the workshop with AFFF discharged to ground prior to 2017. Since approximately 1996/97 the workshop has had drains installed around the perimeter. These drains discharge surface water from the workshop, but not roof water, to a vegetated area south east of the building. Sediment from the drainage system is collected and removed to the East Weipa Bioremediation Pad. The sediments are potentially impacted by PFAS.

PFAS has been detected in soil samples collected from locations adjacent to the workshop, vehicle wash pad and downstream of the discharge point. No sample concentrations exceed the human health and ecological guideline values for industrial/commercial land use. However, 1 soil leachate sample recorded concentrations of PFHxS+PFOS that exceed the human health guideline value for drinking water (Figure 10). This sample also recorded a PFOS concentration that exceeded the adopted ecological guideline value (Figure 13).

The topography of the area is generally flat with a gentle slope to the south west. The AHEQ is located within the Mission River catchment and while identified within the Andoom Creek sub-catchment, surface water was reported to flow towards Tee Tree Swamp approximately 1.5 km to the south west. Laboratory analysis of a surface water sample from Tee Tree Swamp did not detect PFAS above the LOR.

Surface water samples from 2 locations downstream of the AHEQ discharge point recorded detectable concentrations of PFAS. The sample closest to the discharge point contained a concentration of PFOS that exceeded the aquatic ecosystem guideline value (i.e. >LOR). The second sample approximately 100m downstream did not detect PFAS above the LOR.

Groundwater level measurements in the area indicates that groundwater occurs in a shallow sand aquifer and generally flows towards the south-southwest towards the Mission River. Potable water for the AHEQ is supplied from wells located approximately 3.5 km east. Four monitoring rounds from these wells recorded concentrations consistently below the human health guideline values for drinking water, but with detections close to the laboratory LOR.

Groundwater from 6 monitoring wells around the AHEQ recorded detectable concentrations of PFAS. Two samples to the south of the area recorded PFHxS+PFOS concentrations in excess of the human health guideline value for drinking water. All groundwater samples recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).

11.4.3 Secondary Source Areas

Other sources of PFAS in the Mission River Catchment may include:

- **ASB -** a contractor operating from ASB services HME fitted with fire suppression systems that are likely to use PFAS containing AFFF. Six groundwater samples from locations around ASB recorded concentrations of PFAS below human health guideline values. However, all groundwater samples recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).
- **Herring Oil Slot** – The Herring Oil Slot has received waste material from locations that used AFFF and that may have been impacted by PFAS. Four groundwater samples from locations around this area recorded concentrations of PFAS below human health guideline values and only 2 of the samples recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).
- **Release of AFFF in mining areas** - There is potential for diffuse PFAS sources from incidents involving servicing and discharge of the fire suppression systems in HME at unrecorded locations and in a railway locomotive at the 17 km mark north of Mission River Bridge. In addition, AFFF was used in response to two fire incidents involving rail grinders on the railway line north of Mission River Bridge. Surface water samples from 6 locations across the mining area predominantly identified concentrations of PFAS below the adopted guideline values. However, detections of PFAS were recorded in surface water during one monitoring round at the boat ramp on Andoom Creek. Subsequent monitoring at this location identified a concentration of PFAS that was marginally above the LOR and all samples are below human health guideline values. In addition, 3 surface water samples recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).
- **Release of AFFF outside of mine areas** – an anecdotal report suggests that AFFF may have been used in response to a house fire at Casuarina Crescent, Weipa Township. All surface water, groundwater and potable water samples from Weipa township and the northern Weipa Peninsula recorded concentration of PFAS below human health guideline values. However, most of the samples recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).

11.4.4 Potential Source Areas

Potential sources of PFAS in the Mission River catchment may include:

- **Sewage Treatment Plant -** It is recognised that waste water treatment plants may receive PFAS contaminated material and generate impacted bio-solids. The Awonga Point Sewage Treatment Plant (STP) located to the north east of Weipa township discharges to the Mission River.
- **Former Landfills -** uncontrolled landfilling has taken place within the Mission River catchment and PFAS containing materials may have been received at these locations. The landfills are unlined and there is a potential transport pathway to the surrounding environment. Former landfills that represent Potential Source Areas include:
  - Andoom HEQ landfill;
  - Mission River Bridge landfill;
  - Tonkin Road landfill;
  - Trunding Landfill;
  - Denman's Domestic landfill; and
  - Landfill near Trunding Creek.
- There is also potential for a diffuse source of PFAS from the TSF at Andoom and East Weipa. PFAS may be present with the TSF due to impacted soil and process water used in the beneficiation process. The potential magnitude of this diffuse source and potential transport pathways are not currently known and are likely to be complex.

11.4.5 Potential Offsite Sources

RAAF Base Scherger is located east of the Project Area. A report published by Defence (Golder, 2017) confirms that AFFF was used at the Base in a single training exercise in 2005 and was discharged to ground during routine extinguisher maintenance. Groundwater and surface water from the Scherger Base is reported to flow into the Mission River. Surface water testing from Mission River Creek and its tributaries to the west of the Base identified concentrations of PFOS+PFHxS predominantly below the LOR of 0.002 µg/L. One surface water concentration of 0.003 µg/L PFOS+PFHxS (marginally greater than the LOR) was recorded from the north east corner of the Base in a tributary draining north to Mission River.

11.4.6 Revised Conceptual Site Model

The pCSM presented in Section 8 has been revised to characterise the Mission River catchment and this is presented below in Plate 3. Likely SPR linkages are those where PFAS concentrations have been measured that exceed the adopted guideline values for the identified receptor.

There is no identified linkage between impacted groundwater exceeding adopted guideline values and human consumption of drinking water.

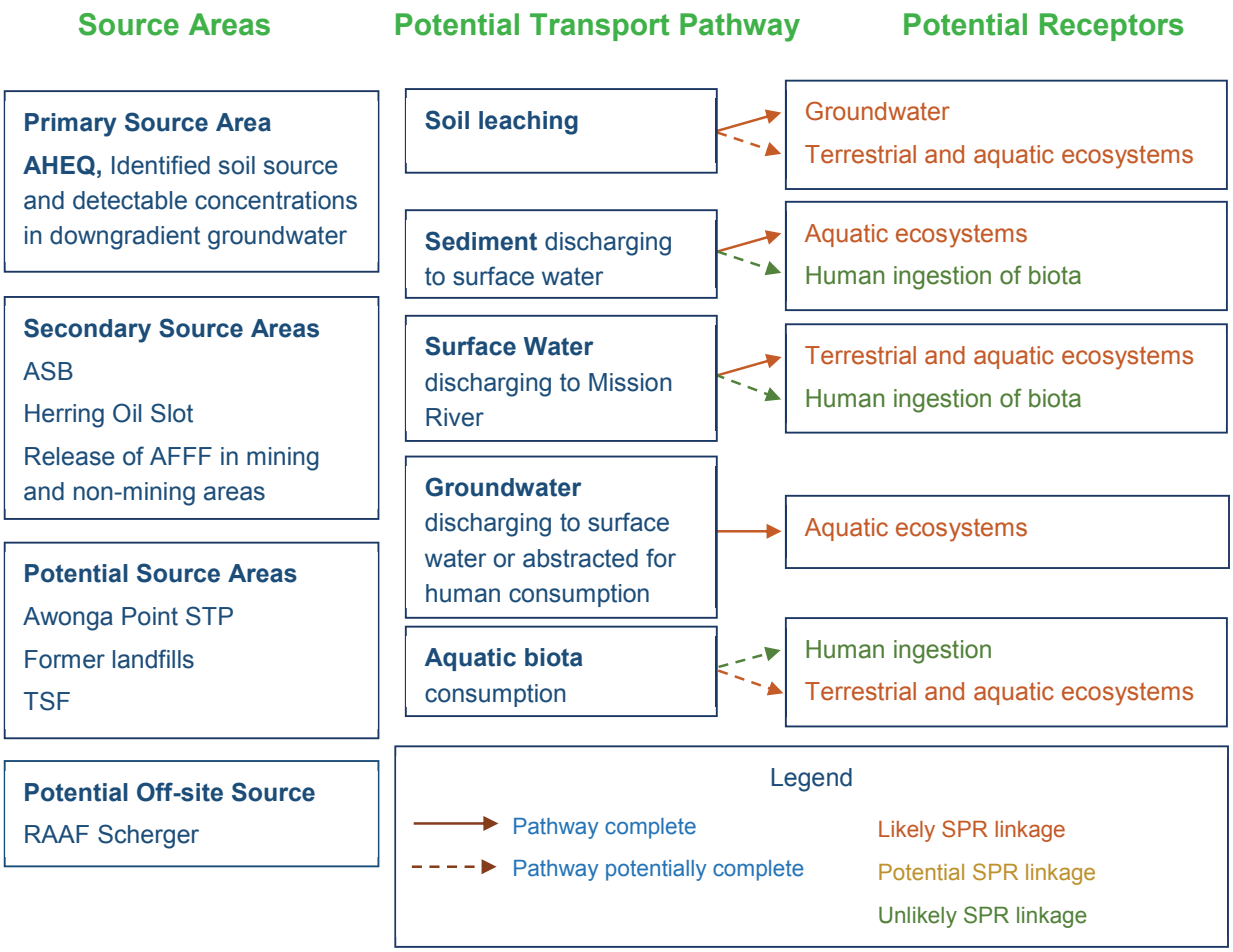


Plate 5:Mission River Catchment Conceptual Site Model.

11.5 Embley River Catchment

11.5.1 PFAS Results Summary

The Embley River Catchment forms the southern portion of the Project Area and includes the southern area of the Weipa Peninsula. Five Primary Source Areas, 5 Secondary Source Areas and 3 Potential Source Areas are identified within the catchment. These are described in Sections 11.5.2 to 11.5.4. Samples collected within the Embley River Catchment and results that exceed the adopted guideline values are summarised in Table 10.

The soil leachate and groundwater results summarised in Table 10 have been compared to the guideline values for drinking water and recreational water. This approach has been taken as an initial screen of the data and does not imply that the groundwater is consumed or used for recreational purposes.

Table 10: PFAS Laboratory Results for Samples collected within the Embley River Catchment

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
West Weipa Penins	*surface water*	2	0	<LOR	0	<LOR	samples from Lake Patrica and Lake McLeod
Evans Landing North and South	*ground water*	*12*	ELN - 1[DW] ELS – 6[DW] ELS – 1[RW]	0.71	ELN – 3 ELS - 6	0.453	6 locations at both ELN and 6 locations at ELS.
	surface water	*3*	0	0.023	2	0.0011	3 locations near the shoreline of Embley River.
Railway Workshop	*ground water*	*7*	1[DW]	0.278	7	0.152	5 locations around the RWW were tested with repeat sampling at 2 locations.
	potable water	*4*	0	0.015	3	0.009	repeat samples from SA110, 260 m south west of the RWW.

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
Lorim Point	*soil*	*14*	0	2.541 mg/kg	*6*	2.43 mg/kg	locations north and south of the F&R building and the drain to the west. Two samples collected north of the building were analysed for TOPA.
	soil leachate	*2*	2^{DW} 1^{RW}	154	2	153	locations north and south west of the F&R building
	ground water	*23*	11	4.13	23	2.25	17 locations across the LPI area with repeat sampling at 4 locations.
	surface water	*3*	0	0.0007	2	0.0007	3 locations near the shoreline of Embley River
	potable water	*30*	0	0.048	30	0.034	repeat sampling from 6 potables wells and the accumulation point.
Lorim Point Fuel	*ground water*	*3*	0	0.0255	*3*	0.0148	3 locations east, south and west of the depot
East Weipa Bioremediation Pad	*ground water*	*3*	0	0.013	3	0.0057	3 locations east, south and west of the BRP

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
Weipa Airport	*soil*	*24*	0	0.0024 mg/kg	0	<LOR	Samples collected from surface water drains adjacent to the runway and near the passenger terminal. TOPA analysis was conducted on 1 sample
	soil leachate	1	1[DW]	0.181	1	0.173	1 location south of the runaway
	ground water	*7*	1[DW]	0.136	7	0.052	5 locations south west of the runway with repeat sampling at 2 locations.
	potable water	*8*	0	0.047	6	0.027	repeat sampling from 2 locations west of the airport
East Weipa Mine Area	*surface water*	*5*	0	0.0038	2	0.0015	4 river locations tested with repeat sampling and PFAS detection at Beening Creek (downstream).

Locality	Sample Matrix	No. Samples	No. of Samples Exceeding the *Human Health* Guideline Values	Max. PFHxS+ PFOS (µg/L)	No. of Samples Exceeding the *Ecological* Guideline Values	Max. PFOS (µg/L)	Sample Distribution
EWHEQ	*soil*	*4*	0	0.0353 mg/kg	0	0.0353 mg/kg	Locations adjacent to the EWHEQ building, vehicle wash pad and within the drain that discharges to the south west. One sample analysed for TOPA
	soil leachate	*1*	1[DW]	0.11	1	0.069	1 sample from the drain south west of the EWHEQ
	ground water	*8*	2[DW]	0.242	8	0.156	Repeat sampling from 5 locations to the south and south west of EWHEQ
	surface water	*3*	1[DW]	0.0923	3	0.0614	2 locations south west of the EWHEQ discharge point with repeat sampling at 1 location.
	potable water	*5*	0	0.009	5	0.005	Repeat sampling from SA027 and the accumulation tank

Note: the recorded concentrations of PFOA are consistently below the adopted guideline values and have not been included in the summary table; concentrations that exceed one or more of the guideline values are highlighted; DW = samples exceeding the drinking water guideline value; and RW = samples exceeding the recreational water guideline value.

11.5.2 Primary Source Areas

11.5.2.1 Evans Landing

The topography of the area is generally flat with a gentle slope towards the south west. Surface water flows towards the Embley River and surface water samples were collected from the EVL jetty, 300m east and 300m west of this point (i.e. along 600 m of shoreline). PFAS was detected in two samples, one near the EVL jetty and one approximately 300m west (Figures 12 and 13). The recorded PFOS concentrations of 0.0011 µg/L and 0.0008 µg/L respectively are below the human health guideline values but exceed the guideline value for aquatic ecosystems (i.e. >LOR). The third sample from 300 m east of EVL did not contain detectable concentrations of PFAS.

Groundwater level measurements in the area indicate that groundwater occurs in a shallow sand aquifer and generally flows towards the Embley River to the south. Previous third-party reports suggest that this gradient may be reversed with an overall northerly flow direction during the dry season and at locations close to the coast. Groundwater from 12 monitoring wells around ELN and ELS recorded detectable concentrations of PFAS. One sample to the south of the ELN area and 6 samples from ELS recorded PFHxS+PFOS concentrations that exceed the human health guideline value for drinking water. In addition, 1 sample from ELS exceeded the human health guideline value for recreational water. Three groundwater samples from ELN and all groundwater samples from ELS recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).

11.5.2.2 Railway Workshop

The RWW has been operational since 1972 and locomotives with fire suppression systems containing AFFF have been serviced at the workshop every 6 months with AFFF discharged to ground prior to 2015. The topography of the area is generally flat with an overall gentle slope to the south west. Surface water was reported to flow to the north and west of the RWW before flowing south towards the Embley River.

Groundwater level measurements in the area indicate that groundwater occurs in a shallow sand aquifer and generally flows in a south westerly direction towards the Embley River. Potable water for the RWW, EVL and Lorim Point is supplied from wells located to the south west and the east of the RWW. Four monitoring rounds from these potable bores recorded concentrations consistently below the human health guideline value for drinking water.

Groundwater from 5 monitoring wells around the RWW recorded detectable concentrations of PFAS. One sample to the south west of the RWW recorded PFHxS+PFOS concentrations that exceed the human health guideline values for drinking water. All groundwater samples recorded PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).

11.5.2.3 Lorim Point

The F&R building has been present since at least 1979 and is the primary location for fire training activities using AFFF. Soil investigation in the areas north, west and south of the F&R building identified detectable concentrations of PFAS. None of the recorded concentrations exceed human health guideline value for industrial/commercial land use. However, 2 soil leachate samples recorded concentrations of PFHxS+PFOS that exceed the human health guideline value for drinking water. In addition, 4 soil samples analysed for a standard suite of PFAS and 2 soil samples analysed using the TOPA method recorded PFOS concentrations which exceeded the ecological guideline values for industrial/commercial land use.

Groundwater level measurements in the Lorim Point area indicate that groundwater occurs in a shallow sand aquifer and generally flows towards the south-southwest towards the Embley River. Potable water for residential mining accommodation and commercial receptors at Lorim Point and Evans Landing is supplied by a network of seven potable wells connected to accumulation tanks (Figures 7 and 12). Potable bores located down, and across-hydraulic gradient of the F&R building include SA014 located 70m to the east and SA015 located 180m south east. The remainder of the potable wells are located to the north and up-hydraulic gradient. PFAS has been detected in all of the potable wells and the accumulation point at Lorim Point. All recorded concentrations were below the human health guideline values for drinking water.

Lorim Point Industrial precinct (LPI) has a network of 24 monitoring wells located 170m to the south of the F&R building. These monitoring wells are distinct from the potable water wells located to the north and east of the LPI. Concentrations of 1 to 4 µg/L PFOS+PFHxS were recorded at 10 of the monitoring wells in the central and western portions of the LPI area. These concentrations exceed the drinking water and recreational water guideline values. Groundwater samples from the eastern portion of this area recorded concentrations up to

the drinking water value of 0.07 µg/L PFOS+PFHxS. The western boundary of the impacted groundwater has not been established. The PFAS results suggest that there is a contaminated groundwater plume extending some 400m south west and downgradient from the F&R building to the Embley River. The concentrations of PFOS in all groundwater samples were above the screening value for aquatic ecosystems (i.e. >LOR).

The available information suggests that there is a potentially viable pathway for PFAS sourced from the F&R area to reach potable abstraction well SA015. There is also a potential pathway to potable abstraction well SA014, however, this well is potentially across hydraulic gradient and may be less susceptible to impact from the groundwater plume. Based on these potentially viable contaminant pathways the potable wells SA014 and SA015 have been isolated from the supply network by RTAW. Further investigation and assessment is proposed to assess and subsequently constrain these potential pathways.

Surface water from the Embley River was sampled at Lorim Point, 600m east and 600m west of this point (i.e. along 1.2 km of shoreline). PFAS was detected in two samples, one near the ship loading jetty at Lorim Point and one approximately 600m west (Figures 12 and 13). The recorded PFAS concentrations are below the human health screening value but exceed the screening value for aquatic ecosystems. The third sample from 600 m east of Lorim Point did not contain detectable concentrations of PFAS.

11.5.2.4 Weipa Airport

Weipa airport has been active since at least 1969. While there have been no incidents of fires at the airport, training events using AFFF have been completed every two years since 2008 and possibly prior to this.

The Weipa Airport Fuel Depot, located south east of the runway, has been present since about 1979 based on aerial photographs. AFFF extinguishers are stored at the fuel depot and these are reported to be visually inspected and not discharged as part of testing. Training exercises with the foam extinguishers may have occurred.

Soil investigation at both ends of the runway and near the passenger terminal in the approximate areas of training events identified detectable concentrations of PFAS. None of the recorded soil concentrations exceed the adopted human health or ecological guideline values. However, 1 soil leachate sample recorded a concentration of PFHxS+PFOS that exceeds the human health guideline value for drinking water. This sample also recorded a PFOS concentration that exceeded the adopted ecological guideline value (i.e. >LOR).

The topography of the area is generally flat with a gentle slope to the south west. The airport is located within the Embley River catchment with the north western area of the airport within the Embley River Tributary sub-catchment and the south eastern area of the airport part of the Beening Creek sub-catchment.

Groundwater level measurements in the airport area indicate that groundwater occurs in a shallow sand aquifer and generally flows towards the south-southwest towards the Embley River. Potable water for the airport is currently supplied from SA026 located to the south west of the runway. Four monitoring rounds from SA026 recorded concentrations consistently below the human health guideline value for drinking water.

Groundwater from 7 monitoring wells to the south west of the runway recorded detectable concentrations of PFAS. One sample from near the Fuel Depot recorded a PFHxS + PFOS concentration is excess of the human health guideline value for drinking water. All groundwater samples recorded PFOS concentrations in excess of the aquatic ecosystem guideline value (i.e. >LOR).

11.5.2.5 East Weipa Heavy Equipment Workshop

EWHEQ has been present since 1991 and HME with fire suppression systems containing AFFF have been serviced annually at the workshop with AFFF discharged to ground prior to 2017. Since 1996/1997 the workshop has had drains installed around the perimeter that discharged surface water from inside the building

to a vegetated area west of the workshop. Sediment from the drainage system has been collected and removed to the East Weipa Bioremediation Pad. These sediments are potentially impacted by PFAS.

PFAS has been detected in soil samples collected from one location adjacent to the workshop, two locations adjacent to the vehicle wash pad and two locations downstream of the discharge point. No sample concentrations exceed the human health and ecological guideline values for industrial/commercial land use. However, 1 soil leachate sample recorded a concentration of PFHxS+PFOS that exceeds the human health guideline value for drinking water. This sample also recorded a PFOS concentration that exceeds the adopted ecological guideline value (i.e. >LOR).

The topography of the area is generally flat with a gentle slope to the south west. The EWHEQ is located within the Embley River catchment and the Beening Creek sub-catchment. Surface water samples from 2 locations downstream of the EWHEQ discharge point recorded detectable concentrations of PFAS with 1 sample exceeding the human health guideline value for drinking water and all samples contained PFOS concentrations that exceed the aquatic ecosystem guideline value (i.e. >LOR).

Groundwater level measurements in the airport area indicates that groundwater occurs in a shallow sand aquifer and generally flows towards the south-southwest towards the Embley River. Potable water for the EWHEQ is supplied from SA027 located approximately 200m south of the EWHEQ area. Four monitoring rounds from SA027 recorded concentrations consistently below the human health guideline value for drinking water.

Groundwater from 5 monitoring wells to the south and south west of the EWHEQ recorded detectable concentrations of PFAS. Two samples to the south west of the area recorded PFHxS+PFOS concentrations that exceed the human health guideline value for drinking water. All groundwater samples recorded PFOS concentrations in excess of the aquatic ecosystem guideline value (i.e. >LOR).

11.5.3 Secondary Source Areas

Other sources of PFAS in the Embley River Catchment include:

- **Civil Workshop** - This building has been present since at least 1979 and it is understood that AFFF has been stored and used at this location for servicing of HME prior to 1991. At this time there were relatively few HME and only a small proportion of these had fire suppression systems utilising AFFF. PFAS has been detected at concentrations below the human health guideline value at potable well SA012 which is 110m south and down hydraulic gradient of the Civil Workshop. Based on this information, the Civil Workshop may be a minor contributing source of PFAS contamination in the Lorim Point area.
- **Lorim Point Fuel Depot** – There are no records of AFFF use or storage at the Lorim Point Fuel Depot, however firefighting equipment containing AFFF may have been deployed at the depot for short periods during fuel unloading. Three groundwater monitoring wells from east, south and west of the depot were tested. The recorded concentrations of PFAS were all below the human health guideline values but exceed the aquatic ecosystem guideline value (i.e. >LOR).
- **East Weipa Bioremediation Pad –** Sediment and waste material from mining areas that may contain PFAS has been deposited at the East Weipa Bioremediation Pad. Three groundwater monitoring wells from around the bioremediation pad were tested. The recorded concentrations of PFAS were all below the human health guideline values but exceed the aquatic ecosystem guideline value (i.e. >LOR).
- **Release of AFFF in mining areas** - There is potential for diffuse sources originating from incidents involving servicing and discharge of the fire suppression systems in HME at unrecorded locations. Surface water samples from 4 locations across the mining area predominantly identified concentrations of PFAS below the adopted guideline values. However, detectable PFAS concentrations were recorded

during two monitoring rounds at the downstream location of Beening Creek. The recorded concentrations were below human health guideline values but exceed the guideline value for aquatic ecosystems (i.e. >LOR).

- **Release of AFFF outside of mine areas** – anecdotal report suggests that the F&R team may have responded with AFFF to car fires near Lakes Patricia and McLeod. Surface water samples from these lakes recorded PFAS concentrations below the LOR.

11.5.4 Potential Source Areas

Potential sources of PFAS may include:

- **Sewage Treatment Plant -** It is recognised that waste water treatment plants may receive PFAS contaminated waste water material and generate impacted bio-solids. The Lorim Point Sewage Treatment Plant discharges to the Embley River. Effluent from the Napranum Sewage Treatment Plant is understood to infiltrate to ground.
- **Former Landfills -** landfilling has taken place within the Embley River catchment and PFAS containing materials may have been received at these locations. The landfills are unlined and there is a potential transport pathway to the surrounding environment. Former landfills that represent Potential Source Areas include:
  - Evans Landing Landfill;
  - Two landfills located north-east of Evans Landing called Area G& Y and Area Y;
  - C South Industrial Waste and C North Extension Landfills;
  - Weipa Airport landfill;
  - Napranum Landfill; and
  - Area Q Landfill.
- There is also potential for a diffuse source of PFAS from the TSF at East Weipa. PFAS may be present with the stockpile due to impacted soil and process water used in the beneficiation process. The potential magnitude of this diffuse source and potential transport pathways are not currently known and are likely to be complex.

11.5.5 Revised Conceptual Site Model

The pCSM presented in Section 8 has been revised to characterise the Embley River catchment and this is presented below as Plate 4.

Likely SPR linkages are those where concentrations have been measured that exceed the adopted guideline values for the identified receptor.

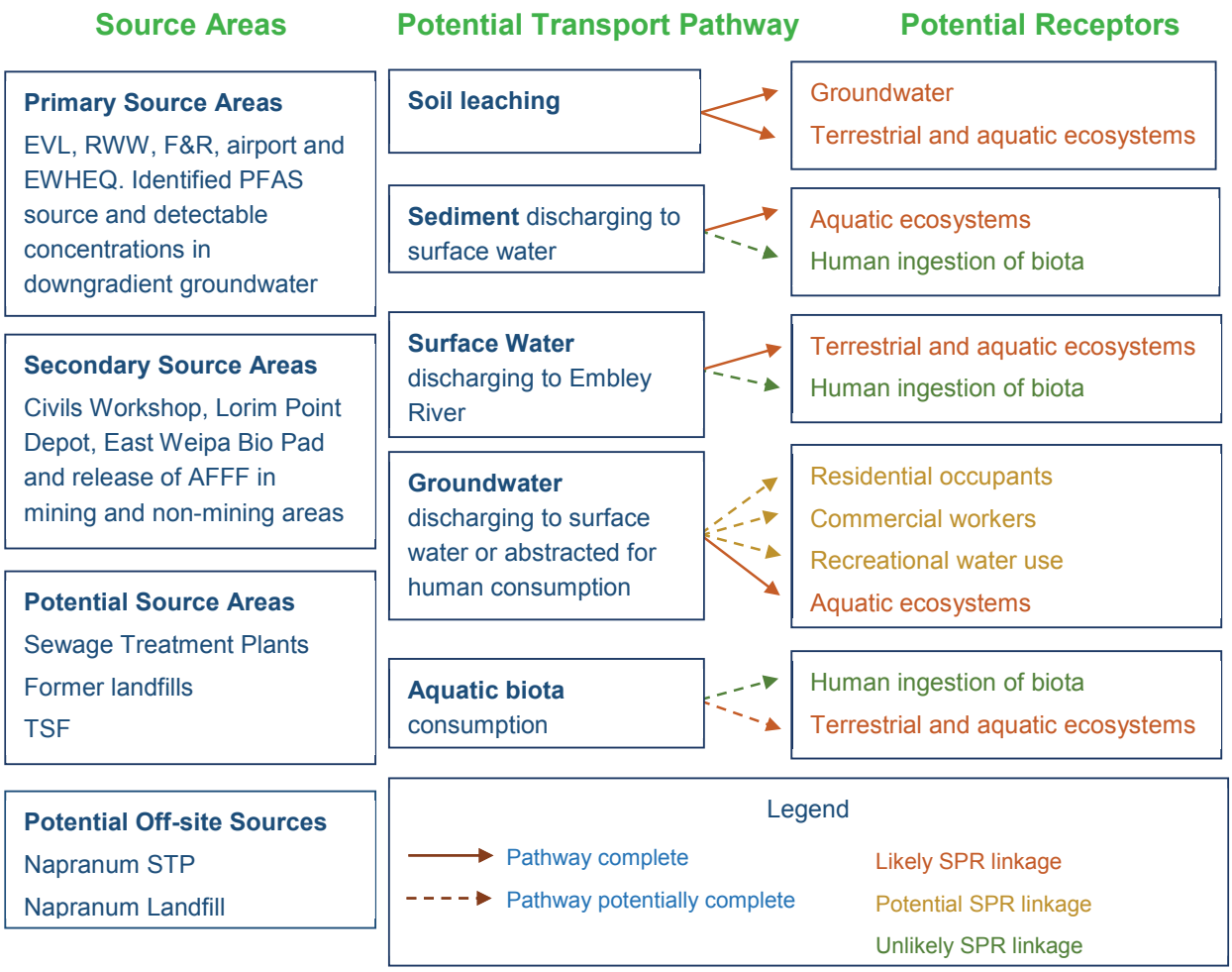


Plate 6:Embley River Catchment Conceptual Site Model.

12.0 CONCLUSIONS

The Project Area comprises the mining leases and activities operated directly by RTAW and indirectly by management companies within the Andoom and East Weipa areas, the adjoining 'off-site' land areas, and the receiving environment that includes the Pine, Mission and Embley River catchments.

This report presents detailed desk study information, interviews and site inspections along with preliminary site investigation. Detectable PFAS concentrations have been identified in soil and water samples from within the Project Area. Seventeen source areas have been summarised below and these are identified on Figure 14. Given the widespread nature of the Project Area and multiple catchments, source areas have been segregated into different categories to identify the various tiers of significance. Primary Source Areas are those considered relevant for the DSI currently being scoped.

The source areas comprise:

- 6 Primary Source Areas with confirmed AFFF storage, use and release to the environment and contaminant concentrations in excess of the adopted guideline values. Detailed investigation and monitoring of these areas is proposed as part of an SAQP and DSI to assess the extent and magnitude of PFAS contamination and assess the potential risk to human health and the environment. The Primary

Source Areas proposed for DSI include AHEQ, Evans Landing, Railway Workshop, Lorim Point, Weipa Airport and EWHEQ.

- 8 Secondary Source Areas with potential, but sometimes conflicting reports regarding AFFF release to the environment and contaminant concentrations predominantly below the adopted guideline values. The Secondary Source Areas include Andoom Service Bay, Herring Oil Slot, Civil Workshop, Lorim Point Fuel Depot, East Weipa Bioremediation Pad, Landfills, release of AFFF in mining areas and release of AFFF outside of mine areas.
- 3 Potential Source Areas that are poorly defined and not characterised by contamination testing. The Potential Source Areas include sewage treatment plants, former and current landfills and TSF.

A biota assessment has been conducted separately (Golder, 2018c) and the conclusions presented below should not be considered in isolation.

12.1 Pine River Catchment

The Pine River Catchment forms the north western portion of both the Project Area and the Andoom mining area. No Primary Source Areas have been identified within the catchment. However, there is potential impact to the catchment from historical discharge of AFFF fire suppression systems in HME. This source is expected to be infrequent, localised and to be relatively minor. Limited sampling and testing of surface water from the Ely and Botchet Creeks has identified no samples that exceed the adopted guideline values for human health or sensitive aquatic ecosystems. There are currently no identified source-pathway-receptor linkages and a CSM has not been prepared for the Pine River Catchment.

12.2 Mission River Catchment

The Mission River Catchment forms the central section of the Project Area and includes the south eastern portion of the Andoom mining area and the northern portion of the East Weipa mining area. One Primary Source area, 4 Secondary Source Areas and 3 Potential Source Areas are identified within the catchment.

12.2.1 Primary Source Area

The AHEQ forms the only identified Primary Source area in the Mission River catchment. It is understood that PFAS has been released to the environment from this facility during annual servicing of fire suppression systems on HME during the period 1997 to 2017. It is inferred that approximately 300 L of AFFF may have been released to the environment each year.

PFAS has been detected in soil, surface water and groundwater samples from around the AHEQ workshop. The recorded concentrations do not suggest contamination presenting a risk to human health, but may present a risk to sensitive aquatic ecosystems. *DSI is proposed to confirm this finding and assess the potential risk to the environment.*

Potable water for the AHEQ is supplied from 3 wells located approximately 3.5 km east. Four monitoring rounds from these wells recorded concentrations consistently below the guideline values for drinking water. *Continued monitoring of potable water is planned.*

12.2.2 Secondary Source Areas

Four Secondary Source Areas are identified within the Mission River catchment. Testing of groundwater samples from around Andoom Service Bay and Herring Oil Slot suggest that PFAS in these areas does not present a risk to human health, but may present a risk to sensitive aquatic ecosystems.

There is potential impact to the Mission River catchment from discharge of the fire suppression systems in HME and in railway vehicles. Limited sampling and testing of surface water from Andoom, Mission River,

Pappan and Trunding Creeks has identified no samples that exceed guideline values for human health. However, some of the recorded concentrations exceed the guideline value for sensitive aquatic ecosystems (i.e. >LOR).

An anecdotal report suggests that AFFF may have been used on a house fire in Weipa township. All surface water, groundwater and potable water samples from Weipa township and the northern Weipa Peninsula recorded concentration of PFAS below human health guideline values. However, most of the samples recorded concentrations above the aquatic ecosystem guideline value (i.e. >LOR).

12.2.3 Potential Source Areas

Potential Source Areas comprise the:

- Awonga Point Sewage Treatment Plant;
- former landfills at AHEQ, Mission River Bridge, Tonkin Road, Trunding Creek and Denman; and
- TSF at Andoom and East Weipa.

12.3 Embley River Catchment

The Embley River catchment forms the southern portion of the Project Area and includes the southern area of the Weipa Peninsula. Five Primary Source Areas, 4 Secondary Source Areas and 3 Potential Source Areas are identified within the catchment.

12.3.1 Primary Source Areas

12.3.1.1 Evans Landing

Operations at EVL include an active bulk fuel depot in the north (ELN) and a former bulk fuel depot in the south (ELS). Groundwater from the south of ELN and from across ELS recorded PFAS concentrations that exceed the guideline value for drinking water and 1 sample from ELS exceeds the guideline value for recreational water. In addition, most samples recorded concentrations above the guideline value for sensitive aquatic ecosystems (i.e. >LOR). The source of PFAS in groundwater at EVL is not known but may relate to remediation of petroleum hydrocarbons in this area during 2011 or an upgradient source to the north or north east of ELS. *DSI is proposed to confirm the extent and magnitude of contamination and assess the potential risk to human health and the environment.*

Surface water samples from the Embley River at EVL contained PFAS concentrations below the human health guideline values, but above the guideline value for sensitive aquatic ecosystems (i.e. >LOR). *Further investigation and monitoring is proposed as part of the DSI in this area to assess the area of PFAS contamination and the potential risk to human health and the environment*.

12.3.1.2 Railway Workshop

The RWW has been operational since 1972 and locomotives with fire suppression systems containing AFFF have been serviced at the workshop every 6 months with AFFF discharged to ground prior to 2015. It is inferred that approximately 50 L of AFFF may have been released to the environment each year during the period 2000 to 2015.

PFAS has been detected in soil, groundwater and potable water samples from around the RWW. The recorded concentrations do not suggest contamination presenting a risk to human health but may present a risk to sensitive aquatic ecosystems. *DSI is proposed to confirm the extent and magnitude of contamination and assess the potential risk to human health and the environment.*

Potable water for the RWW (and EVL/Lorim Point areas) is supplied from wells located to the south west and the east. Four monitoring rounds from these wells recorded concentrations consistently below the guideline values for drinking water. *Continued monitoring of potable water is planned.*

12.3.1.3 Lorim Point

The F&R building has been present since at least 1979 and is the primary location for fire training activities using AFFF. It is inferred that approximately 100 L of AFFF may have been released to the environment each year during the period 2000 to 2017.

PFAS has been detected in soil, surface water and groundwater samples from around the F&R building and within a contaminated groundwater plume extending some 400m south west and downgradient from the F&R building towards the Embley River. Some of the recorded concentrations exceed guideline values for human health and sensitive aquatic ecosystems. *DSI is proposed to confirm the extent and magnitude of contamination and assess the potential risk to human health and the environment.*

Potable wells located down- and across-hydraulic gradient of the F&R building include SA014 located 70m to the east and SA015 located 180m south east. Four monitoring rounds from these wells recorded concentrations consistently below the guideline values for drinking water. The available information suggests that there may be a viable pathway for PFAS sourced from the F&R area to reach potable abstraction well SA015 and potentially SA014. These wells have been removed from the potable water network *and continued monitoring of potable water is planned.*

Surface water samples from the Embley River at Lorim Point contained PFAS concentrations below the human health guideline values, but above the guideline value for aquatic ecosystems (i.e. >LOR). *Further investigation as part of the DSI in this area is proposed to assess the potential risk to human health and the environment.*

12.3.1.4 Weipa Airport

Weipa airport has been active since at least 1969 and training events using AFFF have been completed every two years since 2008 and possibly prior to this. It is inferred that approximately 50 L of AFFF may have been released to the environment every 2 years during training events. There may also have been release of AFFF to the environment from activities at the fuel depot located south east of the runway.

PFAS has been detected in soil and groundwater samples from around the airport. The recorded concentrations do not suggest contamination presenting a risk to human health, but may present a risk to sensitive aquatic ecosystems. *DSI is proposed to confirm the extent and magnitude of contamination and assess the potential risk to human health and the environment.*

Potable water for the airport is supplied from well SA026 located to the south west of the runway. Four monitoring rounds from this well recorded PFAS concentrations consistently below the human health guideline values for drinking water. *Continued monitoring of potable water is planned.*

12.3.1.5 East Weipa Heavy Equipment Workshop

EWHEQ has been present since 1991 and HME with fire suppression systems containing AFFF have been serviced annually at the workshop with AFFF discharged to ground prior to 2017. It is inferred that approximately 300 L of AFFF may have been released to the environment each year.

PFAS has been detected in soil, surface water and groundwater samples from around the EWHEQ. The recorded concentrations do not suggest contamination presenting a risk to human health, but may present a risk to sensitive aquatic ecosystems. *DSI is proposedto confirm the extent and magnitude of contamination and assess the potential risk to human health and the environment.*

Potable water for the EWHEQ is supplied from well SA027 located approximately 200m south of EWHEQ. Four monitoring rounds from this well recorded concentrations consistently below the human health guideline values for drinking water. *Continued monitoring of potable water is planned.*

12.3.2 Secondary Source Areas

Five Secondary Source Areas are identified within the Embley River catchment. Testing of groundwater samples from around the Civils Workshop, LPD and the East Weipa Bioremediation Pad suggest that PFAS in these areas is unlikely to present a risk to human health but may present a risk to sensitive aquatic ecosystems.

There is potential impact to the Embley River catchment from discharge of the fire suppression systems in HME. Limited sampling and testing of surface water from Beening and Marmoss Creeks has identified no samples that exceed guideline values for human health. However, some of the recorded concentrations exceed the guideline value for sensitive aquatic ecosystems (i.e. >LOR).

Anecdotal reports suggest that AFFF may have been used on car fires near Lakes Patrica and McLeod. Surface water samples from the lakes recorded concentration of PFAS <LOR.

12.3.3 Potential Source Areas

Potential Source Areas comprise the:

- Lorim Point and Napranum Sewage Treatment Plants;
- Former landfills at Evans Landing, Area G & Y, Area Y, C South, C North, Weipa Airport, Napranum, and Area Q; and
- East Weipa TSF.

13.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in Appendix I of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

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