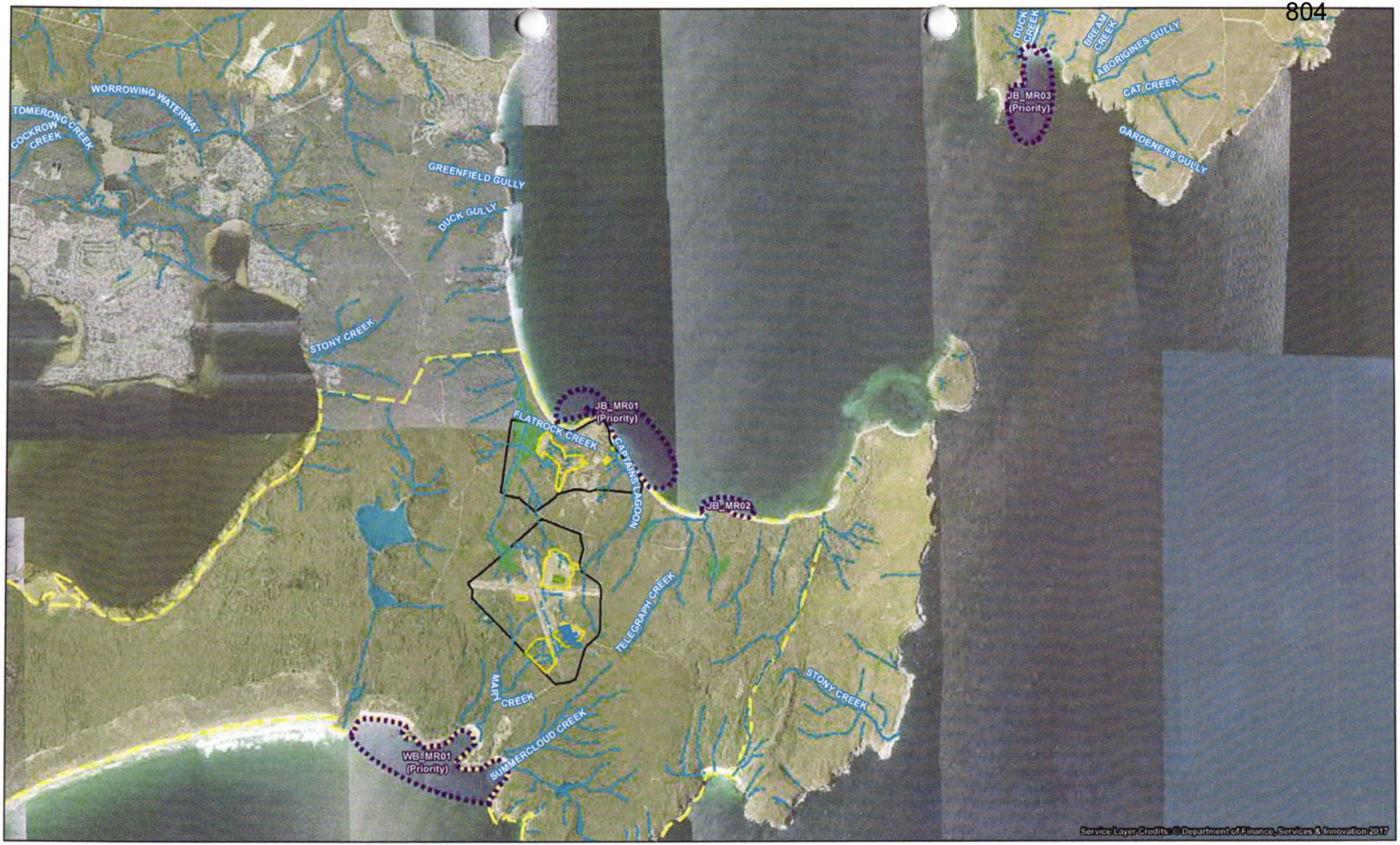

Paper Size A3

0 345 690 1,380 2,070

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Investigation Area Extent
- Jervis Bay Range Facility
- HMAS Creswell
- Areas of Environmental Concern - JBRF
- Areas of Environmental Concern - Creswell
- HATS Site Area
- Water Bodies
- Drainage Areas
- Major Waterways
- Minor Waterways / Drainage Lines
- Minor Waterways / Drainage Lines (Defence)
- Marine Species Sampling Area (Approximate)

Department of Defence

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Marine Biota Sample Locations

Figure D3

G:\21\26171\GIS\Maps\Deliverables\21_26171_2020_EcologyMarine.mxd

Data source: Imagery - Land and Property Information (Imagery Extracted: 2017/09/21), Streets, Waterways - NSW LPI 2015 DTDB, Contours - NSW LPI 2016. Created by:mweber

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https://projects.ghd.com/oc/Sydney/hmascresswelljbtalea/Delivery/Documents/2126171-REP-HHERA Plan-working document.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	October 6, 2017
1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	November 3, 2017
1.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	November 16, 2017

** Approval saved on file*

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Stedman, Andrew (Health)

From: [redacted]
Sent: Thursday, 23 November 2017 1:59 PM
To: [redacted]; Clapham, David; Chester, Heath; Stedman, Andrew (Health); Hudson, Lyndell (Health);
Cc: PFASIM Jervis Bay
Subject: JBRF Groundwater Flow Modelling Plan Rev 1.1
Attachments: 2126171_REP_REV1.1_Groundwater modelling plan final_Reduced.pdf

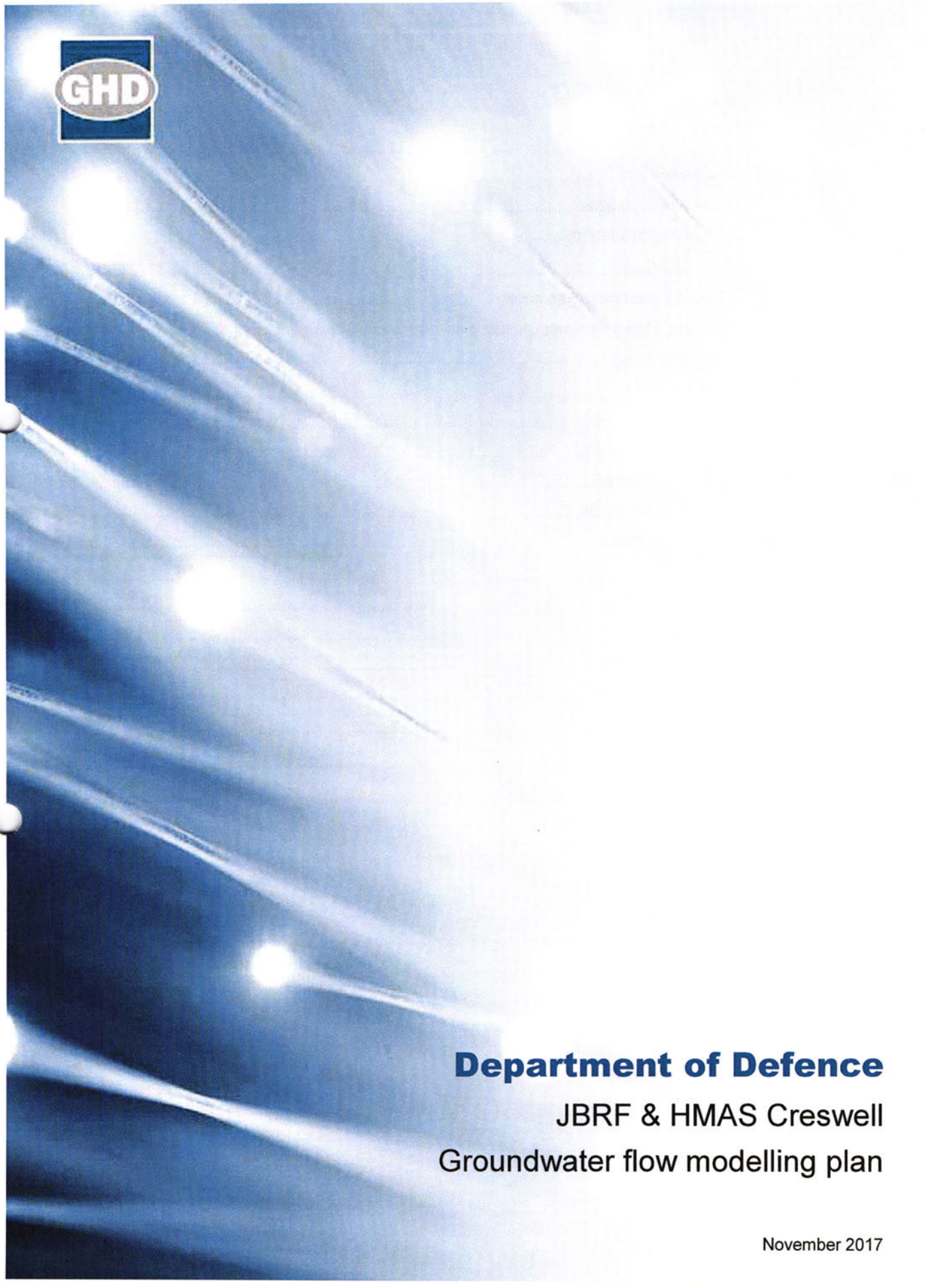
JBRF PCG,

Thank you for your time and inputs to date, for the Jervis Bay Range Facility PFAS investigation.
Attached for your review and comment is the Groundwater Modelling Plan Rev 1.1
Please provide any comments to Defence by 08/12/17 at the address below.
pfasim.jervisbay@defence.gov.au
The attached file is reduced quality for ease of email transfer, should you require the original 11 Mb or 38Mb version, of higher resolution please contact me and I will arrange a large file transfer service.

Regards,

[redacted]

GHD
[redacted]
Level 2, 57 Graham Street (PO Box 621) Nowra NSW 2541 Australia | http://www.ghd.com/
Water | Energy & Resources | Environment | Property & Buildings | Transportation



Department of Defence

JBRF & HMAS Creswell

Groundwater flow modelling plan

November 2017

Table of contents

Figure index

1. Introduction

1.1 Overview

AFFF has been used for fire-fighting purposes around Australia and Defence sites for decades. Depending on the type of AFFF used, the principal PFAS constituents (as active or by-product ingredients) may have included a range of contaminants of potential concern including perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and fluorotelomers such as 6:2 fluorotelomer sulfonate (6:2FtS) and 8:2 fluorotelomer sulfonate (8:2FtS). The historical use of PFAS has resulted in contamination of soil, groundwater, sediments, surface water and infrastructure at Defence bases across its estate. Contamination has also been detected in off-site areas at some of these locations. While the risks to human health and the environment are still the subject of much research, PFAS compounds are highly persistent in the environment, can bio-accumulate, and may be harmful to animal and human health. In response to this issue, Defence has commenced a national program of detailed site investigations at priority sites so that the nature, extent and risk of contamination can be fully evaluated at a site-specific level.

As part of the national program GHD Pty Ltd (GHD) was engaged by the Department of Defence (Defence) to undertake detailed environmental investigations (including risk characterisation) in relation to the historical use of aqueous film forming foam (AFFF) containing perfluoroalkyl and polyfluoroalkyl substances (PFAS) at Jervis Bay Range Facility (JBRF) and Her Majesty's Australian Ship (HMAS) Creswell (both collectively referred to as the site). The site location is shown on Figure 1.

As part of these investigations, Defence has engaged GHD to generate a numerical groundwater model which will be used to further characterise/conceptualise the migration pathways and risks to identified receptors from PFAS in groundwater and surface water.

1.2 Modelling objectives

The aims of the groundwater modelling are to:

- Characterise and conceptualise the key links between groundwater sources, pathways and receptors and their locations.
- Predict the mass flux at key receptors to inform a source/receptor risk ranking.
- Identify data gaps and inform future site investigations, groundwater/surface water monitoring programs and further numerical groundwater modelling (if required).

1.3 Purpose of this report

This groundwater modelling plan has been prepared to outline the methodology that will be used to address the groundwater modelling objectives. It has been prepared for purposes of engaging with key stakeholders at an early stage in the modelling process.

It is noted that the document provides a broad outline of the modelling approach that will be adopted for the project, but that the final modelling approach may differ to that described within this report as new data and existing data is conceptualised during the modelling process.

A description of the proposed modelling method to address the objectives, outlined above, is provided within the following report sections:

- Section 2 – Conceptual Site Model
- Section 3 – Model Design

- Section 4 – Calibration
- Section 5 – Model Predictions
- Section 6 – Conclusions
- Section 7 – Limitations

Paper Size A3

0 300 600 1,200 1,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Investigation Area Extent
- HMAS Creswell Site Boundary
- Jervis Bay Range Facility Boundary
- Areas of Environmental Concern
- Drainage Areas
- Water Bodies
- Major Waterways
- Minor Waterways / Drainage Lines

Department of Defence

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Site Location

Figure 1

812

G:\21\26171\GIS\Maps\Deliverables\Groundwater Modelling Plan\21_26171_Z001_GMP_SiteLocation.mxd

Data source: Imagery - ©Land and Property Information; (Extracted: 09/11/17); Streets, Waterways, Contours - NSW LPI 2015 DTDB. Created by mweber

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2. Conceptual Site Model

2.1 Environmental setting summary

A summary of the regional geological, topographical, hydrogeological, groundwater elevation and surface water (particularly the presence of highland plateau wetlands) conditions at JBRF and HMAS Creswell is provided below. The summary presented is based on the information detailed in the *Preliminary site investigation and sampling, quality and analysis plan (Rev 2),* (GHD, 2017):

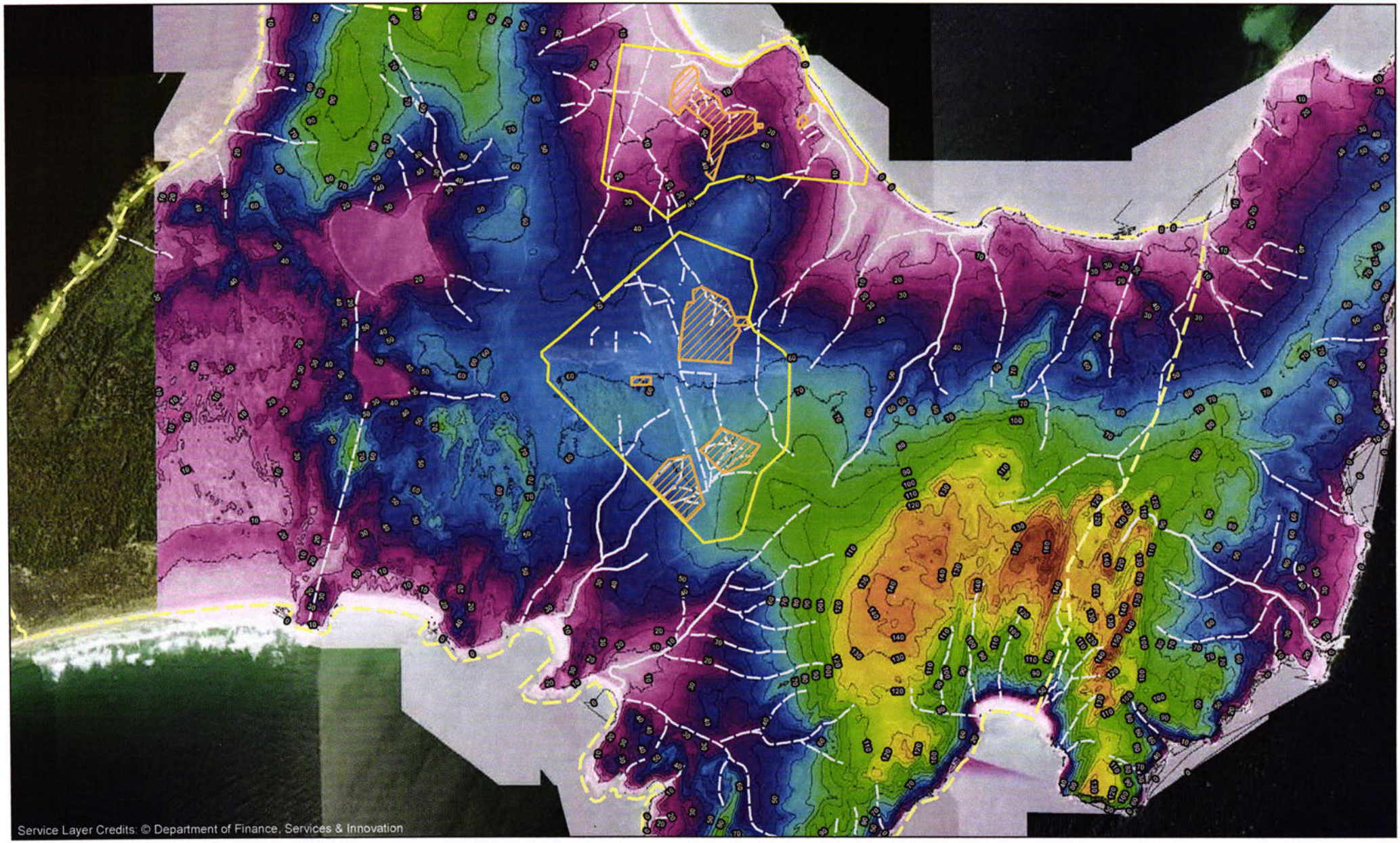
- The JBRF runway and associated facilities are located in an upland plateau, which generally represents the upper catchment in this area. Conceptually, upper catchment areas tend to be associated with groundwater recharge zones whereas lower catchment areas tend to be groundwater discharge zones. In this instance discharge zones would be the incised valley systems or lowland coastal aquifers that ultimately discharge to the ocean/Jervis Bay.
- Downward head gradients usually prevail in upland catchment systems as they are recharge zones, whereas groundwater head gradients are generally upward in discharge areas. This means that in upland areas streams are more likely to be losing streams whereas as, in lowland areas streams (within the same groundwater catchment) are more likely to be gaining streams.
- At Jervis Bay this conceptual condition is more complicated as indicated by the presence of wetland systems on the upper plateau area and shallow groundwater systems (that have been observed in test pits and in shallow groundwater wells). The shallow surface water and groundwater systems are expected to be due to the following hydrogeological conditions:
  - Topographic relief creating trapped or slow surface runoff on the plateau.
  - Relatively slow infiltration rates into the subsurface bedrock geology from the groundwater in the shallow late Pleistocene sands overlying the sandstone.
- The potential presence of a confined system in the underlying sandstone (indicated by high groundwater elevations in wells screened in the shallow bedrock on the plateau) does not appear plausible as an extensive up-gradient recharge area directing groundwater beneath the plateau is not present and the overlying sediments are considered to be too porous to act as a confining unit.
- The shallow groundwater system on the plateau is expected to be recharged by rainfall which subsequently discharges to surface wetland systems. The wetland systems then connect to surface water drainage flowing off the plateau into incised valley systems and to the coast. Discharge may also occur as seeps or stream discharge in the upper catchment where this aquifer is truncated on the edges of the plateau.
- There will be some slow vertical leakage into the bedrock underlying the shallow aquifer systems however, based on the conceptual conditions (i.e. the presence of a shallow aquifer system in a sand aquifer) this is expected to be a relatively small amount.
- Groundwater-surface water interactions are expected at Lake Windermere and Lake McKenzie.
- A deeper more regional aquifer will develop within the jointed and fractured bedrock which will subsequently discharge to streams, coastal Quaternary aquifers and/or as seeps where joints and fractures become exposed further down the catchment.

- Groundwater abstraction is limited within the model domain; no licensed groundwater bores were identified within 3 km of the site or by any respondents in the community survey. For full details, refer to the SAQP (GHD 2017).
    - Groundwater is currently being extracted as part of the construction process (and is being treated to remove PFAS) at the Helicopter Aircrew Training Systems (HATS) project at Area of Environmental Concern (AEC) C.
    - Pump and treat for groundwater remedial works onsite. Additional information has been requested by GHD.

When applying the above conceptual conditions to instream flows it is expected that:

- Streams will generally be gaining streams across the plateau as they receive water from the shallow sand aquifer systems perched on bedrock. Surface flows in sand aquifers is usually a surface expression of groundwater, however, there may be short periods where rainfall occurs after an extended dry period where surface water does recharge groundwater in these areas.
- There will be potential for losing streams to develop within the steeply incised valleys, although surface water runoff in these areas can be expected to be rapid and potential for losses to groundwater reduced. Discharge in areas of exposed jointing and fracturing from the bedrock aquifer system may also result in small gains in flows.
- The streams would then be expected to become gaining streams again in lowland coastal areas as discharge from the deeper bedrock aquifer occurs.

Figure 1 to Figure 4 illustrate the key features bulleted above including the site location, surface water features, site geology/hydrogeology and the site topography.



Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Investigation Area Extent
- Jervis Bay Range Facility Boundary
- HMAS Creswell Site Boundary
- Areas of Environmental Concern
- Major Waterways
- Minor Waterways / Drainage Lines
- Contours (mAHD)

Elevation (mAHD)
High : 168.716
Low : -2.47

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Date 09 Nov 2017

Site Topography

Figure 2

815

G:\21\26171\GIS\Maps\Deliverables\Groundwater Modelling Plan\21_26171_Z002_GMP_SiteTopography.mxd

Data source: Imagery - ©Land and Property Information; (Extracted: 09/11/17); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016; Contours - LPI LiDAR. Created by mwebber

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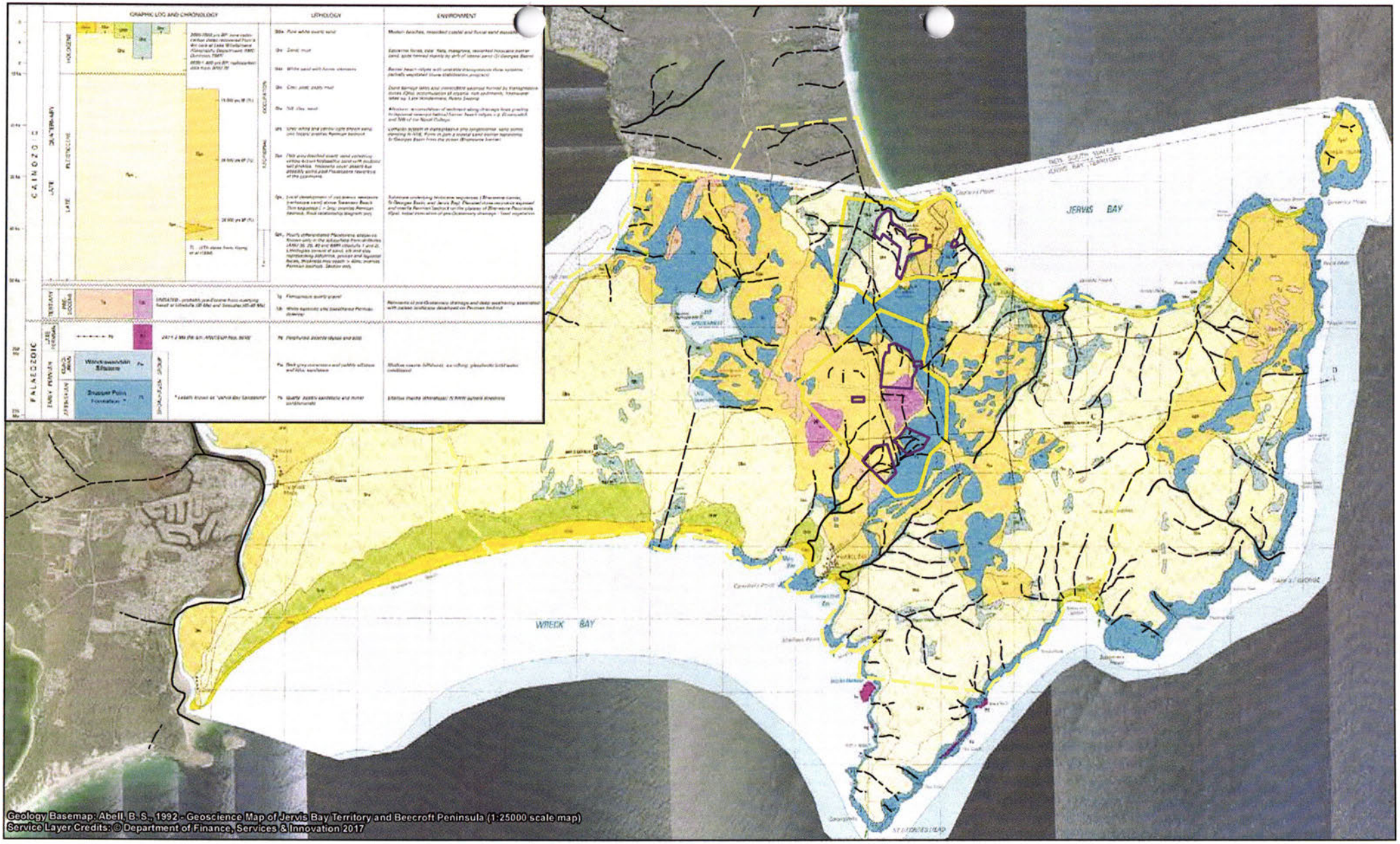

Paper Size A3

0 400 800 1,600 2,400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Investigation Area Extent
- HMAS Creswell Site Boundary
- Jervis Bay Range Facility Boundary
- Areas of Environmental Concern
- Major Waterways
- Minor Waterways / Drainage Lines

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Date	09 Nov 2017

Site Geology

Figure 3

816

G:\21\26171\GIS\Maps\Deliverables\Groundwater Modelling Plan\21_26171_Z003_GMP_Geology.mxd

Data source: Imagery - ©Land and Property Information; (Extracted: 09/11/17); Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016, Geology - Abell, B. S. 1992. Created by mweber

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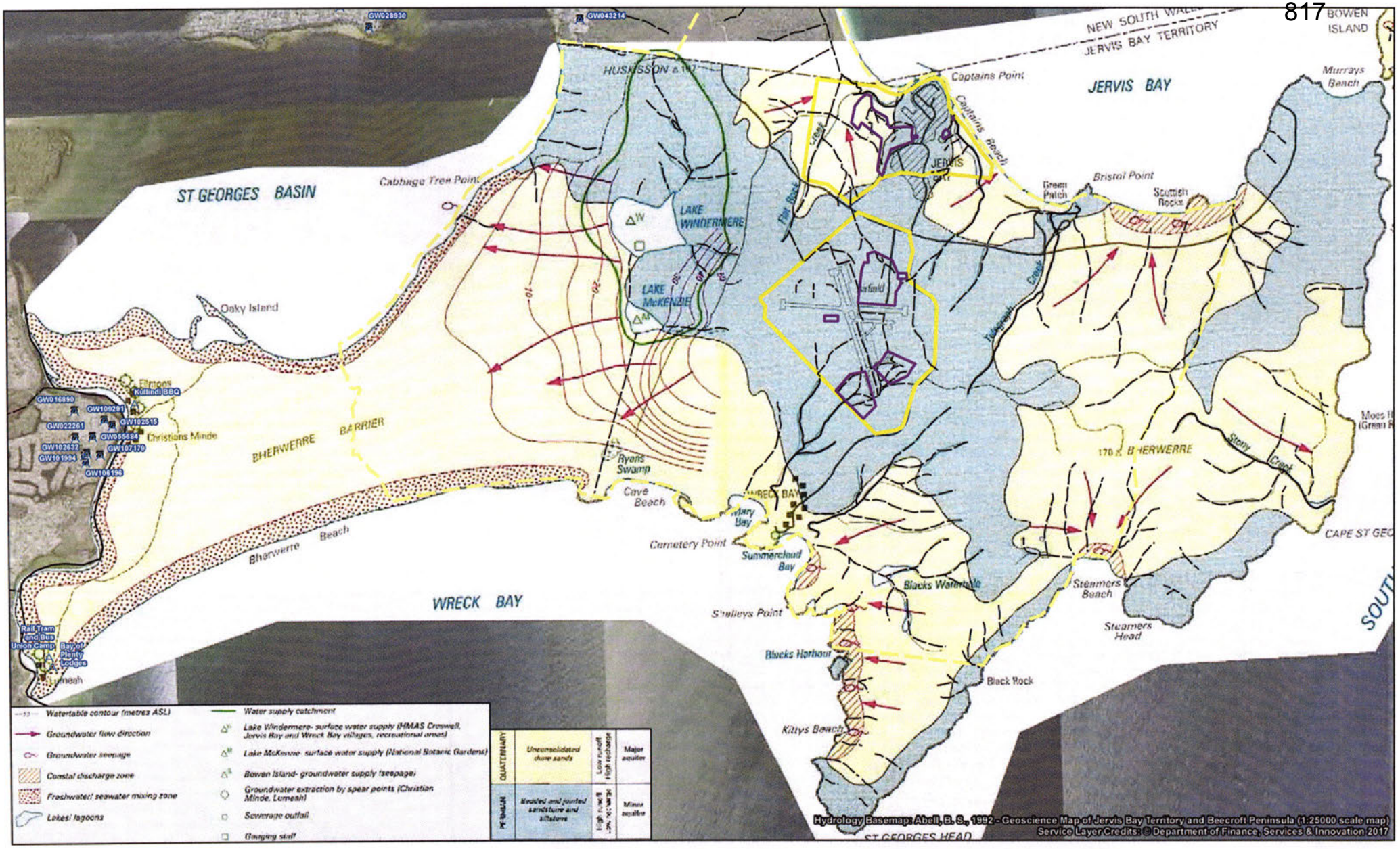

Paper Size A3

0 300 600 1,200 1,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Areas of Environmental Concern
- Registered Groundwater Wells
- Major Waterways
- Minor Waterways / Drainage Lines
- Investigation Area Extent
- HMAS Creswell Site Boundary
- Jervis Bay Range Facility Boundary
- Building

Department of Defence

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Site Hydrogeology

Figure 4

G:\21\26171\GIS\Maps\Deliverables\Groundwater Modelling Plan\21_26171_Z004_GMP_Hydrogeology.mxd

Data source: Imagery - ©Land and Property Information; (Extracted: 09/11/17); Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016, Geology - Abell, B. S. 1992. Created by: mweber

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2.2 Source-pathway-receptor (pollutant linkage) summary

This pollutant linkage discussion focuses on potential contamination associated with the use of AFFF for fire-fighting training, maintenance and fire related incident responses. These activities are considered to be associated with the potential release of PFAS to the environment at the site.

The pollutant linkages comprise three components: sources, pathways and receptors.

Key potential receptors are:

- On-site (zoned as Defence land):
  - Human health – current site users such as Defence personnel (working and living).
  - Environment – soil, surface water, groundwater and sediments and on-site ecological receptors (terrestrial and aquatic).
- Off-site:
  - Human health – visitors and recreational users of the National Park and residents of villages of Wreck Bay and Jervis Bay.
  - Environment – soil, surface water, groundwater and sediments and off-site ecological receptors (terrestrial and aquatic).

2.2.1 Source identification

Based on a review of information provided to GHD, eight key AECs have been identified. PFAS contamination is anticipated to be present in media including soil, groundwater, infrastructure (e.g. concrete) and within the sediment and pooled water of open drains in areas where AFFF has been used, stored or disposed. These are listed below and presented in Figure 1.

- AEC A – Royal Australian Navy School of Survivability and Ship Safety (RAN SSSS) (Defence CSR number SW0025).
- AEC B – Area adjacent to RAN SSSS, Mary Creek (Defence CSR number SW0026).
- AEC C – Former fire training area of the now parachute training school
- AEC D – Former asbestos Building 15 (Defence CSR number SW0145).
- AEC E – Golf course (Defence CSR number SW0035).
- AEC F – Fire station (Defence CSR number SW0040).
- AEC G – Sewage treatment plant and outfall (Defence CSR numbers SW0217 and SW0226).
- AEC H – Former drum disposal area (Defence CSR number SW0027)

Based on the information reviewed, the most likely source of the PFAS are related to firefighting training activities involving AFFF usage at JBRF and its presence at the fire station at HMAS Creswell.

It is noted that golf course (and possibly the Quarter Deck) is irrigated by secondary treated effluent water (pumped from the retention dams to south), which is collected from across the site and may contain PFAS.

Other various point sources include associated storage areas, disposal areas and to a lesser degree, miscellaneous, undocumented incidents. It is likely that soil and concrete impacted by AFFF act as secondary sources of PFAS that could contaminate groundwater and surface water.

A more detailed discussion of PFAS origin and impact within each AEC is presented in Table 8 of the SAQP (GHD, 2017).

2.2.2 Pathway characterisation.

Transport mechanisms

Potential transport pathways by which PFAS introduced to the environment may migrate within and from the site include:

- Leaching from impacted infrastructure (e.g. concrete training surfaces) to surface runoff and adsorption to soil. Leaching tests from concrete surfaces where AFFF has been used have indicated that PFAS contained within the concrete can act as an ongoing source (based on site-specific information from the HATS project (EES (2016b) and technical data from Oakey and Williamtown environmental investigation reports (Defence project websites). This may include surface water drainage and other underground infrastructure.
- Leaching from soil, impacted infrastructure or sediment to surface runoff and transport to surface water bodies.
- Infiltration and leaching from soil, sediment and concrete to groundwater and transport within groundwater.
- Migration of contaminants in surface water and groundwater towards down-gradient receptors.
- Absorption onto sediments from surface water or groundwater.
- Wind dispersion of foams and spray mists - firefighting foams and spray mists associated with fire training and firefighting activities have the potential to be dispersed away from application areas and deposit on surround surface soils.
- Wind erosion and atmospheric dispersion of upper layers of impacted surface soils (predominantly in fire fighting areas). The majority of the site area consists of open grassed spaces, where there is potential for wind erosion and atmospheric dispersion of soil.

PFAS is highly soluble in water and can migrate quickly from source zone(s) to the environment via surface water pathways. Drainage channels and topographical lows were identified using light detection and ranging (LIDAR) imagery at JBRF and HMAS Creswell.

Anecdotal information indicates there is a stormwater conduit that connects JBRF to a collection pond used to irrigate the HMAS Creswell golf course. The conduit continues eastward to the wastewater treatment plant located at the eastern boundary of HMAS Creswell and drains to an outfall located to the mouth of Captains Lagoon.

Human pathways

The principal exposure pathway associated with PFAS is considered to be via surface water ingestion, given that groundwater is not extracted for any purposes. Exposure to PFAS via dermal contact and inhalation may occur, but it is not considered to be a major pathway given the low dermal absorption of PFAS and its low volatility. Ingestion may occur from handling or using contaminated soils or surface water, consumption of marine/freshwater biota or home grown produce (such as fruit and vegetables) exposed to contaminated waters, or incidental intake from impacted surface waters.

Based on currently available information with regard to the current and ongoing use of the site and the current land uses of the surrounding areas the following human receptors have been identified:

On-site

- JBRF and HMAS Creswell personnel who work at the base on a daily basis comprising:
  - Full time base staff and residents (including families of base staff and students for the duration of their training) that may have direct contact with soil, surface water or groundwater during day to day working or living activities. Additionally, staff and students may come into contact with soil, surface water or groundwater during training activities across the site area such as fire training, water craft or bush training activities.
  - On-site residents consuming garden produce (assumed some although not highlighted in community survey (Section 2.7) in gardens (i.e. residential housing).
  - On-site residents with infants consuming breast milk (where mother consumes garden produce (if applicable).
  - Direct contact and inhalation of water mist by workers on-site who conduct non-intrusive maintenance activities such as maintaining the gardens and grassed areas or other types of works at the site (including management of the STP and / or irrigation of the golf course and possibly the Quarter Deck).Ingestion of soils or surface water or groundwater by intrusive maintenance workers who may conduct infrequent maintenance/construction activities or future infrastructure upgrade works.

Off-site

Jervis Bay Village and Wreck Bay Village

- Residents using surface water for domestic purposes from surface water surrounding the site (such as drinking, washing or cooking from water collected from Lake McKenzie, Lake Windermere, Mary Creek, Blacks Waterhole, Summercloud Creek, and Green Patch Lagoon.
- Residents using water from Lake McKenzie, Lake Windermere, Mary Creek, Blacks Waterhole, Summercloud Creek, Green Patch Lagoon, Flat Rock Creek, Telegraph Creek, Captains Lagoon, Jervis Bay and Wreck Bay for swimming or other recreational activities.
- Residents consuming freshwater and marine biota from Booderee National Park, most frequently in Captains Lagoon, Lake McKenzie, :Lake Windermere, Telegraph Creek, Summercloud Creek, Mary Creek, Jervis Bay and Wreck Bay.
- Residents with direct contact with soil and sediments as well as using soil or sediment for sunscreen, rubbing into sores, ceremony, or playing from within the Booderee National Park in areas including clay pits on Village Road, Bay Road, Summercloud Beach, Mary Beach and lagoons near JBRF.
- Residents consuming flora from across the Booderee National Park including Geebungs, berries, Lilli Pillis, Pigface, Passionfruit, Sarparilla, five corners and others.
- Residents consuming home grown produce.
- Residents with infants consuming breast milk (where mother consumes flora or fauna, home produce or uses surface water or clays/sediments etc (if applicable)).

Booderee National Park workers

- Workers using surface water for drinking purposes from surface water surrounding the site (such as water present in Lake McKenzie, Lake Windermere, Mary Creek, Blacks Waterhole, Summercloud Creek, and Green Patch Lagoon).

- Workers using water from Lake McKenzie, Lake Windermere, Mary Creek, Blacks Waterhole, Summercloud Creek, Green Patch Lagoon, Flat Rock Creek, Captains Lagoon, Jervis Bay and Wreck Bay for swimming or other recreational activities.
- Workers consuming freshwater and marine biota from Booderee National Park, mostly frequently in Captains Lagoon, Lake McKenzie, Lake Windermere, Telegraph Creek, Summercloud Creek, Mary Creek, Jervis Bay and Wreck Bay.
- Workers with direct contact with soil and sediments as well as using soil or sediment for sunscreen and rubbing into sores within the Booderee National Park in areas including clay pits on Village Road, Bay Road, Summercloud Beach, Mary Beach and lagoons near JBRF.
- Workers consuming flora from across the Booderee National Park including Geebungs, berries, Lilli Pillis, Pigface, Passionfruit, Sarparilla, five corners and others.

Recreational land users

- Recreational visitors using surface water for domestic purposes (such as drinking, washing or cooking) from water collected from waters present in Lake McKenzie, Lake Windermere, Mary Creek, Blacks Waterhole, Summercloud Creek, Telegraph Creek and Green Patch Lagoon.
- Recreational visitors using groundwater water for domestic purposes from groundwater at camp sites near Sussex Inlet. However it is noted that Sussex Inlet is outside of the Investigation Area.
- Recreational visitors using water from Lake McKenzie, Lake Windermere, Mary Creek, Blacks Waterhole, Summercloud Creek, Green Patch Lagoon, Flat Rock Creek, Captains Lagoon, Telegraph Creek, Jervis Bay and Wreck Bay for swimming or other recreational activities.
- Recreational visitors consuming freshwater and marine biota from Booderee National Park, mostly frequently in Captains Lagoon, Lake McKenzie, Lake Windermere, Telegraph Creek, Summercloud Creek, Mary Creek, Jervis Bay and Wreck Bay.

Jervis Bay Village School / Jervis Bay Village Police Station

- School children or teachers/workers at the school or police station having direct contact with soil or surface water runoff.

Lake Windermere

- Migration of surface water or groundwater into Lake Windermere, where the water is used for the regional potable water supply.

Ecological

Key pathways for migration to the off-site ecological receptors include:

- Surface water migration and runoff as well as groundwater seepage.
- Direct contact and uptake of:
  - Soil
  - Surface water and sediments (including pore water)
  - Groundwater
- Consumption of flora and fauna already affected from exposure to contaminated soil, groundwater and/or surface water, and bioaccumulation

Based on currently available information with regard to the current ecological environment at the site and surrounding areas, the following ecological receptors have been identified:

On-site

The operational areas of JBRF and HMAS Creswell has been cleared in areas where infrastructure has been constructed, however much of the site includes untouched areas of bushland with thick native vegetation. Given the ability of PFOS and PFOA to bio-accumulate, the levels of these compounds in animal tissue increases at each stage of the food chain (Refer to food web map (Charts 1 to 3). Full species lists are available upon request.

- Plants including grasses and aquatic plants, which are consumed by higher order species
- Lower order animals such as earthworms and insects
- Higher order animals such as fish, birds and mammals

Abiotic ecological receptors include:

- The groundwater aquifer
- Surface water bodies including the creek lines on and near the site, and receiving surface water runoff from the site
- Sediments including pore water

Off-site

Off-site comprises the natural bushland of the Booderree National Park. Given the ability of PFOS and PFOA to bio-accumulate, the levels of these compounds in animal tissue can increase at each stage of the food chain (Refer to food web map Charts 1 to 3).

- Plants including grasses and aquatic plants, which are consumed by higher order species
- Lower order animals such as earthworms and insects
- Higher order animals such as fish, birds and mammals

Key species consumed by the communities (as well as recreationally) include:

- Terrestrial Flora - Geebungs, berries, Lilli Pillis, Pigface, Passionfruit, Sarparilla, five corners and others (non-specified).
- Freshwater fauna - fish, yabbies and others (non-specified).
- Marine fauna - Pippies, Periwinkles, Whiting, Lobsters, Flathead, Bream, Mullet, Squid and others (non-specified).

Abiotic ecological receptors include:

- The groundwater aquifers.
- Surface water bodies including the creek lines on and near the site, and receiving surface water runoff from the site such as unnamed creeks, Flat Rock Creek, Mary Creek, Captains Lagoon, Telegraph Creek, Wreck Bay and Jervis Bay and lakes including Lake McKenzie and Lake Windermere.
- Sediments including pore water in receiving waters such as unnamed creeks, Flat Rock Creek, Mary Creek, Captains Lagoon, Telegraph Creek, Wreck Bay and Jervis Bay and lakes including Lake McKenzie and Lake Windermere

2.3 Summary

The information presented in Section 2.1 to Section 2.2 has been summarised below.

Based on an overview of the identified sources, receptors and transport and exposure pathways forming the CSM, there are plausible linkages between the identified contamination sources and potential receptors.

One of the primary pathways is considered to be via surface water and drainage lines throughout the AECs, which lead to surface water bodies. These are used by humans for recreation, potable water, sources of native food, and are potential habitats of ecological receptors.

The infiltration and migration of PFAS through groundwater is also an important pathway, including the leaching of the groundwater into major water bodies which are used by off-site receptors.

The shallow depth to groundwater and the waterlogged nature of some of the areas near source zones and drainage pathways is suggestive of significant (and seasonally controlled) surface water and groundwater interactions. As demonstrated on other sites, this has the potential to mobilise PFAS in complex ways and over long distances.

Whether exposure to these media presents an unacceptable risk to the receptors is based on a number of factors including the concentrations of the PFAS and the frequency and duration of exposure. These factors will be assessed as part of the detailed site investigation planned for the site and off-site sources.

3. Model Design

To adequately represent the conceptual conditions outlined above the following preliminary model design is proposed. The groundwater model will be developed in general accordance with the Australian Modelling Guidelines (Barnett et al, 2012).

It is noted that this is a preliminary design and the approach may change to match the revised conceptual understanding as additional data is generated and interpreted from ongoing site investigations.

3.1 Modelling software

It is proposed that the modelling is undertaken using the Groundwater Vistas modelling Graphical User Interface (GUI) which was set up to simulate groundwater flow using MODFLOW-SURFACT (Hydrogeologic, 1996). MODFLOW-SURFACT is an enhancement to the MODFLOW 96 suite of groundwater modelling code. In particular MODFLOW-SURFACT was selected for this application because it provides additional capabilities which include representation of groundwater flow in the saturated and unsaturated zone.

The numerical code proposed for the modelling is MODFLOW-SURFACT v4 (HydroGeoLogic, 1996), a proprietary modification to the United States Geological Survey's open source MODFLOW-96 (finite difference) code. MODFLOW-SURFACT v4 provides several useful enhancements to MODFLOW-96 including:

- A more robust and flexible numerical solver (PCG5).
- Simulation of saturated and unsaturated zone flow, resolving many of the issues with cell drying and rewetting and associated numerical instabilities of standard MODFLOW.
- A more flexible and robust well boundary package (FWL4/5).
- A more flexible recharge package (RSF4), which allows for simulation of recharge rejection when groundwater levels are shallow.
- Complete analysis of flow and transport problems, i.e., MODFLOW-SURFACT incorporates flow and contaminant transport modules together.

3.2 Modelling complexity

Once all data has been collated for the model an assessment will be made in accordance with the Australian groundwater modelling guidance of the model complexity that will be achievable and how it relates to achieving the modelling objectives. As part of this assessment consideration will be given to managing the uncertainty associated with the complexity limitations in the modelling approach. This may include the development of a range of plausible base case models rather than one base case model.

3.3 Model dimensions

3.3.1 Model domain

The model domain will be designed to incorporate the identified sources, pathways and receptors and characterise their pollutant linkages. To do this it is expected that the vertical extent of the model will extend below mean sea level (e.g. –20 m above height datum (AHD)).

The proposed horizontal extent of the model domain is presented in Figure 5.

3.3.2 Grid size

The model cell size will be designed to facilitate rapid computation while ensuring adequate characterisation of contaminant migration pathways around source zones. This will result in a coarse grid in areas of less concern and a refined grid in areas of key concern. The cell size will be cognisant of ensuring the fate and transport package effectively integrates with the numerical flow package. This will necessitate calculation and consideration of courant and peclet numbers in the model grid design.

3.3.3 Model layering

At present the number of layers incorporated into the model has not been established, however, it is expected that the model will be designed to:

- Incorporate the two primary aquifers identified in the conceptual site model, namely the:
  - Shallow unconfined aquifer systems located within unconsolidated systems on the plateau and on the coastal fringe.
  - The deeper bedrock aquifer in the Snapper Point Formation (known locally as the Jervis Bay Sandstone).
- Effectively calibrate the model to vertical distribution in groundwater elevation observations.
- Effectively represent vertical PFAS migration and concentrations within the regional groundwater system.

Based on the above it is expected that there would be a minimum of five layers within the model.

All model layers will be set as unconfined (T varies) type layers in line with the MODFLOW-SURFACT code requirements.

3.4 Boundary conditions

Rainfall recharge will be represented in the model using available data from regional literature and with consideration of the Australian Bureau of Meteorology information such as the Australian Water Resource Assessment Modelling System (AWRAMS) and/or Commonwealth Scientific and Industrial Research Organisation (CSIRO) recharge modelling systems.

It is expected that a range of potential recharge values will be adopted in the calibration process with a final value being established as part of this process.

Consideration will be given to varying recharge within the model domain based on surficial geology and topographical conditions (slope).

Jervis Bay and Tasman Sea are expected to be represented as constant head boundaries with elevations indicative of mean sea level.

General head boundaries will be used to represent groundwater flow in areas to the east, west and north where the model boundary intersects land. Elevations of the general head boundaries will be interpolated from available groundwater data or ground surface / depth to groundwater relationships.

Streams and lakes within the model domain will be represented using, stream cells, river cells and or drain cells depending on the conceptual conditions that exist and required outcomes of the model. Elevations of these boundaries will be developed from detailed LIDAR data and from site-specific surveying undertaken in accordance with the SAQP (GHD, 2017). The behaviour of boundary elevations over time will be supported by the flow monitoring data collected in accordance with the SAQP (GHD, 2017a).

Contaminant source zones in the model are expected to be represented in the model on the back of recharge and or via injection wells. At this stage it is expected that, until such time as a detailed understanding of mass inputs from each source is obtained, concentrations or injection rates will be established using a trial an error approach to best represent the groundwater conditions observed at and down gradient of each source.

3.5 Aquifer parameters

3.5.1 Hydraulic conductivity

Hydraulic conductivity parameters will be based on a review of literature as well as site specific hydraulic testing, the details of which are presented within the sampling analysis and quality plan – SAQP (GHD, 2017). This will include slug testing (on unconsolidated and consolidated aquifers) and particle sized distribution (PSD) analysis (unconsolidated).

Vertical hydraulic conductivity will be established as part of the calibration process, with initial Kz/Kh ratios set at 1 to 0.01 unless further constrained from local data and literature reviews. Site specific characterisation of shallow and deeper groundwater conditions will provide the observation data to constrain the calibration process in this regard.

Purging data from low flow groundwater sampling techniques will also be used to characterise hydraulic conductivities where possible.

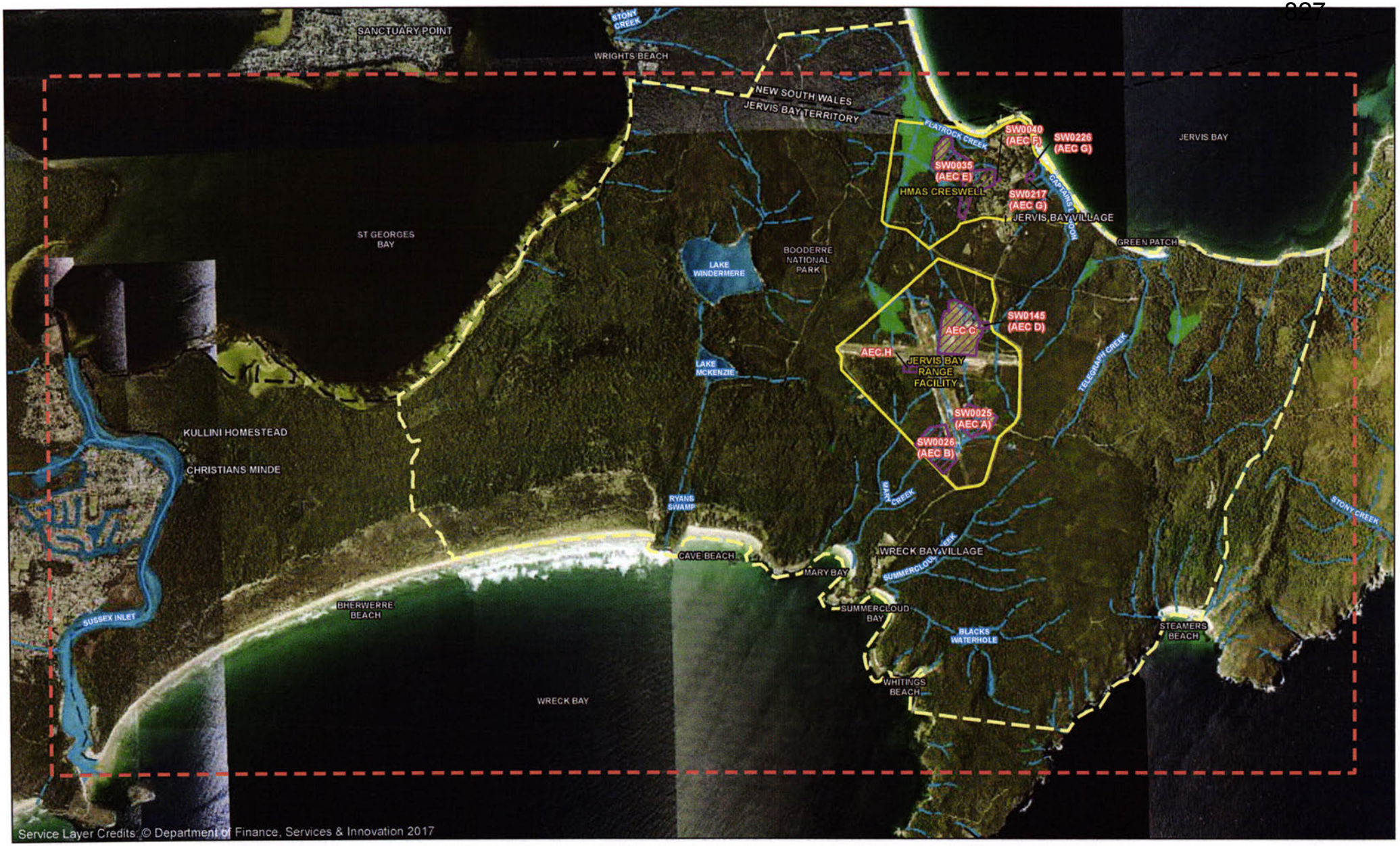
3.5.2 Storage parameters

Storage parameters will be based on detailed literature reviews for the encountered lithology, estimates of fracture densities from the cored bore logs and laboratory analysis of the porosity of unconsolidated sediments (where possible).

3.5.3 Fate and transport parameters

Fate and transport parameters will be established from detailed literature to establish representative data for dispersivity (including consideration of plume length and model cell dimensions), partitioning co-efficients and biodegradation parameters. The SAQP has proposed the collection of a large amount of total organic carbon analysis (TOC) which will support the establishment of representative partitioning values in the model.

With regard to fate and transport parameters it is expected that the model will focus on the key human health and environmental PFAS risk driver, which at present is expected to be PFOS (and/or + PFHxS).



Paper Size A3

0 300 600 1,200 1,800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

LEGEND

- Model Boundary
- Investigation Area Extent
- HMAS Creswell Site Boundary
- Jervis Bay Range Facility Boundary
- Areas of Environmental Concern
- Drainage Areas
- Water Bodies
- Major Waterways
- Minor Waterways / Drainage Lines

Department of Defence

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Proposed Model Domain

Figure 5

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Data source: Imagery - ©Land and Property Information; (Extracted: 09/11/17); Streets, Waterways, Contours - NSW LPI 2015 DTDB. Created by mweber

Level 15, 13[illegible] Pitt Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

4. Calibration

4.1 Approach

It is expected that the calibration will include the following key steps:

- A broad manual calibration to average groundwater elevations to ensure the starting parameters used for automated calibration are within a realistic framework. This will be completed under steady state conditions.
- Set-up and completion of automated calibration using the parameter estimation software PEST. This will be completed in steady state using average groundwater conditions.
- Set-up and completion of automated calibration using PEST to groundwater elevations and surface water flow data (where possible) under transient conditions.

4.2 Calibration data

4.2.1 Groundwater observation

Current and proposed groundwater elevation monitoring locations are presented in Figure 6.

This includes extensive characterisation around source zones within the shallow aquifers and at least six wells proposed for screening within the deeper aquifer system.

There are currently 12 groundwater data loggers monitoring groundwater elevation at 15 minute intervals for approximately two months at locations across the site to characterise groundwater elevation response. This data will be used for transient model calibration and will be supported by a number of manual monitoring events undertaken during groundwater quality sampling (as outlined in the SAQP (GHD, 2017).

4.2.2 Surface Water

Two surface water monitoring locations are proposed in the revised SAQP to aid in the understanding of groundwater inputs to surface water. This data will be used to interpret groundwater inflows over time, which will then be used for transient calibration where possible. These locations are yet to be finalised but it is expected that they will be located in at the edge of the plateau near the JBRF site boundaries on Mary Creek and Telegraph Creek or tributary of Flatrock Creek.

4.3 Calibration criteria

Calibration success will be measured against a range of criteria, in accordance with the Australian Groundwater Modelling guidelines. This is expected to include:

- Suitable model water balance errors (< 1%).
- Calculation of calibration statistics including the scale root mean square (SRMS) error. With an aim of achieving a value of 5%, although this may relaxed with appropriate justification.
- Graphical representation of observed and simulated groundwater elevations for the shallow and deep groundwater systems to ensure that that the calibration is consistent over the range of observed groundwater elevations (e.g. the slope of the best-fit line approximates a ratio of 1:1).

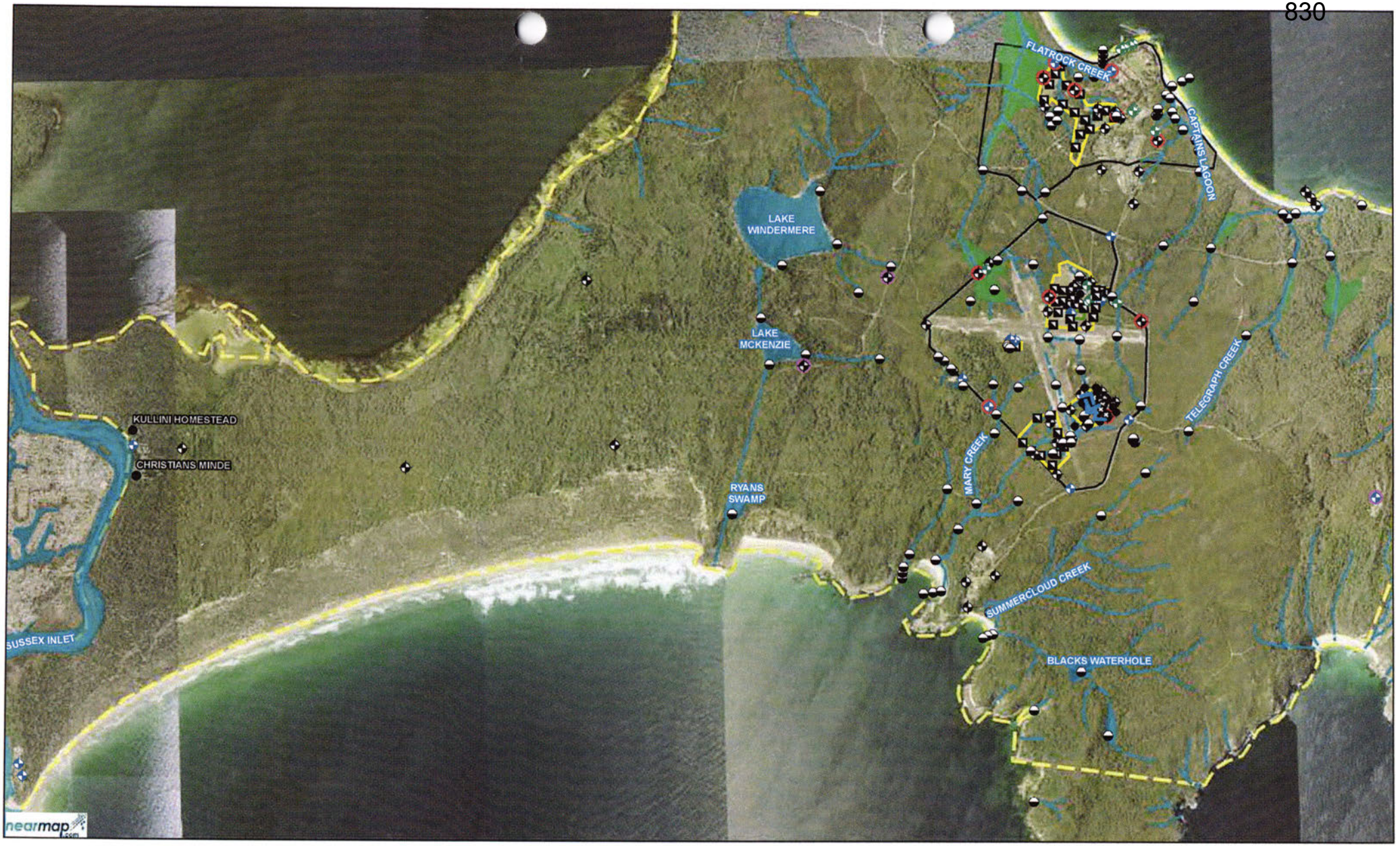
- Figures of the calibrated and observed groundwater elevations (residual differences) in the shallow and deeper groundwater system to visualise differences and identified areas of higher uncertainty.

Uncertainty in the model outcomes will be managed by developing a number of equally plausible models. This will be completed by pushing key uncertain parameters to extremes and re-calibrating the model to within acceptable boundaries. This would usually entail development of high and low flow models and high and low storage models if transient data is insufficient. All plausible models will be carried through to the predictive run.

4.4 Sensitivity analysis

Sensitivity analysis will be completed in accordance with the Australian Groundwater Modelling guidance where required to identify sensitive and non-sensitive parameters that should be considered further within the report discussion and or incorporated into the assessment of model uncertainty and non-uniqueness. The specific methods that will be adopted have not been finalised as yet, but will include systematic variation in parameters to understand the overall impacts on model outcomes. This process may be automated using PEST.

The results of this assessment will also be used to inform further field investigations (if required).



Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - JBRF
- Areas of Environmental Concern - Creswell
- Jervis Bay Range Facility
- HMAS Creswell
- HATS Site Area
- Water Bodies
- Major Waterways
- Drainage Areas
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
- Proposed Soil Bore Location
- Proposed Groundwater Well
- Proposed Groundwater Well (Deep)
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
- Water Tank Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Well (Deep) (To Be Sampled)
- Existing Groundwater Data Logger Locations
- Existing Groundwater Well (Not Sampling)

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Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by: mking3

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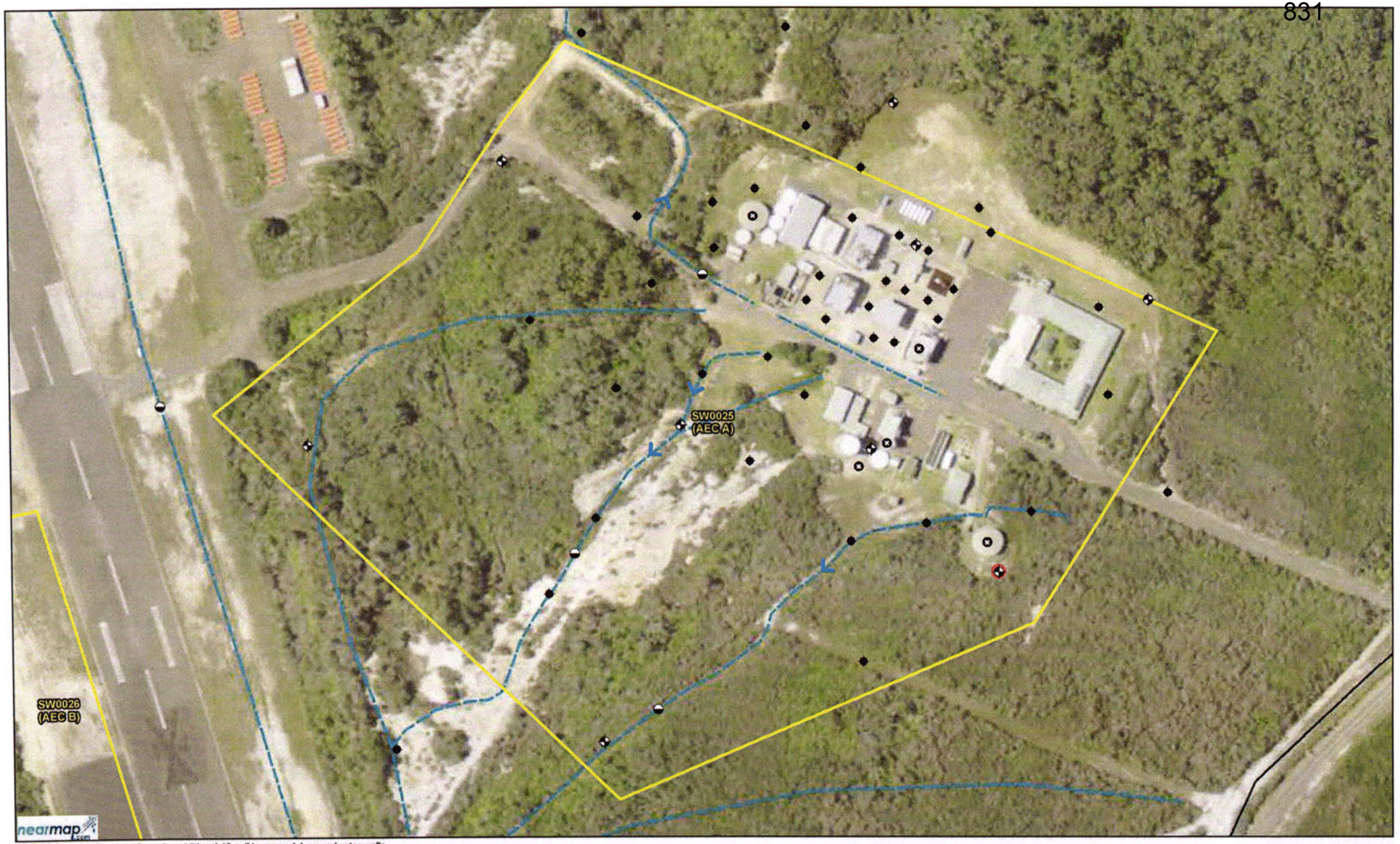

Note: Second mobilisation allows for additional 12 soil bores and 4 groundwater wells

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - JBRF
- Jervis Bay Range Facility
- Minor Waterways / Drainage Lines
- Proposed Soil Bore Location
- Proposed Groundwater Well
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
- Water Tank Sample
- Existing Groundwater Well (To Be Sampled)

GHD

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Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by:mking3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - JBRF
- Jervis Bay Range Facility
- Major Waterways
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
- Proposed Soil Bore Location
- Proposed Groundwater Well
- Proposed Surface Water & Sediment Sample

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Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by: mking3

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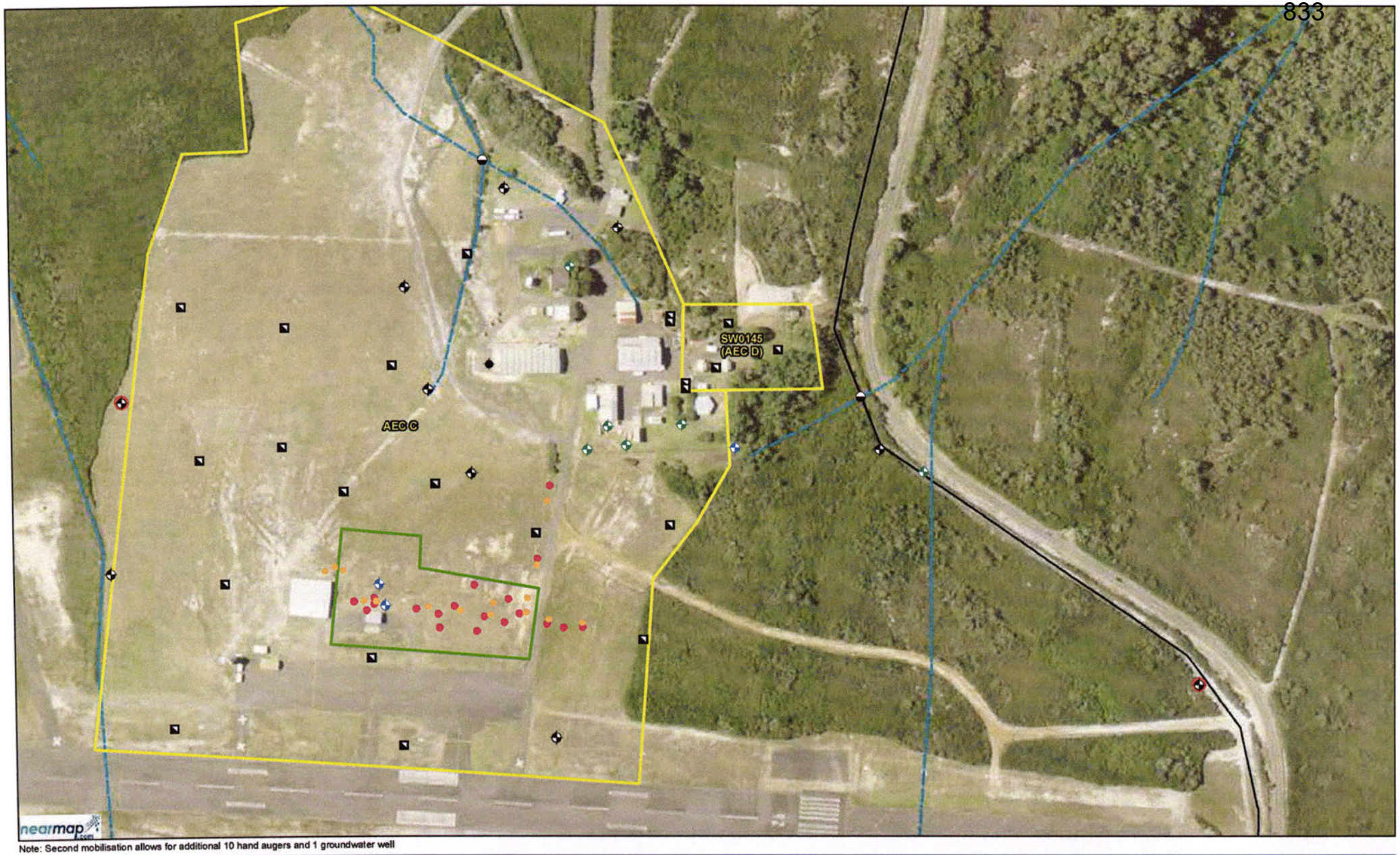

Note: Second mobilisation allows for additional 10 hand augers and 1 groundwater well

Paper Size A3

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Metres

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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - JBRF
- Jervis Bay Range Facility
- HATS Site Area
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
- Proposed Soil Bore Location
- Proposed Groundwater Well
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Well (Not Sampling)
- Previous Investigation Location (Coffeys, 2014)
- Previous Investigation Location (EES, 2016)

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Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by: mking3

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Note: Four irrigation samples to be collected from golf course and quarter deck (E_IRRIGATION_01 to E_IRRIGATION_04)

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - Creswell
- HMAS Creswell
- Water Bodies
- Major Waterways
- Drainage Areas
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
- Proposed Groundwater Well
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Data Logger Locations
- Existing Groundwater Well (Not Sampling)

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Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by:mking3

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - Creswell
- HMAS Creswell
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
- Proposed Groundwater Well
- Proposed Surface Water & Sediment Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Data Logger Locations
- Existing Groundwater Well (Not Sampling)
- Well Not Found

GHD

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Calibration Data

Figure 6

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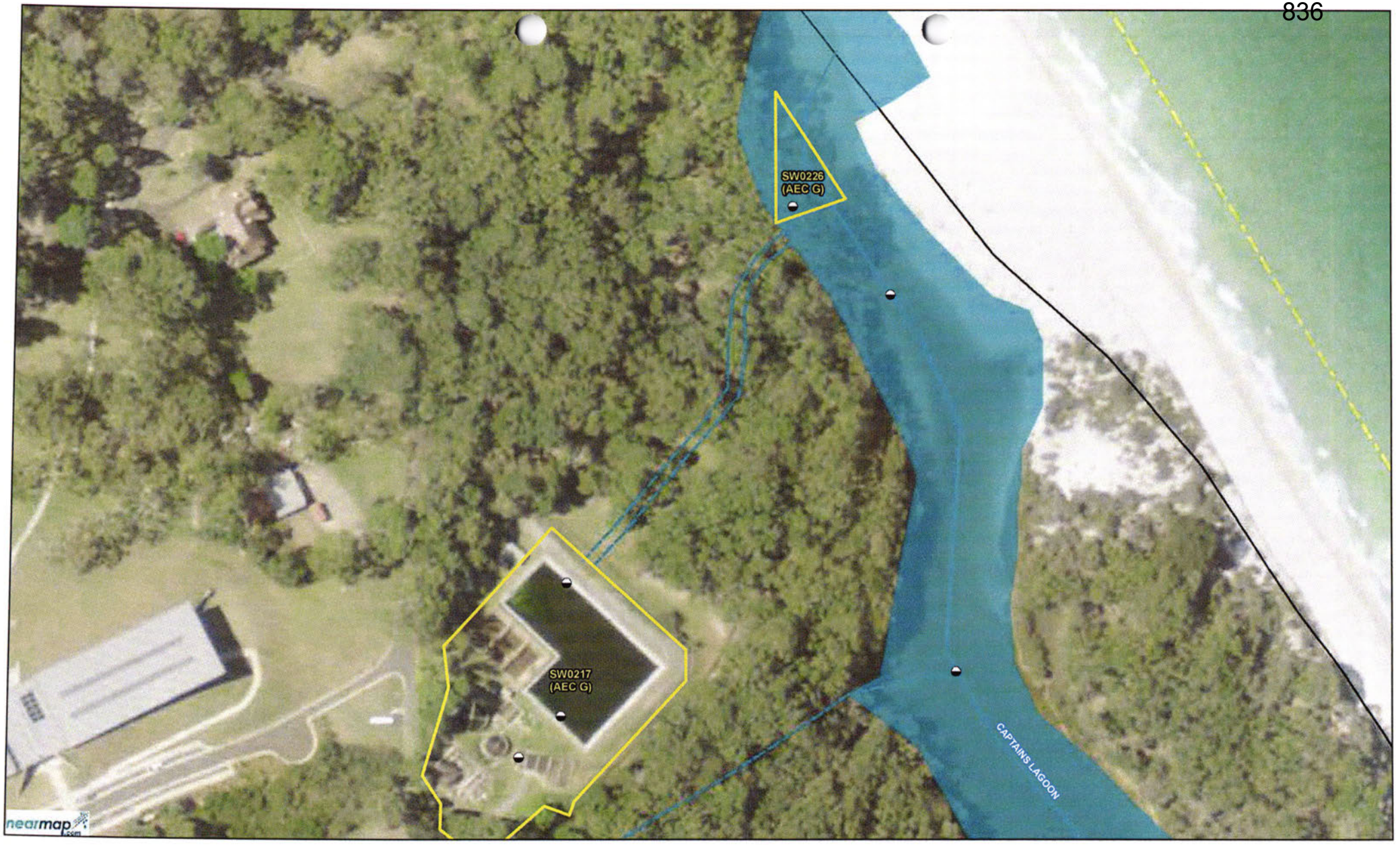

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Grid: GDA 1994 MGA Zone 56

N

LEGEND
- Investigation Area Extent
- Areas of Environmental Concern - Creswell
- HMAS Creswell
- Water Bodies
- Major Waterways
- Minor Waterways / Drainage Lines
- Proposed Surface Water & Sediment Sample

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Calibration Data

Figure 6

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND
- Investigation Area Extent
- Jervis Bay Range Facility
- Proposed Hand Auger Location
- Proposed Surface Water & Sediment Sample
- Existing Groundwater Well (To Be Sampled)

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Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by: mking3

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Paper Size A3

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Metres

Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - JBRF
- Areas of Environmental Concern - Creswell
- Jervis Bay Range Facility
- HMAS Creswell
- HATS Site Area
- Water Bodies
- Major Waterways
- Drainage Areas
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
- Proposed Soil Bore Location
- Proposed Groundwater Well
- Proposed Groundwater Well (Deep)
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
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- Existing Groundwater Data Logger Locations
- Existing Groundwater Well (Not Sampling)

Department of Defence

Job Number 21-26171
Revision A
Date 08 Sep 2017

Calibration Data

Figure 6

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Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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LEGEND

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Department of Defence

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Calibration Data

Figure 6

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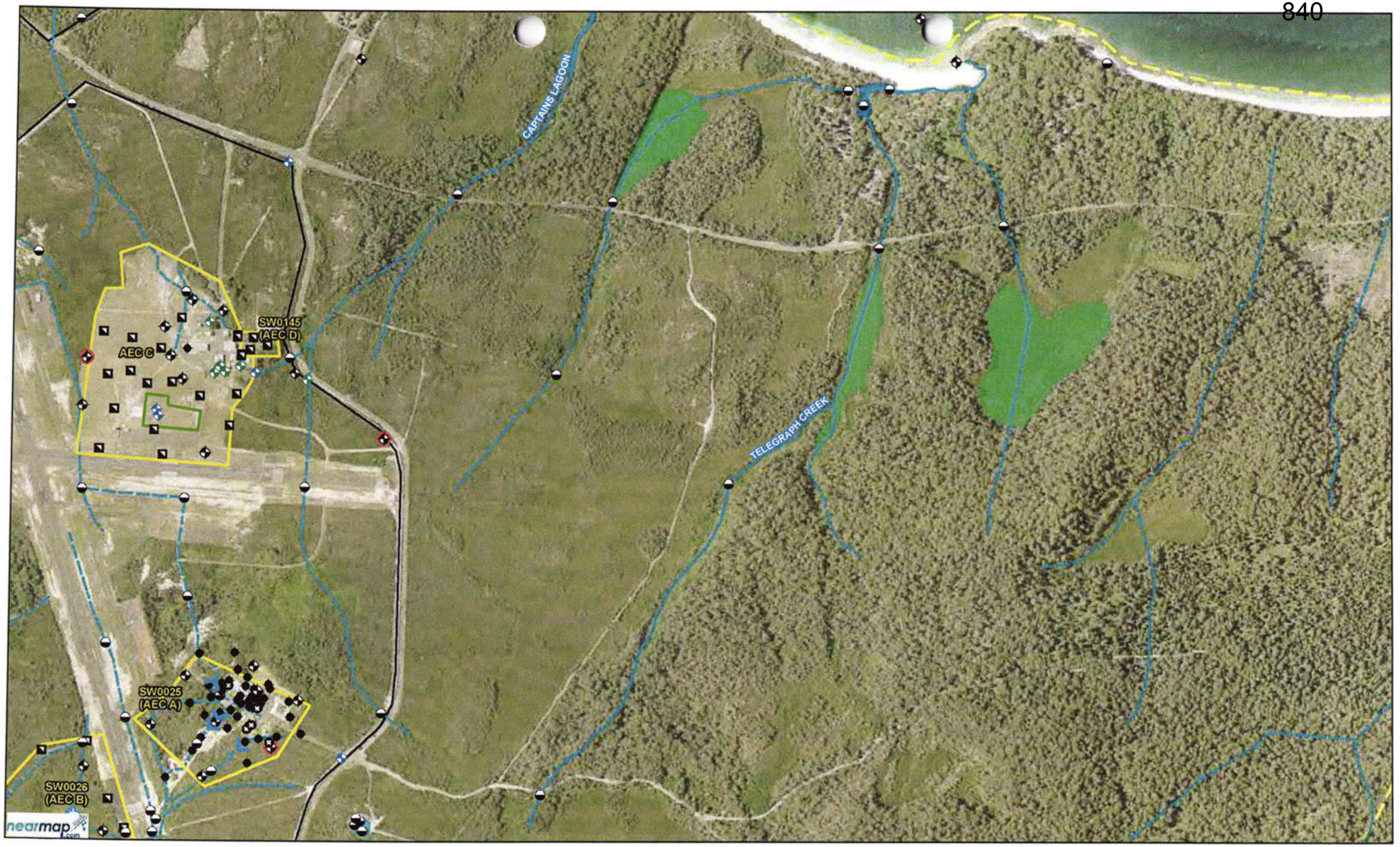

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LEGEND

- Investigation Area Extent
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- Water Tank Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Well (Not Sampling)

Department of Defence

Job Number	21-26171
Revision	A
Date	08 Sep 2017

Calibration Data

Figure 6

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Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by: mking3

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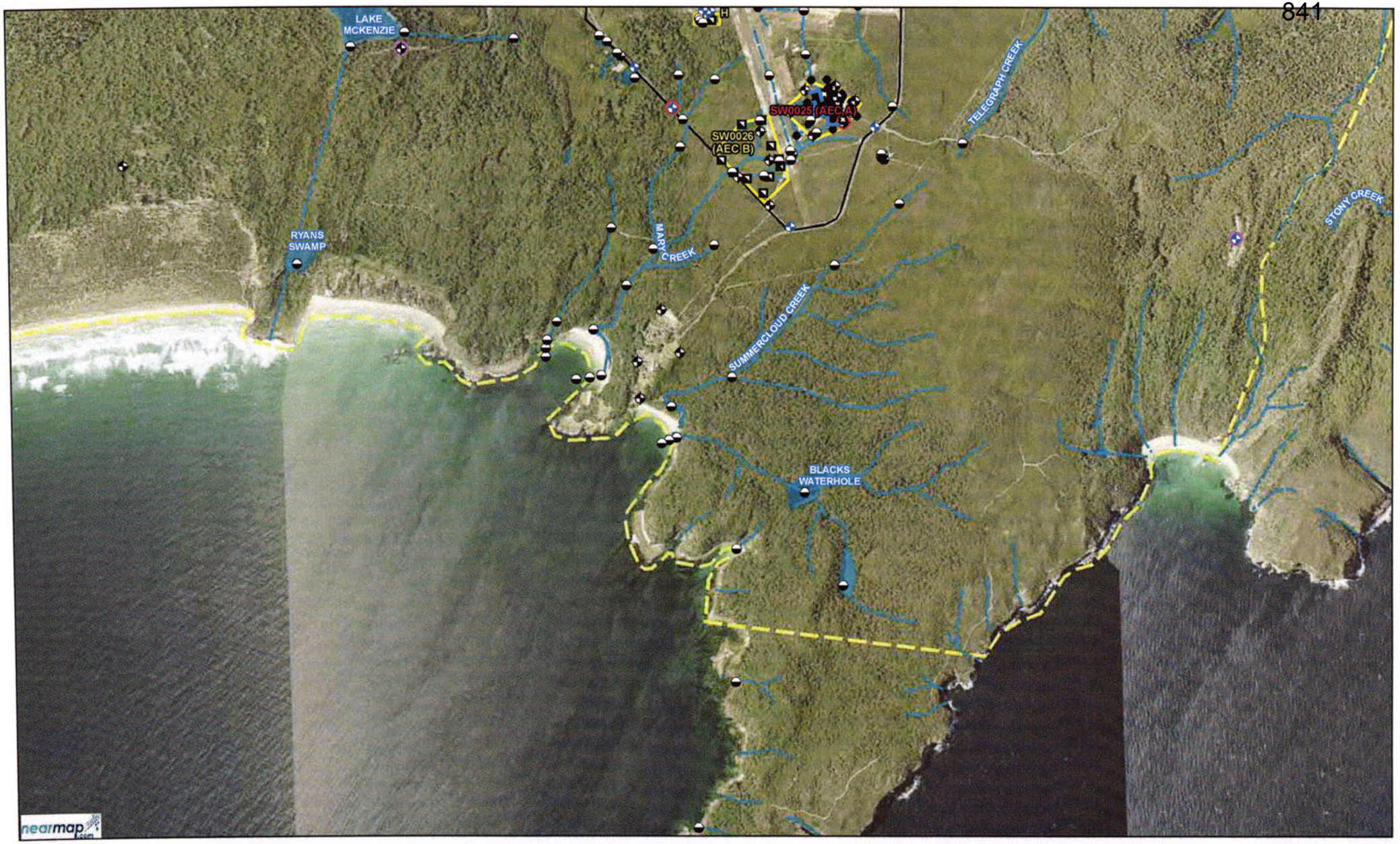

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
- Areas of Environmental Concern - JBRF
- Jervis Bay Range Facility
- Water Bodies
- Major Waterways
- Minor Waterways / Drainage Lines
- Proposed Hand Auger Location
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- Proposed Groundwater Well (Deep)
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
- Water Tank Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Well (Deep) (To Be Sampled)
- Existing Groundwater Data Logger Locations

Department of Defence

Job Number	21-26171
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Date	08 Sep 2017

Calibration Data

Figure 6

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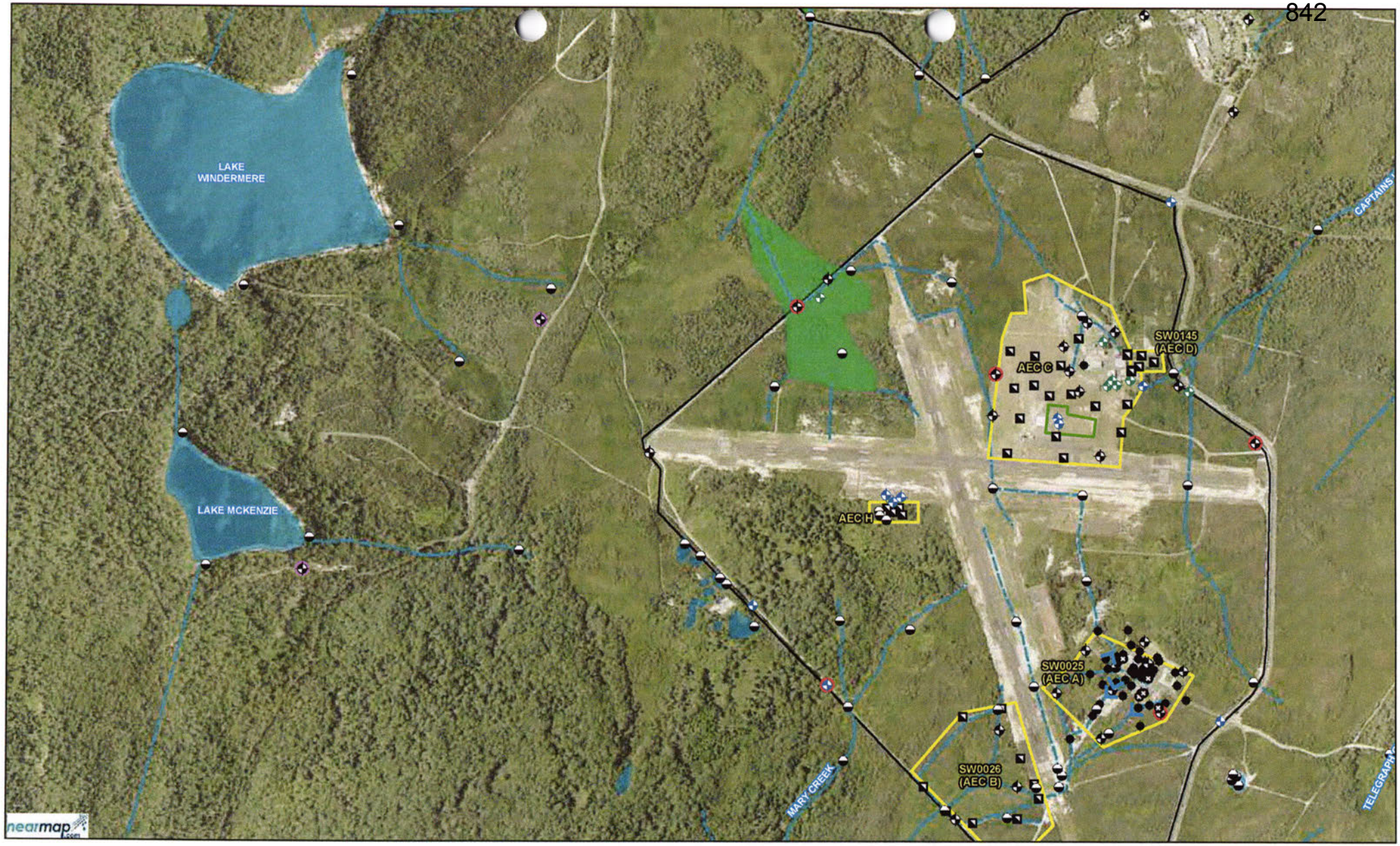

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

LEGEND

- Investigation Area Extent
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- Proposed Soil Bore Location
- Proposed Groundwater Well
- Proposed Groundwater Well (Deep)
- Proposed Groundwater Data Logger Locations
- Proposed Surface Water & Sediment Sample
- Water Tank Sample
- Existing Groundwater Well (To Be Sampled)
- Existing Groundwater Data Logger Locations
- Existing Groundwater Well (Not Sampling)

GHD

Department of Defence

Job Number	21-26171
Revision	A
Date	08 Sep 2017

Calibration Data

Figure 6

\\ghdnet\ghd\AU\Sydney\Projects\21\26171\GIS\Maps\Deliverables\Groundwater Modelling Plan\21_26171_2006_GMP_CalibrationData.mxd

Data source: Imagery - Nearmap (Imagery Date: 2016/08/14); Streets, Waterways - NSW LPI 2015 DTDB; Contours - NSW LPI 2016. Created by: mking3

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

5. Model Predictions

The calibrated flow model(s) will be used to undertake a predictive fate and transport model run to understand the migration pathways, characterise/rank the areas of key concern (receiving the most mass) and the potential times over which impacts will emerge.

The fate and transport model will adopt most likely case groundwater quality monitoring data and source zone dimensions. This is considered the best option as the adoption of high end values could potentially result in the adoption of less conservative fate transport migration parameters to achieve a broad fit to observed conditions (were possible).

The model(s) will then be run for the period the sources have been in existence (their age) to simulate the emergence of any well defined source plumes present at the site. If there is a poor fit, fate and transport input parameters will be varied within acceptable bounds to achieve a broad fit. The degree of calibration is expected to be broad only due to the potential for the generation of secondary and diffuse sources that complicate migration and plume development of PFAS.

Use of a short source zone age is considered to be conservative in this instance as it will promote the adoption of fate and transport parameters that promote more rapid migration. It is envisaged that this will partially compensate for the adoption of the broad calibration process. Further to this the adoption of F&T parameters that result in a slight over estimate of existing conditions will add another level of conservatism that is expected to compensate for limitations of the calibration approach.

The broadly calibrated model(s) will then be run for an extended period to characterise:

- Approximate travel times to receptors.
- Maximum concentrations under ongoing constant source conditions (this is considered to be highly conservative given that use has now stopped and only residual sources are present).
- Plume migration pathways and primary discharge zones and the associated interaction with key receptors.
- Mass discharge of PFOS at receptors for the purpose of identifying priority areas of risk, in the knowledge that mass load estimates will not be well constrained.

Until a more comprehensive understanding of overall mass in groundwater and remaining in soil is developed a detailed assessment of breakthrough times and mass flux balances at each receptor is not proposed. Once more certainty in the overall residual masses are available for groundwater and for primary and secondary sources (soil, sediment, concrete) additional modelling scenarios will be considered under a following phase of work.

6. Limitations

The document is designed to provide a broad framework to describe the overall modelling approach that will be adopted for this project. As the modelling process is only at inception stage and that a data review has not been undertaken, the final approach adopted may differ to that described within this report.

This report: has been prepared by GHD for Department of Defence and *may only be used and relied on by Department of Defence for the purpose agreed between GHD and the Department of Defence as set out in this report.*

GHD otherwise disclaims responsibility to any person other than Department of Defence arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

7. References

Barnett, B., Townley, L. R., Post V, V., Evans, R. E., & Hunt, R. J. (2012). *Australian groundwater modelling guidelines.* 2012, ACT, Australia: National Water Commission.

GHD Pty Ltd. (2017). *Department of Defence Jervis Bay Range Facility & HMAS Cresswell - Preliminary Site Investigation & Sampling, Analysis and Quality Plan - Rev 2.* Sydney.

GHD Pty Ltd. (2017a). *HMAS JBRF & HMAS Creswell - Lead Consultant Fee - Variation 4.* Sydney.

GHD

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2126171-98147/https://projects.ghd.com/oc/Sydney/hmascresswelljbtalea/Delivery/Documents/Groundwater modelling/2126171_REP_REV1.1_Groundwater modelling plan_Nov 2.docx

Document Status

Revision	Author	Reviewer(s)		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	
1.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	

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Stedman, Andrew (Health)

From: [redacted]
Sent: Thursday, 7 December 2017 8:50 AM
To: Hudson, Lyndell (Health); Stedman, Andrew (Health)
Cc: [redacted]
Subject: FW: JBRF HHERA plan Rev 1.1

Importance: High

Hi Lyndell and Andrew,

I was asked to provide comments on the Defence Creswell/Jervis Bay site, as were ACT Health.

NSW Health has provided the following comments to NSW EPA regarding the HMAS Creswell / Jervis Bay Defence Site.

We limited our advice to the some generic risk assessment comments and issues specific to NSW waters and aquatic biota.

However we also are aware of the elevated concentrations of PFAS in the upstream parts of Mary Creek. Note comment (4) below.
We do however defer to ACT Health about this issue as you have been dealing with it and are the lead on this issue.

If this advice is not in line with that of ACT Health or if there is additional information, then please let us know and I will contact NSW EPA to let them know our position.

Please give me a call if you wish to discuss.

Regards,

[redacted] | Health Risk and Regulation Unit | **Environmental Health Branch**
73 Miller Street, North Sydney NSW 2060
Tel 02 9461 7750 | [redacted].health.nsw.gov.au
www.health.nsw.gov.au

NSW GOVERNMENT | Health

From: [redacted]
Sent: Wednesday, 6 December 2017 3:45 PM
To: [redacted]
Cc: [redacted]
Subject: FW: JBRF HHERA plan Rev 1.1
Importance: High

[redacted]

NSW Health comments:

1) An aquatic biota assessment is proposed including of areas in NSW waters. NSW DPI fisheries to lead the review of the adequacy of the proposal.

Additionally, NSW DPI-fisheries should consider the suitability of the proposed control site in the north of Jervis Bay as the Defence Beecroft Weapons range "is owned and occupied by the Royal Australian Navy and has been regularly used for Defence weapons and other training activities since the 1800s." (link) whilst this does not necessarily include "fire training" it does not exclude it. A Defence site where there is only 'background' PFAS contamination is yet to be identified, especially where there has been ordinance use and regular fire / bushfire outbreaks.

2) The toxicity assessment should also consider PFHxA. *Toxicity profiles for the perfluorinated compounds, PFHxS and PFHxA*. (ToxConsult 2016a) has derived a toxicity reference value of 0.1 mg/kg bw/day which is being used for other Defence site HHRA's.
3) For the consideration of ingestion by infants of breast milk, the Commonwealth Health Protection Policy Branch advice to Defence (4 July 2017) should be referred to:
    - "The TDI is the estimate of the amount of a chemical in food or drinking water, expressed on a body weight basis, that can be ingested daily over a life-time without appreciable health risk to the consumer;
    - The TDI is expressed in proportion to body weight to extrapolate between test animals and humans, and also to take into account differences in human size (e.g. infants and children compared with adults);
    - Increased susceptibility associated with different life stages, including the embryo, foetus, and neonate is taken onto account as part of risk assessment by experimental studies in animals throughout different life-stages; and
    - Therefore, providing the TDI is not exceeded for the mother, no additional human health risk assessment is required for the breast feeding infant."
4) Mary Creek: Upstream (onsite) concentrations of PFOS/PFHxS are significantly elevated above the recreational guideline for PFOS+PFHxS, 0.7 ug/L. B_SW03, 10.9 ug/L, B_SW01, 4.94 ug/L. The water use survey details that Mary Creek is used by the Wreck Bay community for swimming, occasional drinking water and cooking water, fishing and recreation. Concentrations along the Creek are unknown however, NSW Health is concerned at the multiple exposure pathways to the community from use of Mary Creek water. **ACT Authorities, Commonwealth / Defence should consider if a detailed rapid assessment of Mary Creek and/or intervention/precautionary advice is required.**
5) Page 4 – Need to report the results from the testing of Wreck Bay drinking water, rather than saying Lake Windermere surface water does not appear to have been impacted by PFAS.
6) Page 8 – Complete exposure pathways- approach for PFASs other than three most toxic compounds and use of TEQ if the figure is >10% - Reference for that approach should be provided?
7) Page 8 – Human exposure pathways – home grown produce does not mention that eggs, beef or poultry, later in the document (page 32) they mention that no use of domestic stock has been reported at the location – These pathways should be considered as people in future may have domestic stock.
8) Page 31 - Background exposures and use of study by CRC care guidance – is that acceptable reference for background reference?
    a. Consider the ToxConsult 2016 references
        i. Toxicity profiles for the perfluorinated compounds, PFHxS and PFHxA.
        ii. Toxicity Profiles for the perfluorinated compounds, PFOS, PFOA, 6:2FTS and 8:2FTS.

Regards,

[redacted] | Health Risk and Regulation Unit | **Environmental Health Branch**
73 Miller Street, North Sydney NSW 2060
Tel 02 9461 7750 | [redacted]health.nsw.gov.au
www.health.nsw.gov.au

NSW GOVERNMENT Health

From: [redacted]
Sent: Tuesday, 28 November 2017 11:22 AM
To: [redacted]
Cc: [redacted]
Subject: Fwd: JBRF HHERA plan Rev 1.1

Hi [redacted]

I think we need to look over this focusing on off site effects in NSW. It would be good to clarify if ACT is involved but they must be.

Due 7/12

Regards
[redacted]

Get Outlook for iOS

From: [redacted]
Sent: Tuesday, November 28, 2017 8:31 am
Subject: FW: JBRF HHERA plan Rev 1.1
[redacted]

Hi everyone,

Can you please provide me with any comments you may have on the Jervis Bay HHERA by COB 7 December 2017.

Thanks,

[redacted] – **NSW PFAS Strategy**
Hazardous Incidents and Environmental Health, NSW Environment Protection Authority
[redacted]
[redacted].nsw.gov.au www.epa.nsw.gov.au @EPA_NSW
Report pollution and environmental incidents 131 555 (NSW only) or +61 2 9995 5555

From: [redacted]
Sent: Thursday, 23 November 2017 1:42 PM
To: [redacted]

[redacted]; Stedman, Andrew (Health) <Andrew.Stedman@act.gov.au>; [redacted]; Lyndell.Hudson@act.gov.au; [redacted]

Cc: PFASIM Jervis Bay <pfasim.jervisbay@defence.gov.au>
Subject: JBRF HHERA plan Rev 1.1

Hi JBRF PCG,

Thank you for your time and inputs to date, for the Jervis Bay Range Facility PFAS investigation. Attached for your review and comment is the Human Health and Ecological Risk Assessment Rev 1.1 (HHERA). Please provide any comments to Defence by 08/12/17 at the address below.
pfasim.jervisbay@defence.gov.au
The attached file is reduced quality for ease of email transfer, should you require the original 17 Mb version, of higher resolution please contact me and I will arrange a large file transfer service.

Regards,

[redacted]

GHD
[redacted]
Level 2, 57 Graham Street (PO Box 621) Nowra NSW 2541 Australia | http://www.ghd.com/
Water | Energy & Resources |Environment |Property & Buildings |Transportation

---

Stedman, Andrew (Health)

From: [redacted]>
Sent: Thursday, 14 December 2017 2:57 PM
To: [redacted]u; Clapham, David; Chester, Heath; [redacted]u; Stedman, Andrew (Health); [redacted], Lyndell (Health); [redacted]
Cc: PFASIM Jervis Bay
Subject: JBRF PCG Meeting 9 minutes and Agenda Meeting 10
Attachments: JBRF PCG_Meeting 10_Agenda.pdf; JBRF-PGC Meeting Minutes 9 - Oct17.pdf

Dear JBRF PCG,

Attached are the minutes from the JBRF PCG meeting held 17 November 2017.
Our next meeting is scheduled, Tuesday week, 19 December at 2 pm.

Merry Christmas,

[redacted]

GHD
[redacted]
Level 2, 57 Graham Street (PO Box 621) Nowra NSW 2541 Australia | http://www.ghd.com/
Water | Energy & Resources | Environment | Property & Buildings | Transportation

Australian Government
Department of Defence
Estate and Infrastructure Group

PFAS Environmental Management Program
Monthly PCG Meeting (09) – JBRF

Administrative Details	
Date	19 December 2017
Time	**14:00hrs (AEDST)**
Venue	Teleconference
Dial-in Details	[redacted] Australia Toll free Access code: [redacted]
Chair	[redacted]
Minutes	GHD
Attendees	
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
Stedman Andrew	Andrew.Stedman@act.gov.au
[redacted]	[redacted]
Radomir Krsteski	radomir.krsteski@act.gov.au
Heath Chester	heath.chester@act.gov.au
David Clapham	David.Clapham@act.gov.au
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
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[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
Agenda	
Introductions	
Investigation Progress (DSI scope and schedule)	- **Detailed Site Investigation (DSI)** - SAQP & Conceptual Site Model (CSM) - Factual memorandums
Future Stages (schedule)	- Human Health and Ecological Risk Assessment (HHERA) - Numerical Groundwater Model
Site Auditor	- Update from site auditor
Stakeholder Engagement	- Meetings and briefs - Community enquiries
Risks and Issues	
Other Business	
Close	

Australian Government
Department of Defence
Estate and Infrastructure Group

PFAS Environmental Investigation – Jervis Bay Range Facility
PROJECT CONTROL GROUP MEETING # 9

Administrative Details	
Date	Tuesday 17 November 2017
Time	14:00 – 14:35
Venue	Teleconference
Dial-in Details	Toll ----- [redacted] Toll-free ----- [redacted] Participant PIN: [redacted]
Chair	[redacted] Defence Project Director
Minutes	Taken by [redacted]

ATTENDEES	
Defence	
[redacted]	Project Manager PFAS Branch
[redacted]	Project Manager PFAS Branch
[redacted]	Project Manager PFAS Branch
[redacted]	Assistant Director PFAS Branch
[redacted]	Commanding Officer HMAS Creswell
[redacted]	Base Support Manager – Shoalhaven
Lead Contractor (LC), GHD	
[redacted]	Service Line Leader - LC Project Director
[redacted]	Principal Environmental Consultant
[redacted]	Environmental Consultant
[redacted]	Stakeholder Engagement
[redacted]	Project Manager
[redacted]	Principal – Stakeholder Engagement
Site Auditor (SA), AECOM	
[redacted]	Environment Defence appointed peer review
Agencies	
Mr David Clapham (DC2)	ACT Senior Policy Officer - Intergovernmental Relations
Ms Lyndell Hudson	ACT Health
[redacted]	NSW Health
[redacted]	ACT Construction, Environment and Workplace Protection
[redacted]	NSW EPA

Welcome and Conduct of PCG Meetings

[redacted] Defence PFAS -Welcomed attendees to the JBRF PFAS Investigation meeting.

Investigation Progress Detailed Site Investigation

1. [redacted] (GHD)Provided an overview of the investigation:
   - Investigation has progressed with other investigation tasks while awaiting permit for off site land investigations.
   - Block 151 (JBTA) Five soil samples and 1 groundwater sample sourced from a sump beneath the federal Police station. Soil samples did not report PFAS level above residential screening criteria. The water sample reported PFAS levels below drinking water screening criteria, but above recreational water screening criteria. The water sample sourced from the sump may not accurately represent the PFAS levels in the groundwater for this area and installation of groundwater well is planned in this area to confirm.
   - The results of sewerage system PFAS investigation were presented to the PCG in factual memorandum 10. In summary the results to date suggests the main source of elevated PFAS levels in the sewer system are the RAN School of SSS. Water samples were also taken from the quarterdeck sprinkler system which contained concentrations of PFAS in the order 0.146 µg/l
   - GHD continuing to investigate the closed loop water systems at RANSSSS with results to be presented in factual memorandum 11 when received. The results are being considered for potential PFAS exposure to RANSSSS staff and students, with a letter to be issued to Defence to identify the potential human health risks as interim advice.
2. [redacted] Defence will provide response to NSW EPA Comments in the near future.
3. Comments requested:
   - Nil

SAQP and Conceptual Site Model

4. [redacted] *GHD – **Note:** topic was not addressed during meeting. SAQP Rev 2.1 issued October 17 to all stakeholders with comments received and recorded.*

Future Stages - Human Health and Ecological Risk Assessment (HHERA)

5. [redacted] GHD. The HHERA plan and Groundwater modelling plan have been reviewed by Defence and auditor, with updated plans to be issued to the PCG in the near future. The human health risk assessment is contingent on offsite access, waiting on the results from offsite soil, sediment, biota, surface and groundwater sampling to identify the pathways, receptors and potential risks to human health and ecological risks. GHD, Defence and auditor have reached agreement on the methodology for the risk assessment, which is presented in the HHERA and Groundwater modelling plans.
6. ([redacted]) Defence will provide HHERA and groundwater modelling Plans to the PCG and WBACC in the near future.
7. Comments requested:
   - Nil

Site Auditor Update

8. [redacted] Site auditor has reviewed HHERA Plan versions Rev 0,1 & 2 and Groundwater Plan Rev 0, 1 and worked with Defence and GHD to finalise the plans.
9. [redacted] Site auditor has reached out to WBACC to offer independent consultation on the SAQP. WBACC have not requested support or advice.

Stakeholder Engagement

10. [redacted] GHD and defence hosted the Community walk in sessions on the 6th November with three sessions held. The Defence presentation was well attended. No community attended the Jervis Bay school hall session. The Wreck Bay community hall session was attended by 11 community members. The WB sessions focused on the detailed site investigation identifying:
    - On site sampling locations and results.
    - Planned off site sampling locations.
11. [redacted] GHD negotiations with WBACC are ongoing to obtain permits to access WBACC and national parks lands. WBACC is receiving advice from specialists associated with the University of Newcastle who have provided comment on the SAQP, which will be addressed by GHD, defence and auditor.
12. [redacted] GHD are engaging with WBACC to arrange an extra ordinary board meeting to discuss and progress the SAQP and off site access permit.
13. [redacted] Defence and GHD will continue to work with WBACC and their advisers, providing response to comments and copies of the HHERA and Groundwater modelling plans. With aim to achieve off site sampling in the new year.
14. Comments requested:
    - Nil

Community Enquiries

15. No activity or calls to the Community Hotline or email inbox.
16. Emails from WBACC in response to communications arranging community employment opportunities, board meeting attendance and provision of SAQP.

Risks and Issues

17. [redacted] requested key risks and issues:
    - GHD risks are unchanged with land access issues the primary risk (Defence).

PFAS investigation results

18. All investigation results have been provided to PCG via factual memorandums to date.

Other Business

Meeting Close - 14:35 PM

Actions

Item	Owner	Due date

Stedman, Andrew (Health)

From: [redacted]>
Sent: Wednesday, 20 December 2017 6:15 PM
To: [redacted]; Clapham, David; Chester, Heath; [redacted]; Stedman, Andrew (Health); [redacted]; Hudson, Lyndell (Health); [redacted]
Cc:

Subject: RE: JBRF PCG Meeting 9 minutes and Agenda Meeting 10
Attachments: JBRF-PGC Meeting Minutes 10 - December 2018.pdf

Dear JBRF PCG,

Attached are the minutes from the JBRF PCG meeting held 19 December 2017.
Our next meeting in January is cancelled due to the reduced activity over the holiday period, with next meeting scheduled for 20 febuary 2018.
On behalf of GHD, Defence PFAS branch and Auditor, I would like to thank everyone for their contribution and support to the project.

Best wishes for Christmas and a happy new Year.

Kind Regards,

[redacted]

GHD
[redacted]
Level 2, 57 Graham Street (PO Box 621) Nowra NSW 2541 Australia | http://www.ghd.com/
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Australian Government
Department of Defence
Estate and Infrastructure Group

PFAS Environmental Investigation – Jervis Bay Range Facility
PROJECT CONTROL GROUP MEETING #10

Administrative Details	
Date	Tuesday 19 December 2017
Time	14:00 – 14:40
Venue	Teleconference
Dial-in Details	Toll ----- [redacted] Toll-free ----- [redacted] Participant PIN: [redacted]
Chair	[redacted], Defence Project Director
Minutes	Taken by [redacted]

ATTENDEES	
Defence	
[redacted]	Project Director PFAS Branch
[redacted]	Project Manager PFAS Branch
Lead Contractor (LC), GHD	
[redacted]	Principal Environmental Consultant
[redacted]	Stakeholder Engagement
[redacted]	Project Manager
Site Auditor (SA), AECOM	
[redacted]	Environment Defence appointed peer review
Agencies	
David Clapham (DC2)	ACT Senior Policy Officer - Intergovernmental Relations
Lyndell Hudson (LH)	ACT Health
[redacted]	NSW Health
[redacted]	Jervis Bay Territory Administration
[redacted]	NSW Health
[redacted]	Senior Environmental Officer NSW EPA PFAS unit

Welcome and Conduct of PCG Meetings
([redacted] Defence PFAS -Welcomed attendees to the JBRF PFAS Investigation meeting. Peter Watson is the new PCG rep for NSW EPA (vice [redacted])
Investigation Progress Detailed Site Investigation