Scarborough Project – Nearshore Component

Dredging and Spoil Disposal Management Plan

February 2023

Revision 5

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
ADCP	acoustic doppler current profiler
AFC	antifouling coating
AHO	Australian Hydrographic Office
AHT	Anchor Handling Tug
ALARP	as low as reasonably practicable
AMSA	Australian Maritime Safety Authority
BC Act	*Biodiversity Conservation Act*
BCH	benthic communities and habitat
BHD	backhoe dredge
BIA	biologically important area
BoM	Bureau of Meteorology
BPPH	benthic primary producer habitat
BWM	Ballast Water Management Convention
CALM	Department of Conservation and Land Management
CEO	Chief Executive Officer
CFA	Commonwealth Fisheries Association
CHMP	Cultural Heritage Management Plan
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DEWHA	Department of the Environment, Heritage, Water and the Arts, ACT
DJTSI	Department of Jobs, Tourism, Science and Innovation
DLI	daily light interval
DMIRS	Department of Mines, Industry Regulation and Safety
DoEE	Department of the Environment and Energy
DoT	Department of Transport
DPA	Dampier Port Authority (now Pilbara Ports Authority)
DPIRD	Department of Primary Industry and Resource Development
DPIV	Deepwater pipeline installation vessel
DSDMP	Dredging Spoil and Disposal Management Plan
DSN	Dredging Science Node
DWER	Department of Water and Environmental Regulation
EEZ	Exclusive Economic Zone
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPO	environmental protection outcome
EQC	environmental quality criteria
EQG	environment quality guideline

Acronym	Description
EQMF	environmental quality management framework
EQO	environmental quality objective
EQP	Environmental Quality Plan
EQS	environment quality standard
EV	environmental value
FPU	floating production unit
GPS	global positioning system
HAT	highest astronomical tide
HSE	health, safety and environment
IMO	International Maritime Organization
IMS	invasive marine species
IMSMA	Invasive Marine Species Management Area
IOPP	International Oil Pollution Prevention Certificate
KP	kilometre point
LAU	local assessment unit
LC	lethal concentration
LEP	level of ecological protection
L_{pk}	peak sound pressure level
LNG	liquefied natural gas
LOR	limits of reporting
MAC	Murujuga Aboriginal Corporation
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	multibeam echosounders
MFE	mass flow excavation
MFO	marine fauna observer
MHWS	mean high water springs
MODIS	Moderate Resolution Imaging Spectroradiometer
MPB	microphytobenthos
MS	Ministerial Statement
NAGD	National Assessment Guidelines Dredging
NATA	National Association of Testing Authorities
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NTU	nephelometric turbidity unit
NWS	North West Shelf
OPP	Offshore Project Proposal
PAH	polycyclic aromatic hydrocarbons
PK	peak pressure
PPA	Pilbara Ports Authority
PSD	particle size distribution
PV	pipeline installation vessel

Acronym	Description
RIV	rock installation vessel
ROV	remotely operated vehicle
SAP	Sampling and Analysis Plan
SHB	split hopper barge
SOPEP	Shipboard Oil Pollution Emergency Plan
SSC	suspended sediment concentration
SSFATE	Suspended Sediment FATE
SSS	side scan sonar
SWLB	shallow water lay barge
TACC	Dampier Technical Advisory and Consultative Committee
TBT	tributyltin
TMMF	tiered monitoring and management framework
TPH	total petroleum hydrocarbons
TRH	total recoverable hydrocarbons
TSHD	trailing suction hopper dredge
TSS	total suspended solids
WA	Western Australia
WAMSI	Western Australian Marine Science Institution
Woodside	Woodside Energy Limited
ZoHI	zone of high impact
ZoMI	zone of moderate impact
ZoI	zone of influence

Executive summary

Proposal name	Scarborough Project - Nearshore Component
Proponent name	Woodside Energy Ltd
Ministerial Statement No.	1172
Purpose of the EMP	Provide a Dredging and Spoil Disposal Management Plan in accordance with Condition 6-3 of the Ministerial Statement No.1172
Key environmental factor/s, outcome/s and/or objectives	Key environment factors are: • Marine environmental quality • Benthic communities and habitat • Marine Fauna • Social Surroundings Environmental protection outcomes (EPO) as per Condition 6 include: • No detectable net reduction of live coral cover at any of the coral impact monitoring locations attributable to the proposal • Avoid where possible and otherwise minimise direct and indirect impacts on marine fauna listed as specially protected fauna under the *Biodiversity Conservation Act 2016*. Additional objectives include: • Maintain ecosystem integrity as per the existing Mermaid Sound EQP.
Condition clauses	Condition 6 (refer to Table 1-3 for details)
Key components in the EMP (if applicable)	The structure of the DSDMP is: • context, scope and rationale of the plan, including the legislative framework governing this plan (Section 1) • a summary of the stakeholder engagement undertaken on the plan, with issues raised by stakeholders carried into the risk assessment and management actions where appropriate (Section 2) • a description of the activity, including the relevant trenching, spoil disposal, borrow ground dredging, sand backfill, rock placement and construction activities method and rationale (Section 3) • a description of the existing environment to provide a basis for which any potential impacts and risks can be quantified and assessed (Section 4) • the dredge plume modelling and associated management zones (Section 5) • the management frameworks that will be implemented for each environmental factor to manage the potential impacts and risks associated with the activities defined in Section 3 to an acceptable level (Section 7 to 10) • the environmental monitoring program to inform the adaptive management framework and surveys to verify EPO 6-1(1) compliance (Section 11) • the implementation strategy, including inductions and training, reporting, roles and responsibilities, inspections and review requirements (Section 12).
Proposed construction date	March 2023
EMP required pre-construction?	Yes X No ☐

1 Context, Scope and Rationale

1.1 Proposal

The Scarborough gas resource is located in the Carnarvon Basin, approximately 375 km west-north-west of the Burrup Peninsula in Western Australia. The Scarborough gas resource is part of the Greater Scarborough gas fields which are estimated to hold 13.0 Tcf (100%) of natural gas. The Greater Scarborough gas fields include Thebe (~1.2 Tcf, 2C, 100%), Jupiter (~0.3 Tcf, 2C, 100%) and Scarborough (~11.5 Tcf, 2P, 100%).

The relevant offshore petroleum titles for the Greater Scarborough gas fields are all located in Commonwealth waters. The Scarborough gas resource will be developed through a phased development drilling program, which will be tied back to a semi-submersible floating production unit (FPU) moored in 950 m of water close to the Scarborough field.

The offshore facility is intended to be connected by an approximately 430 km trunkline to a second LNG train (Pluto Train 2) at the existing Pluto LNG onshore facility in Dampier, Western Australia (Figure 1-1). To install, stabilise and protect the trunkline in State waters, seabed intervention and shore crossing activities, including dredging and associated works are required.

The proponent for the DSDMP is Woodside as operator for and on behalf of the Scarborough Joint Venture. The Scarborough Joint Venture comprises Woodside Energy Scarborough Pty Ltd (73.5%) and Woodside Energy (Australia) Pty Ltd (26.5%).

1.2 Purpose, Scope and Structure of EMP

The purpose of this Dredging and Spoil Disposal Management Plan (DSDMP) is to:

- demonstrate how the seabed intervention and shore crossing activities described in Section 3 will be managed to reduce risks to an acceptable level, as per the *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (EPA, 2021a)
- comply with relevant conditions of the Scarborough Nearshore Component Ministerial Statement No. 1172 as they relate to the contents of this DSDMP, and specifically the Environmental Protection Outcomes.

Note the Scarborough Development Nearshore Component was assessed on Referral Information and additional information, which required the provision of a DSDMP with a public review period of four weeks. Revision 0 of the DSDMP was subject to public review in August 2019.

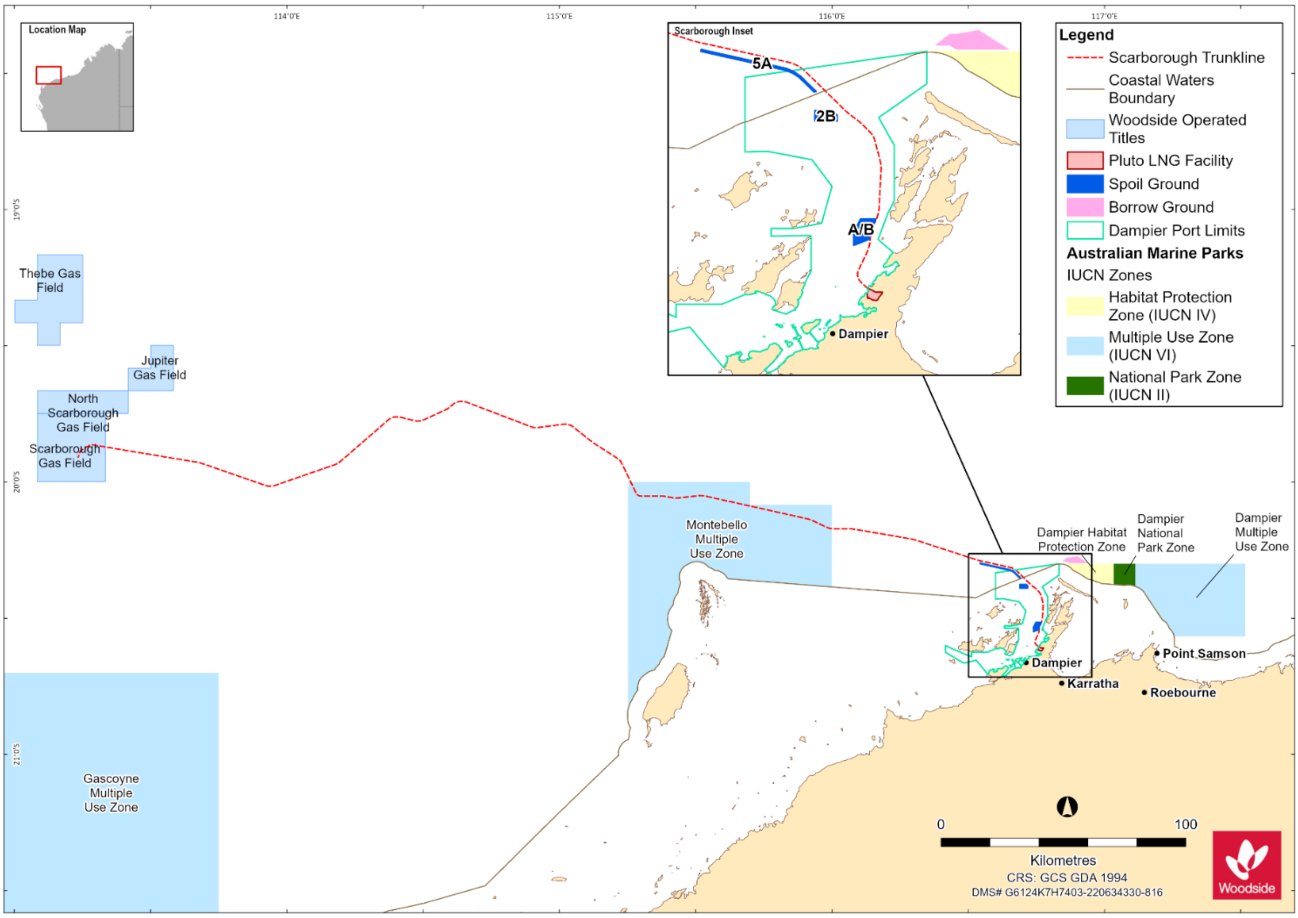

Figure 1-1: Location of the proposed Scarborough Project

This DSDMP has been prepared to manage the seabed intervention and shore crossing activities described in Section 3, as per Condition 6 of Ministerial Statement No. 1172. This includes:

- Seabed intervention
    - Trailing suction hopper dredge (TSHD) trenching along the trunkline route with material disposal at existing Spoil Ground 2B and Spoil Ground 5A (in Commonwealth waters)
    - Backhoe dredge (BHD) trenching along the trunkline route with sediment placed in support split hopper barges (SHB) for disposal in Spoil Ground A/B (restricted to BHD activities) and Spoil Ground 2B
    - Sand backfill along the trunkline by TSHD, with suitable material sourced from a borrow ground in Commonwealth waters
    - Rock placement along the trunkline for pipeline protection/stabilisation
    - Trunkline pre- and post-lay span rectification
    - Contingent seabed intervention activities including maintenance dredging/excavation of resettled material in the trench prior to pipelay, post lay dredging, grout bags and rock placement
    - Hydrographic/bathymetric surveys
- Trunkline installation anchoring activities
- Shore crossing activities:

  - Construction of a temporary rock platform/groyne on the shoreline between the pre-excavated trench and the Pluto LNG Jetty
  - Pre-lay marine excavation activities including trenching comprising armour rock removal from historically formed trench, and installation of a bedding layer in the trench
  - Post-lay rock installation & re-instatement including rock installation with filter and armour material and site re-instatement.

Activities undertaken in Commonwealth waters, including borrow ground dredging, are outside the scope of this DSDMP, although have been included in this plan for information only, and to provide context for the broader dredging, spoil disposal and trunkline protection / stabilisation activities. The following activities are also outside the scope of this DSDMP:

- Activities that extend beyond the State Waters boundary, into Commonwealth Waters will be covered under Environment Plans to be accepted by National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).
- Onshore construction, trunkline shore pull and pipelay vessel activities (excluding anchoring), commissioning and operations, which where relevant, will be covered under Environment Plans to be accepted by Department of Mines, Industry Regulation and Safety (DMIRS).
- Activities outside the development envelope (as illustrated in Ministerial Statement No. 1172) including pipe transport, quarrying of rock, importation and loadout facilities.
- Construction and operation of the trunkline from the beach valve (approximately 1.5 m above highest astronomical tide (HAT)) to the pig receiver at the Pluto LNG Facility (covered under the existing Ministerial Statement (MS) 757).

While this DSDMP references cultural and spiritual values as it relates to the natural environment, the Scarborough Project will also have an approved Cultural Heritage Management Plan (SA0006GH1401311448) in place to meet the relevant requirements of Ministerial Statement No. 1172. As such, the management of registered or potential heritage sites does not form part of the scope of this DSDMP.

The structure of the DSDMP is:

- context, scope and rationale of the plan, including the legislative framework governing this plan (Section 1)
- a summary of the consultation undertaken on the plan, with issues raised by stakeholders carried into the risk assessment and management actions where appropriate (Section 2)
- a description of the activity, including the relevant trenching, spoil disposal, borrow ground dredging, sand backfill, rock placement and construction activities method and rationale (Section 3)
- a description of the existing environment including survey and study findings and key assumptions and uncertainties to provide a basis for which any potential impacts and risks can be quantified and assessed (Section 4)
- the dredge plume modelling and associated management zones, as per *EPA Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2021b) and informed by outcomes from the Western Australian Marine Science Institute (WAMSI) Dredging Science Node (Section 5)
- the objective based environmental management frameworks that will be implemented for each environmental factor to manage the potential impacts and risks associated with the activities defined in Section 3 to an acceptable level, and the rationale for choice of indicators and/or management actions (Section 7 to Section 10)

- the environmental monitoring program to inform the adaptive management framework and surveys to verify Environmental Protection Outcome (EPO) 6-1(1) compliance (Section 11)
- the implementation strategy, including inductions and training, reporting, roles and responsibilities, inspections and review requirements (Section 12).

1.3 Key Environmental Factors

Table 1-1 outlines the Key Environmental Factors and the relevant impacts and risks.

Table 1-1 Key Environmental Factors

Key Environmental Factors	EPA Factor Objective	Existing Environment	Summary of Activities, Impacts and Risks
Marine environmental quality	To maintain the quality of water, sediment and biota so that environmental values are protected.	Refer to Section 4.2.	Planned: • Reduced water quality/increased turbidity from dredging, spoil disposal and backfill activities • Changes to sediment quality and characteristics from dredging, spoil disposal and backfill activities • Reduced water quality from Project vessel discharges Unplanned: • Reduced water and sediment quality from accidental hydrocarbon release
Benthic communities and habitat (BCH)	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained	Benthic communities and habitats likely to be present, including corals, macroalgae, mangroves seagrass, and mixed communities (including marine invertebrates), (Mscience, 2014). The significant BCH of the Dampier Archipelago, including the Port of Dampier, are discussed in detail in Section 4.3, and are shown in Figure 4-2.	Planned: • Physical removal of BCH • Indirect impacts (increased turbidity, reduced light, increased sediment deposition) on BCH from dredging and spoil disposal activities. • Project vessel discharges impacting BCH by reducing water quality Unplanned: • Accidental hydrocarbon release impacting BCH • Introduction of IMS impacting BCH
Marine Fauna	Protect marine fauna so biological diversity and ecological integrity are maintained.	The Dampier Archipelago is an important area for protected species listed under the EPBC Act and/or the *Biodiversity Conservation Act 2016* (BC Act). Protected species that may occur within the vicinity of the development envelope include protected species of mammals, birds, reptiles and fish that may be within the vicinity of the Proposal. Biological Important Areas (BIAs) have been identified for the EPBC Act listed species	Planned: • Reduced water quality/increased turbidity • Removal/modification of important/critical habitats • Light emissions impacting marine turtle and seabirds and migratory shorebirds • Noise emissions impacting marine fauna Unplanned: • Accidental hydrocarbon release impacting marine fauna

Key Environmental Factors	EPA Factor Objective	Existing Environment	Summary of Activities, Impacts and Risks
		with a potential to occur within the Dampier Archipelago, specifically humpback whales, loggerhead, green, hawksbill and flatback turtles, wedge-tailed shearwater, Caspian tern and roseate tern. Refer to Section 4.4 for further details.	• Vessel strike impacting marine fauna • Entrainment of marine turtles • Introduction of IMS impact biodiversity
Social Surroundings.	To protect social surroundings from significant harm.	The Proposal is located within the Pilbara region in the Port of Dampier limits managed by PPA. The region supports significant commercial shipping activity, tourism, recreational fishing, commercial fisheries and aquaculture. Murujuga is the traditional Aboriginal name for the Dampier Archipelago and surrounds, including the Burrup Peninsula and Murujuga National Park. The Traditional Custodians of Murujuga are the Ngarda-Ngarli people, a collective term for the Ngarluma, Yindjibarndi, Yaburara, Mardudhunera and Wong-Goo-Tt-Oo people. Ngard—-Ngarli people have an ongoing connection to Murujuga's cultural and spiritual landscape which his understood to date back tens of thousands of years. The Dampier Archipelago (including Burrup Peninsula) is an Indigenous class feature on the National Heritage List. MAC and the state are pursuing World Heritage listing for the Murujuga Cultural Landscape. Refer to Section 4.5 for further details.	Planned: • Physical presence of construction vessels displacing other users • Light emissions impacting marine turtle and seabirds and migratory shorebirds • Visual impacts from dredge plumes • Visual impacts from routine vessel discharges Unplanned: • Accidental hydrocarbon release preventing water-based activities • Accidental hydrocarbon release impacting fish and fisheries • Introduction of IMS impacting fisheries resources • Impacts to Aboriginal heritage sites/places

1.4 Condition Requirements

In December 2018, Woodside submitted a referral and supplementary report for assessment by EPA in accordance with Part IV (section 38) of the *Environment Protection Act 1986 (Assessment no. 2194)*, and to the former Department of Environment and Energy (DoEE), now Department of Climate Change, Energy, the Environment and Water–(DCCEEW), under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

DoEE determined the project was not a controlled action if undertaken in particular manner (reference number 2018/8362) on 12 August 2019 (refer to Section 1.4.2). EPA decided to assess the project based on the referral information and additional information, including this DSDMP (Rev 0 to Rev 2), which underwent a four-week public review and comment period. The Minister for Environment approved the project under Ministerial Statement No. 1172 on 11 August 2021 (refer to Section 1.4.3).

The proposal for the Scarborough Project activities in Commonwealth waters was submitted as an Offshore Project Proposal (OPP) to NOPSEMA in February 2019. The OPP was accepted by NOPSEMA on 30 March 2020. Environment Plans will also be submitted to NOPSEMA for relevant activities in Commonwealth waters and to DMIRS for relevant activities in State waters.

In Australia, loading and dumping of controlled material (amongst other things) at sea is regulated under the *Environment Protection (Sea Dumping) Act 1981* (Sea Dumping Act). In certain circumstances, permits are required to load and dump controlled material. Permit applications are assessed by DCCEEW and this process encompasses evaluating disposal alternatives and waste minimisation procedures, site and impact assessments and management and monitoring programs. A Sea Dumping Permit was granted for the project by DoEE on 3 December 2019 (SDP2019/3982) (refer to Section 1.4.4).

1.4.1 Legislative framework

This section describes the legislative framework and approval conditions governing the activities described in Section 3.

Applicable legislation, conventions, regulations and guidelines that have been considered when developing this DSDMP include the following.

- **State**
    - *Biodiversity Conservation Act 2016*
    - *Environmental Protection Act 1986*
    - *Environmental Protection Regulations 1987*
    - *Port Authorities Act 1999*
    - Pilbara water quality guidelines
    - Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals 2021
    - Technical Guidance – Protecting the Quality of Western Australia’s Marine Environment 2016
    - Technical Guidance – Protection of Benthic Communities and Habitats 2016
    - Pilbara Coastal Waters Consultation Outcomes 2006 (updated 2019)
- **Commonwealth**
    - Australian Ballast Water Management Requirements 2017
    - *Biosecurity Act 2015*
    - Biosecurity (Ballast Water & Sediment) Determination 2017

  - *Environmental Protection (Sea Dumping) Act 1981*
  - *Environmental Protection and Biodiversity Conservation Act 1999*
  - *Hazardous Waste (Regulation of Exports and Imports) Act 1989*
  - *Navigation Act 2012*
  - *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
  - *Protection of the Sea (Harmful Anti-Fouling Systems) Act 2006*
  - *Submarine Cables and Pipelines Protection Act 1963*
  - Marine Order 91 – pollution prevention – oil
  - Marine Order 94 – pollution prevention – packaged harmful substances
  - Marine Order 95 – pollution prevention – garbage
  - Marine Order 96 – pollution prevention – sewage
  - National Biofouling Management Guidance for Non-trading vessels 2009
  - National Assessment Guidelines for Dredging 2009
  - National Light Pollution Guidelines for Wildlife 2020
  - National Water Quality Management Strategy (Commonwealth Government of Australia 1992)
  - Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018.
- **International**
  - 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (London Protocol)
  - International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (BWM Convention; International Maritime Organization (IMO), 2009)

1.4.2 Environment Protection and Biodiversity Conservation 2018/8362 particular manner requirements

Table 1-2 sets out the EPBC 2018/8362 particular manner requirements as relevant to the proposed activity, and the relevant section references where each have been addressed in this plan. Note that pile driving in the nearshore area is no longer required, as alternatives have been selected through detailed engineering and design processes and hence particular manners 1 to 9 are not included here.

Table 1-2: Environment Protection and Biodiversity Conservation 2018/8362 particular manner requirements (relevant to the proposed activity)

Clause	Clause details	Section reference
To mitigate potential impacts of dredging on marine turtles, dredging operations must be taken in the following manner:		
10	Whenever dredging is occurring, turtle deflecting devices must be used on the drag heads of the dredge(s) and dredging must not take place without these devices in place.	Section 9.1
To mitigate potential impacts of the action on whales, the action must be taken in the following manner:		

Clause	Clause details	Section reference
11	When operating a vessel: a) at a speed in excess of six knots b) in state (Western Australia, or 'WA') waters north of minus 20.45 decimal degrees south c) between 1 August and 31 October (inclusive) in any year, the person taking the action must ensure that a marine fauna observer observes for whales from a high observation platform on the vessel using binoculars by day and thermal imaging equipment at night or in periods of low visibility.	Section 9.1
12	Vessels must not: a) travel faster than six knots within 300 m of a whale b) approach closer than 100 m from a whale.	Section 9.1
13	If a whale(s) shows any sign of being disturbed inside the distances specified in particular manner measure 12(b), the vessel will immediately withdraw from the whale(s) at a constant speed of less than six knots.	Section 9.1
Definitions	**Marine fauna observer:** a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for marine fauna. **Marine turtles:** include the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), flatback turtle (*Natator depressus*), leatherback turtle (*Oermochelys coriacea*), and any marine turtle whose species cannot be identified. **Whale(s):** includes the humpback whale (*Megaptera novaeangliae*), blue whale (*Balaenoptera musculus*) and any whale whose species cannot be identified.	

1.4.3 Ministerial Statement No. 1172 Condition 6 requirements

Table 1-3 sets out the DSDMP requirements as per Condition 6 of Ministerial Statement No. 1172 and the relevant section references where each have been addressed in this plan. Note that pile driving in the nearshore area is no longer required, as alternatives have been selected through detailed engineering and design processes and hence clause 6-3(10 -d) is no longer relevant.

Table 1-3: Ministerial Statement No. 1172 Condition 6 Dredging and Spoil Disposal Management Plan conditions

Clause	Clause details	Section reference
6-1	The proponent must ensure implementation of the proposal achieves the following Environmental Protection Outcomes:	
6-1(1)	no detectable net reduction of live coral cover at any of the coral impact monitoring locations attributable to the proposal; and	Section 7.4
6-1(2)	avoid where possible and otherwise minimise direct and indirect impacts on marine fauna listed as specially protected fauna under the *Biodiversity Conservation Act 2016*.	Section 9
6-2	Prior to dredging activities, the proponent shall finalise and submit a further revision of the Dredging and Spoil Disposal Management Plan (SA006AH0000002, Rev 2. November 2019), in consultation with Murujuga Aboriginal Corporation, to meet Environmental Protection Outcomes specified in condition 6-1.	This plan Section 2.3.2.1
6-3(1)	The Dredging and Spoil Disposal Management Plan as required by condition 6-2 shall include: a requirement for all dredging and spoil disposal activities to be managed with the objective of achieving the Environmental Protection Outcomes required by condition 6-1;	Section 7.4 Section 9
6-3(2)	a benthic habitat map showing the extent and distribution of benthic communities and habitats;	Figure 4-2
6-3(3)	sediment plume modelling outputs to inform predicted impacts and losses of benthic communities and habitat, including a cumulative loss assessment;	Section 5

Clause	Clause details	Section reference
6-3(4)	presentation of the sediment plume outputs in an impact zonation scheme;	Section 5.6
6-3(5)	management trigger indicators based on pressure response pathways and proposed adaptive management actions;	Section 7.4.2
6-3(6)	monitoring program including reference and impact monitoring site locations and methods (including timing) to provide data to allow assessment against the management trigger indicators and the Environmental Protection Outcomes required by condition 6-1(1), and to inform adaptive management actions;	Section 11
6-3(7)	a tiered monitoring/management feedback loop to manage dredging, spoil disposal and backfill operations to achieve Environmental Protection Outcomes required by condition 6-1(1);	Section 7.4
6-3(8)	procedures to be implemented to minimise the environmental impact of trunkline installation vessel operations, including vessel anchoring;	Section 8.1
6-3(9)	procedures developed in consultation with Department of Primary Industries and Regional Development for managing all vessels and immersible equipment activities prior to mobilisation and during the life of the proposal to prevent introduction of marine pests into the State, within the State and into or out of the Dampier Archipelago;	Section 8.2
6-3(10)	monitoring and management measures to achieve the Environmental Protection Outcomes in condition 6-1(2), including but not limited to:	
6-3(10) – a	measures to avoid direct vessel strikes with marine fauna;	Section 9.1
6-3(10) – b	measures to minimise direct entrainment impacts on turtles, including not operating dredge pumps during transit;	Section 9.1
6-3(10) – c	exclusion zones and observation zones for dredging;	Section 9.1
6-3(10) – d	noise management procedures to avoid temporary and permanent changes to hearing sensitivity in marine fauna and minimise behavioural responses, including but not limited to during any pile driving activities (including implementing soft start procedures, restricting pile driving to daylight hours and precluding pile driving operations during the period May to October inclusive, exclusion zones and trained fauna observers);	N/A scope not included
6-3(10) – e	measures to minimise indirect impacts on turtles from lighting, including by minimising lighting use on vessels and during onshore construction;	Section 9.1
6-3(10) – f	recording sightings and locations of marine fauna in the vessels' daily log book; and	Section 9.1
6-3(10) – g	documenting and reporting to relevant regulators any incidents relating to marine fauna injury/mortality.	Section 9.1
6-3(11)	procedures for determining whether any management trigger exceedances are attributable to the implementation of the proposal;	Section 7.4.3
6-3(12)	contingency management strategies to be employed if management triggers are reached as a result of the proposal;	Section 7.4.4
6-3(13)	clear reporting procedures if management triggers are reached;	Section 12.5
6-3(14)	mechanisms to provide the public with details of exceedances of management triggers and contingency actions as soon as practicable	Section 12.5.2.1
6-3(15)	mechanisms to notify the public if marine recreational values are likely to be impacted as a result of the dredging, spoil disposal and/or backfill activities; and	Section 12.5.2.1
6-3(16)	evidence of the consultation required and the outcomes of this consultation.	Section 2
6-4	Dredging activities may not commence until the proponent has received notice in writing from the Chief Executive Officer (CEO) that the Dredging and Spoil Disposal Management Plan satisfies the requirements of condition 6-3.	Noted
6-5	The proponent:	
6-5(1)	may review and revise the Dredging and Spoil Disposal Management Plan, or	Noted
6-5(2)	must review and revise the Dredging and Spoil Disposal Management Plan as and when directed by the CEO	Noted

Clause	Clause details	Section reference
6-6	The proponent shall implement the latest revision of the Dredging and Spoil Disposal Management Plan required by condition 6-2, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 6-3.	Noted
6-7	In the event that monitoring carried out under the Dredging and Spoil Disposal Management Plan determines that the relevant Environmental Protection Outcomes required by condition 6-1 are not being achieved, the proponent shall:	-
6-7(1)	immediately implement the relevant contingency management actions specified in the Dredging and Spoil Disposal Management Plan, and continue implementation of those actions until it can be demonstrated that the Environmental Protection Outcomes required by condition 6-1 are being achieved and will continue to be achieved;	Section 11.3.5
6-7(2)	investigate the likely cause of the Environmental Protection Outcomes required by condition 6-1 not being achieved;	Section 11.3.5
6-7(3)	within twenty-four (24) hours of determining that any of the Environmental Protection Outcomes required by condition 6-1 are not being achieved, report the non-achievement to the CEO;	Section 12.5.2
6-7(4)	within seven (7) days of determining that any of the Environmental Protection Outcomes required by condition 6-1 are not being achieved submit to the CEO a report detailing the following	Section 12.5.2
6-7(4) – a	the results of the monitoring that led to the determination that any of the Environmental Protection Outcomes required by condition 6-1 are not being achieved;	
6-7(4) – b	the investigation being undertaken as required by condition 6-7(2);	
6-7(4) – c	any notifications and contingency management actions implemented by the proponent following determination that any of the Environmental Protection Outcomes required by condition 6-1 are not being achieved; and	
6-7(4) – d	provide a report detailing the findings of the investigation required by condition 6-7(2) to the CEO within twenty-one (21) days of first determining that any of the Environmental Protection Outcomes set in condition 6-1 are not being achieved.	
6-8	The proponent shall submit to the CEO annual Compliance Assessment Reports in accordance with condition 4-6, which includes:	Section 12.5.2
6-8(1)	all monitoring data and reportable incidents required by conditions 6-7(3) and 6-7(4);	
6-8(2)	an analysis and interpretation of monitoring data to demonstrate compliance with the requirements of condition 6-1; and	
6-8(3)	an assessment of the effectiveness of monitoring, management and contingency measures implemented to ensure compliance with the requirements of condition 6-1.	

1.4.4 Sea Dumping Permit No. SD2019/3982 requirements

Table 1-4 sets out the Sea Dumping Permit No. SD2019/3982 requirements and the relevant section references where each have been addressed in this plan.

Table 1-4: Sea Dumping Permit No. SD2019/3982 requirements

Clause	Clause details	Section reference
1	Except so far as the contrary intention appears, terms used in the conditions of this permit have the same meaning as such terms in the Act.	Noted
Material to be dumped		
2	Woodside Energy must ensure no more than 2,781,700 cubic metres (in-situ) of material derived from capital dredging from the trunkline trenching works at the Port of Dampier, Western Australia as specified in the Application and the map at Appendix 3, is loaded and dumped.	Noted
Disposal site		

Clause	Clause details	Section reference
3	Woodside Energy must only dump within the disposal site.	Section 8.1
4	Woodside Energy must ensure the dredged material is dumped in a manner over the disposal site to minimise mounding from dumping activities	Section 8.1
5	Woodside Energy must establish by GPS that, prior to dumping, the vessel is within the disposal site.	Section 8.1
Monitoring and Management **Mitigation Measures for Protection of Marine Species**		
6	Before commencing the dumping activities, Woodside Energy must ensure a check is undertaken, using binoculars from a high observation platform, for marine species within the observation zone.	Section 9.1
7	If any marine species are sighted in the observation zone, Woodside Energy must not commence dumping activities until either 10 minutes after the last marine species is observed in the observation zone, or the vessel has moved to another area of the disposal site where it can maintain a minimum distance of 300 metres between the vessel and any marine species.	Section 9.1
Environmental Risk and Incidents		
8	If, at any time during the course of the dumping activities, an environmental incident occurs or an environmental risk is identified, all reasonable measures must be taken immediately by Woodside Energy to minimise or mitigate the risk or the impact. Woodside Energy must provide a report on the environmental incident or environmental risk to the Department within 72 hours, with details of the incident or risk, the measures taken, the success of those measures in addressing the incident or risk and any additional measures proposed to be taken.	Section 12.5.2
9	Woodside Energy must document any incidents involving the dumping activities that result in injury or death to any marine species. The date, time and nature of each incident and the species involved, if known, must be recorded, and the incident is to be reported to the Department within 72 hours.	Section 9.1
Compliance of all Parties engaged in dumping activities		
10	Woodside Energy must ensure all persons engaged in the dumping activities under this permit, including the owner(s) and person(s) in charge of the vessel, comply with this permit and the requirements of the Act. The fulfilment of these conditions remains the responsibility of Woodside Energy .	Noted
Access for Observers		
11	If requested by the Department, Woodside Energy must provide access for at least two nominees of the Department to witness, inspect, examine and/or audit any part of the operations, including any dumping activities or monitoring activities, the vessel or any other equipment, or any documented records. Woodside Energy must provide all reasonable assistance to the nominees of the Department for performing their duties.	Noted
Record-keeping and Reporting		
12	Woodside Energy must make and retain records comprising either weekly plotting sheets or a certified extract of the ship's log which detail:	
12 (a)	the dates and times of when each dumping run commenced and finished	Section 8.1
12 (b)	the position (as determined by GPS) of the dumping vessel at the beginning and end of each dumping run, including the path of each dumping run	Section 8.1
12 (c)	the volume of dredged material (in-situ cubic metres) dumped and quantity in dry tonnes for the specified operational period and compared to the total amount permitted under the permit on a daily basis	Section 8.1
12 (d)	the person(s) undertaking the marine species observation required in condition 6 and any marine species observed within the observation zone for each run, including the date, time and approximate distance from the vessel, and the action taken to comply with condition 7	Section 9.1

Clause	Clause details	Section reference
12 (e)	a register maintaining a record of environmental incidents or environmental risks.	Section 8.1
13	Woodside Energy must retain the records required by conditions 8, 9 and 12 for verification and audit purposes.	Noted
14	Woodside Energy must ensure a bathymetric survey of the disposal site is undertaken by a suitably qualified person: a) prior to the commencement of dumping activities under this permit; and b) within 1 month of the completion of all dumping activities authorised under this permit.	Section 8.1
15	Within 2 months of the final bathymetric survey being undertaken, Woodside Energy must provide a digital copy of the bathymetric surveys to the Australian Hydrographic Office, via email at datacentre@hydro.gov.au.	Section 12.5.2
16	Woodside Energy must provide a report on the bathymetry to the Department within 3 months of the final bathymetric survey being undertaken. The report must include a chart showing the change in sea floor bathymetry as a result of dumping activities and include written commentary on the volumes of dumped material that appear to have been retained within the disposal site.	Section 12.5.2
17	To facilitate annual reporting to the International Maritime Organization, Woodside Energy must report to the Department by 31 January each year, including on the day of the expiry of the permit or completion of all dumping activities under this permit, information at Appendix 2 to this permit, or in a format as approved by the Department from time to time.	Section 12.5.2
Definitions	**Act** means the *Environment Protection (Sea Dumping) Act 1981* Application means the Application for a permit under the *Environment Protection (Sea Dumping) Act* ***1981*** submitted by Woodside Energy Limited and received by the Department on 8 August 2019 with further information received on 18 September 2019 **Department** means the Australian Government Department responsible for administering the Act **Disposal site** means the disposal areas Spoil Ground A/B, Spoil Ground 2B and Spoil Ground 5A bound by the following co-ordinates (WGS84). *Note permit lists specific coordinates not replicated here.* **Dumping activities** means all activities associated with dumping permitted under this permit, including: (i) loading for the purpose of dumping of dredged material (ii) dumping of the material at the prescribed disposal site. **Environmental incident** means any event which has the potential to, or does impact, on the environment. **Environmental risk** means any risk, which has the potential to, or does impact, on the environment. **GPS** means Global Positioning System. **Marine Species** means all whales, dolphins, dugongs and marine turtles listed under the *Environment Protection and Biodiversity Conservation Act 1999*. **Minister** means the Australian Government Minister administering the *Environment Protection (Sea Dumping) Act 1981* and includes a delegate of the Minister. **Observation zone** means the area within a 300 m radius of the vessel; **Woodside Energy** means Woodside Energy Limited, 11 Mount Street, Perth, Western Australia. **Vessel** means any vessel or vessels used for or in connection with dumping activities.	

1.5 Rationale and approach

1.5.1 Environmental Protection Outcomes and Objectives

Table 1-5 outlines the Environmental Protection Outcomes and objectives and how compliance will be demonstrated.

Table 1-5 Demonstration of Compliance with Environmental Protection Outcomes and Objectives

Environmental Protection Outcome	Approach to Demonstrating Compliance
EPO 6-1(1) No detectable net reduction of live coral cover at any of the coral impact monitoring locations attributable to the proposal	Section 7 and 8 describe the marine environmental quality management framework and the benthic communities and habitat management framework respectively. These management frameworks include a suite of management measures to mitigate potential impacts to coral. In particular, the tiered monitoring and management framework which has been designed to manage dredging activities within acceptable water quality boundaries, to avoid reversible impacts to coral communities as the most sensitive receptor. The suite of monitoring locations and their functions related to the water quality monitoring program and coral community assessment program are presented in Section 11.2 and 11.3 respectively. The coral community assessment program has been designed to detect net changes in live coral cover at impact sites, which are significantly different from natural changes occurring concurrently at reference sites. The statistical design has considered how much coral cover changes naturally from time to time and how that varies among different sites. Section 11.3 also details how Project attributability will be assessed. Together the monitoring and management approach will be used to effectively achieve and monitor compliance with EPO 6-1(1).
EPO 6-1(2) Avoid where possible and otherwise minimise direct and indirect impacts on marine fauna listed as specially protected fauna under the *Biodiversity Conservation Act* 2016.	Section 9 outlines the management framework that has been designed to mitigate potential impacts to marine fauna. The framework provides a suite of management actions that will be in place to avoid or minimise potential impacts to relevant marine fauna as a result of the proposed activity. This includes but not limited to the implementation of observation and exclusion zones to minimise potential interactions and specific controls to limit inadvertent take of marine turtles via entrainment. This approach will effectively achieve and monitor compliance with EPO 6-1(2).
Additional Objectives	**Approach to Demonstrating Compliance**
Maintain ecosystem integrity as per the existing Mermaid Sound Environmental Quality Plan.	Section 7 outlines the environmental quality management framework that has been designed to mitigate potential impacts to marine environmental quality as per the Mermaid Sound Environmental Quality Plan. The framework and the monitoring described in Section 11 are consistent with the Mermaid Sound Environmental Quality Plan and have been designed to mitigate potential impacts to ecosystem integrity and monitoring compliance with the stated objective.

1.5.2 Survey and study findings

A number of studies and surveys have been completed within the Dampier Archipelago to support the Proposal. These have informed the description of the existing environment (Section 4) and assessment of potential impacts and risks for the Proposal. Key studies include sediment sampling and analysis (Appendix B), baseline coral habitat assessment (Appendix D) and dredge sediment dispersion modelling (Appendix E).

Sediment dispersion modelling has been completed to predict the potential magnitude, intensity and spatial distribution of suspended sediment concentrations (SSC) associated with the trenching and spoil disposal and borrow ground dredging and backfill activities (Appendix E). The predicted outcomes are used to assess the unmitigated[1] potential for impact on significant BCH in the region associated with a deterioration in water quality.

To support the impact and risk assessment process, a conceptual model illustrating the predicted relationships between environmental receptors (key environmental factors) and sources of environmental stress to which they may be exposed is presented in Appendix H. The conceptual model is informed by the activities described in Section 3 to determine the sources of potential environmental stress and the description of the existing environment in Section 4 to determine the key receptors and key environmental factors. This information has also been used to inform the marine environmental quality management framework and associated tiered monitoring and management framework described in Section 7.

1.5.3 Key assumptions and uncertainties

Key assumptions and uncertainties in relation to the existing environment are detailed in Section 4 and associated study reports provided in Appendix B, Appendix C and Appendix D.

Key assumption and uncertainties in relation to the dredge plume modelling are detailed in Section 5 and Appendix E. It is noted that an expert peer review has been undertaken, which concluded that while a level of uncertainty will always exist with modelling studies, the uncertainty has been managed through detailed review of relevant information in the literature, extensive past project experience, adoption of well-established models, adherence to suggested best practice as outlined in the WAMSI Dredging Science Node reports and adoption of conservative values for input parameters where deemed necessary.

1.5.4 Objective-based EMP

An objective based environmental management frameworks has been implemented for each environmental factor to manage the potential impacts and risks associated with the activities defined in Section 3 to an acceptable level.

1.5.5 Rationale for choice of indicators and/or management actions

For each environmental factor, the rationale for choice of indicators and/or management actions to manage the potential impacts and risks associated with the activities defined in Section 3 to an acceptable level are outlined in Section 7 to Section 10.

As described above, a conceptual model illustrating the predicted relationships between environmental receptors (key environmental factors) and sources of environmental stress to which they may be exposed is presented in Appendix H. The model is informed by the activities described in Section 3 to determine the sources of potential environmental stress and the description of the existing environment in Section 4 to determine the key receptors and key environmental factors, which in turn informs the choice of indicators and selection of management actions.

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[1] Note, unmitigated loss is not expected to eventuate through the implementation of the tiered monitoring and management framework (Section 7.4).

2 Consultation

2.1 Overview

This section describes Woodside's approach to consultation as the Operator of the Scarborough Project.

Woodside's objectives for consultation while preparing the DSDMP were to:

- build awareness and understanding of the development of the Scarborough Project
- provide information about the development of the Scarborough Project, including the physical, ecological and socioeconomic and cultural environment that may be affected, the potential risks and impacts that may occur, and the prevention and mitigation measures proposed to avoid or minimise those risks and impacts
- gain feedback about the development of the Scarborough Project and, where possible, address feedback through further consultation or by implementing additional mitigation measures.
- specifically consult with Murujuga Aboriginal Corporation as required by Condition 6-2 of MS 1172

A phased consultation approach has been performed to support the development and refinement of this DSDMP as described in Section 2.3, with preliminary consultation commencing in February 2018.

Woodside will complete an update of its voluntary social impact assessment in the Karratha and Roebourne communities in early 2023, to assess the social opportunities and impacts arising from the Scarborough Project. Woodside is employing a participatory approach to this assessment, consulting and gaining input to identify and assessing these impacts and opportunities.

2.2 Stakeholder identification

The process for consultation, as performed by Woodside as the Operator of the Scarborough Project, included identifying stakeholders to consult with in relation to the DSDMP. Table 2-1 summarises stakeholders and stakeholder groups that have been preliminarily identified by Woodside for consultation on the DSDMP. This list is not exhaustive. Additional stakeholders may be identified as a part of ongoing consultation throughout the life of this DSDMP.

Stakeholders for consultation on the DSDMP include those known as a result of Woodside's ongoing activities in Western Australia, as well as those identified through engagements with regulators, government agencies, desktop research and regional contacts.

Table 2-1: Identified stakeholders

Commonwealth Government	
Australian Customs Service – Border Protection Command	National Offshore Petroleum Titles Administrator
Australian Hydrographic Service	Office of Federal Minister for Resources and Northern Australia
Australian Maritime Safety Authority (AMSA)	Office of Shadow Minister for Environment
Department of Industry, Innovation and Science	Office of Shadow Minister for Resources
National Offshore Petroleum Safety and Environmental Management Authority	Senator Pat Dodson
Department of Agriculture, Water and the Environment	Shadow Minister for Environment; Water
Office of Federal Minister for Environment	Parks Australia (a division of the DoEE)

Office of Federal Minister for Energy and Emissions Reduction	Department of Agriculture and Water Resources – Biosecurity
Australian Fisheries Management Authority	
State Government	
Australian Industry Participation Authority	Department of Health
Department of Primary Industries and Regional Development	Development WA
Department of Transport (DoT)	Environmental Protection Authority
Department of Water and Environmental Regulation (DWER)	Member for the Pilbara
Pilbara Ports Authority (PPA)	Office of State Minister for Mines and Petroleum
Department of Jobs, Tourism, Science and Innovation (DJTSI)	Office of the Leader of the Opposition, Public Sector Management, State Development, Jobs and Trade and Federal-State Relations
Department of Biodiversity, Conservation and Attractions (DBCA)	Office of the Minister for Fisheries
Department of Defence	Office of the Premier & Minister for State Development
Western Australian Museum (Maritime Archaeology Department)	Office of the State Minister for Environment
Department of Planning, Lands and Heritage	Office of the State Minister for Regional Development
Department of Primary Industries and Regional Development	Office of the State Minister for Transport, Planning and Lands
Upper House Member for Mining and Pastoral	Office of the State Treasurer, Minister for Finance, Energy and Aboriginal Affairs
Department of Mines, Industry Regulation and Safety	
Traditional Owner Groups, Local Government, Community, Educational Institutions and Environment Non-Government Organisations	
Ngarluma Yindjibarndi Foundation	Wong-Goo-Tt-Oo
Murujuga Aboriginal Corporation (MAC)	Yaburara and Coastal Mardudhunera Aboriginal Corporation
City of Karratha	Australian Conservation Foundation
Conservation Council of Western Australia	Wilderness Society
World Wildlife Foundation – Australia	World Wildlife Fund
International Fund for Animal Welfare	Friends of Australian Rock Art
Greenpeace	Market Forces
Australia Maritime and Fisheries Academy	Karratha Airport
Australian Conservation Foundation	Pilbara Development Commission
Karratha and Districts Chamber of Commerce and Industry	Karratha Visitors Centre
Karratha Community Liaison Group (includes Karratha Districts Chamber of Commerce and Industry, Dampier Community Association, Karratha Community Association, City of Karratha, Regional Development Australia, Pilbara Development Commission, PPA, Ngarluma Yindjibarndi Foundation Ltd and Yara Pilbara)	Karratha Heritage Group (includes Yaburara and Coastal Mardudhunera Aboriginal Corporation-/Wirrawandi Aboriginal Corporation, Wong-Goo-Tt-Oo People-, Ngarluma Aboriginal Corporation)
Tourism WA	
Industry	

Australian Petroleum Production and Exploration Association	Chamber of Minerals and Energy of Western Australia
Australian Marine Oil Spill Centre	Oil and gas operators, near neighbours and titleholders
Pilbara Ports Authority	Dampier Technical Advisory and Consultative Committee (TACC)
Fisheries	
Commonwealth Fisheries Association (CFA)	Pearl Producers Association
Relevant Commonwealth commercial fisheries	Relevant State commercial fisheries
Recfishwest	Australian Southern Bluefin Tuna Association
Tourism operators	Western Australia Fishing Industries Council
Charter boat operators and recreational fishers	

2.3 Consultation approach

Woodside is performing a phased program of consultation for the DSDMP:

- **Phase 1:** Preliminary consultation which occurred during the impact assessment process and preparation of the primary approvals.
- **Phase 2:** Formal consultation (including four weeks of public review) during preparation of the draft DSDMP. Consultation with MAC during the preparation of the DSDMP as per condition 6-2 of Ministerial Statement No. 1172 (Section 2.3.2.1).
- **Phase 3:** Ongoing consultation after acceptance of the DSDMP.

2.3.1 Phase 1: Preliminary consultation

Preliminary consultation was focused on a number of stakeholders and aimed to:

- introduce those stakeholders to the DSDMP and provide project timeframes and the mechanisms by which they can receive further updates or provide additional comment
- inform stakeholders of the work being performed under the DSDMP to assess impacts
- provide stakeholders with the opportunity to comment and allow for identification of further potential mitigation and management measures
- Engage Traditional Custodians who are potentially directly impacted by the DSDMP including about heritage matters, including submerged rock art, as consistent with discussions with the EPA
- obtain broader community input
- review feedback and incorporate into project activities and update controls where relevant and appropriate
- provide a point of contact or other information source for the project.

Preliminary consultation commenced in early 2018, building on the broader consultation and engagement process that Woodside has in place for existing operations in the region.

Phase 1 consultation activities included:

- A dedicated project website – https://www.woodside.com/what-we-do/australian-growth-projects/scarborough – was developed, which includes a detailed video explaining key characteristics of the Scarborough Project, information regarding the approvals, information sheets and point of contact.

- the Scarborough Project information sheets were developed, hosted on the Scarborough Project website, and provided directly to stakeholders via email or in person, including dedicated information sheets about:
    - pipelay and dredging management
    - oil spill management and response.
- An animation was developed that illustrated dredging and environmental management for the Scarborough Project, available on the dedicated project website.
- Five public information sessions were hosted in Karratha and Roebourne on 15 and 16 May 2019, providing opportunities for local community members to engage with the project team, learn more about the Scarborough and Pluto Train 2 Projects and provide feedback. Of the 50 attendees, two comments were received about environmental approvals, which were addressed during the relevant session. Public information sessions were advertised through the local community newspaper the ‘Pilbara News’, social media, community noticeboards and targeted communications.
- A submerged heritage assessment and ethnographic consultation were completed.
- Information was provided to stakeholders, including details of the Scarborough Project and key milestones, including approval submissions.
- Project updates were provided on the project website and Woodside’s social media channels, including key project updates provided by Australian Securities Exchange Announcements, Media Releases, quarterly, half yearly and annual reporting as appropriate and required.
- Stakeholders continue to be engaged through existing community forums. This includes engagement with Traditional Owners, including quarterly Community Liaison Group and Heritage meetings, supplemented by direct engagement.

The Phase 1 consultation activities performed are summarised in Appendix A.1.

2.3.2 Phase 2: Dredging and Spoil Disposal Management Plan consultation

The State waters component of the Scarborough Project was referred to WA EPA for assessment *(Assessment no. 2194)*. The level of assessment was set at ‘referral information and additional information (public review required)’. This includes providing additional information, including this DSDMP and details of consultation with Traditional Custodians about heritage matters, including submerged rock art. The public review period for the DSDMP was four weeks, as determined by DWER.

The assessment included publishing the DSDMP on the WA EPA website and having a period of public consultation, which gives the public at large, an opportunity to review and provide comment.

After the public review of the DSDMP, EPA concluded the Proposal may be implemented subject to conditions of Ministerial Statement No. 1172, including condition 6-2, which requires finalisation and submission of the DSDMP in consultation with MAC.

Phase 2 engagement continued after the public review of the DSDMP. Engagement has been targeted to:

- continue providing information on the project and providing details and key milestones (including approval submissions)
- inform stakeholders of the work being performed to obtain feedback on impacts
- continue to engage Traditional Custodians including about heritage matters, including submerged heritage

- provide an opportunity to receive comment on our baseline assumptions and allow for further identification of potential mitigation and management measures
- obtain broader community input
- continue to provide information on the project timeframes and the mechanisms by which further updates or additional comments can be made
- review feedback and incorporate it into project activities and controls where relevant and appropriate
- continue to provide a point of contact for feedback on the project.

Woodside has continued to consult broadly through existing community forums, including with traditional custodians via quarterly Community Liaison Group and Heritage meetings, supplemented by direct engagement and further opportunities for public information sessions in Karratha and Roebourne. The Phase 2 consultation to date is summarised in Appendix A.2.

2.3.2.1 Murujuga Aboriginal Corporation consultation program

Murujuga Aboriginal Corporation (MAC) is the approved body corporate established under the Burrup and Maitland Industrial Estates Agreement, which establishes the Burrup Industrial Estate over the land on which the Pluto LNG onshore facility is located which is relevant to the DSDMP. MAC represents the Ngarda Ngarli—Traditional Custodians of Murujuga made up of Mardudhunera, Ngarluma, Wong-Goo-Tt-Oo, Yaburara and Yindjibarndi people.

Woodside has consulted extensively with MAC as a representative of Murujuga's Traditional Custodians on the DSDMP. A summary of key engagements with MAC is included in Appendix A.3.

Briefings on the Scarborough Project, including matters the subject of this DSDMP have been provided to MAC since June 2018 as part of the Phase 1 consultations. MAC was engaged in July 2019 and invited to comment on a draft DSDMP, and Woodside provided a briefing on that draft in September 2019. MAC's comments were provided to the EPA on 7 September 2019.

During Phase 2 of consultation, Woodside provided MAC with funding to engage an independent consultant to assist including in relation to the DSDMP and, for the second half of 2020, employ a staff member to ensure MAC was properly resourced to represent Traditional Custodians views on the DSDMP and other matters.

An initial meeting to discuss MAC's comments on the DSDMP was held on 15 October 2019. Woodside and MAC exchanged detailed comments and responses on the DSDMP in late 2019 and early 2020, and on 30 March 2020 MAC provided an itemised list of issues for consultation on the DSDMP. A total of 12 meetings (which were predominantly conducted over a full day) addressing MAC's comments on the DSDMP were held as part of an agreed consultation program between 15 October 2019 and 3 June 2022, supplemented by further exchange of written information and engagements with MAC's board, executive team and Circle of Elders.

The objectives of the consultation program were to:

- align Woodside and MAC on an agreed approach to consultation
- provide for an agreed consultation program that allowed for timely, pragmatic and transparent resolution of issues
- finalise the DSDMP in consultation with MAC as specified in condition 6—2 to meet the outcomes of condition 6-1 of Ministerial Statement 1172.

MAC has commented on Revision 0, 1 and 2 of the DSDMP, and Woodside has provided a written response and made updates to the DSDMP to reflect MAC comments where appropriate. Revision 3 of the DSDMP incorporated the updates along with others agreed during the consultation process and was provided to MAC on 22 April 2022. Revision 3 of the DSDMP was then presented to members of MAC's board and Circle of Elders at a meeting on 3 June 2022. Key changes to the DSDMP through consultation with MAC are set out in Table 2-2.

Mechanisms for notifying MAC regarding exceedances of management triggers and other notifications are detailed in Section 12.5.2.1 and 12.5.2.2.

Table 2-2 Key changes/additions to the DSDMP during MAC consultation

Aspect	Description of key changes/additions	Reference
Activity	Removal of the inshore borrow ground as an option for sourcing of sand for trunkline backfill. This was to further minimise the potential risk of elevated suspended sediment concentrations to Conzinc Island and Conzinc Bay.	N/A
	Commitment to restrict the use of Spoil Ground A/B to the split hopper barges only, which support the backhoe dredging operations predominantly operating in inshore areas. The exclusion of the trailing suction hopper dredge from disposing material in spoil ground A/B will reduce the overall volume and associated quantity of fines available for dispersion and resuspension in the area. This was to further minimise the potential risk of elevated suspended sediment concentrations to Conzinc Island and Conzinc Bay.	Table 7-3
	Pipelay anchoring plan to minimise potential impact to calcarenite ridges	Table 8-1
	Inclusion of Shallow Water Lay Barge nearshore anchoring exclusion zones	Figure 3-4
Environment	Inclusion of MAC reported cultural values of the marine environment of Mermaid Sound and assessment in context of the activity	Section 4.5.6
	Review of a suite of additional sediment sampling and analysis results in the vicinity of the activities to support existing sampling and analysis plan conclusions.	Section 4.2.2
Modelling	External peer review of dredge plume modelling and assessment of conservatism and appropriateness of the modelling for environmental impact assessment. This included modelling inputs, processes, outcomes and interpretation, to provide further confidence in the predictions.	Section 5.2
Social Surroundings	New section added to demonstrate how MAC reported cultural values of the marine environment are addressed and considered in the DSDMP. This includes a value mapping exercise that identifies any plausible pressure: response pathways linking the proposed activity to the identified marine environmental values that are of cultural importance, set out in MAC (2021) and if so to determine the adequacy of the current DSDMP in terms of protecting that value.	Section 10
Monitoring	New section that provides a rationale for the selection of monitoring sites, including those on recommendation by MAC, as well as how the sites collectively are protective of the marine environmental values of cultural importance identified by MAC (2021).	Section 11.1.1
	Inclusion of dredge plume assessment for trenching and spoil disposal to: determine the distance from the TSHD at which turbidity associated with the trenching and spoil disposal operations returns to background levels; to validate the dredge plume modelling related to TSHD sediment losses; and, to collect supplementary data to provide confidence that there are no contaminants of concern being mobilised by the activity based on the highest risk area as an indicator.	Section 11.4.1
	Inclusion of remote sensing image capture and sharing on Project website.	Section 11.4.2
Reporting	Suite of MAC notification and reporting requirements, including periodic meetings and briefings.	Section 12.5.2.2
Appendices	Multiple revisions of the threshold technical note to include additional detail on background data used.	Appendix G
	Inclusion of the Sediment Sampling and Analysis Plan Implementation Report	Appendix B

2.3.3 Phase 3: Ongoing consultation

On acceptance of the DSDMP, Woodside will continue to consult with stakeholders during the execution phase.

Proposed engagement and consultation will be planned for in a Stakeholder Engagement Plan, and outcomes will be tracked and recorded by Woodside. Stakeholder engagement may include:

- newspaper and radio advertisements
- Notice to Mariners notifications
- MAC briefings and consultations (frequency and format is subject to agreement with MAC)
- Stakeholder Reference Group and Quarterly Heritage meetings
- presentations to the Dampier TACC
- posters and signage at wharves or launching zones
- information available on a project website.

Mechanisms for notifying the public regarding impacts to recreational values and exceedances of management triggers are detailed in Section 12.5.2.1.

3 Description of the activity

3.1 Overview

3.1.1 Summary of work scope

The scope of this DSDMP includes:

- Seabed intervention
    - Trailing suction hopper dredge (TSHD) trenching along the trunkline route with material disposal at existing Spoil Ground 2B and Spoil Ground 5A (in Commonwealth waters)
    - Backhoe dredge (BHD) trenching along the trunkline route with sediment placed in support split hopper barges (SHB) for disposal in Spoil Ground A/B (restricted to BHD activities) and Spoil Ground 2B
    - Sand backfill along the trunkline by TSHD, with suitable material sourced from a borrow ground in Commonwealth waters
    - Rock placement along the trunkline for pipeline protection/stabilisation
    - Trunkline pre- and post-lay span rectification
    - Contingent seabed intervention activities including maintenance dredging/excavation of resettled material in the trench prior to pipelay, post lay dredging, grout bags and rock placement
    - Hydrographic/bathymetric surveys
- Trunkline installation anchoring activities
- Shore crossing activities:
    - Construction of a temporary rock platform/groyne on the shoreline between the pre-excavated trench and the Pluto LNG Jetty
    - Pre-lay marine excavation activities including trenching comprising armour rock removal from historically formed trench, and installation of a bedding layer in the trench
    - Post-lay rock installation & re-instatement including rock installation with filter and armour material and site re-instatement.

Note, activities undertaken in Commonwealth waters, including borrow ground dredging, are outside the scope of this DSDMP, although have been included in this plan for information only, and to provide context for the broader dredging, spoil disposal and trunkline protection / stabilisation activities.

3.1.2 Indicative volumes

Figure 3-1 presents an overview of the trunkline dredging, protection and stabilisation activities, with the estimated maximum and likely dredging volumes for the project shown in Table 3-1. The estimated maximum volumes reflect those presented in the referral documentation, while the estimated likely volumes have been refined during the design process and are the basis of the dredge plume modelling presented in Section 5. Trunkline dredging, protection and stabilisation and anchoring design will continue to be refined (with volumes likely to be further reduced) to provide an optimum solution in terms of environmental impact, safety, cost and schedule.

These works are planned to be completed over a period of around 18 months, although it is important to note that these activities will not be occurring at all times during this period (refer to Section 3.1.3).

Table 3-1: Estimated maximum and likely volumes

Activity	Estimated maximum volumes [2] (as per referral documentation)	Estimated likely volumes (rounded from plume modelling)
State waters trenching	1,612,600 m³	1,125,000 m³
Commonwealth waters trenching[3]	1,169,100 m³	740,000 m³
Total trenching	2,781,700 m³	1,865,000 m³
State waters sand backfill	1,982,100 m³	1,180,000 m³
Commonwealth waters backfill[2]	1,488,000 m³	800,000 m³
Total backfill[4]	3,470,000 m³	1,980,000 m³
Rock dump volume	238,600 m³	73,500 m³
Rock dump tonnage	429,400 T	132,000 T

*Commonwealth volumes provided for information only

3.1.3 Indicative schedule

Dredging and trunkline installation activities are expected to start in Q1 2023 and are estimated to be completed in around 18 months, subject to relevant approvals, weather conditions and other factors. Table 3-2 provides a breakdown of the estimated duration of the main construction activities. The schedule is subject to change. As such, both a winter and summer start date have been considered in the dredge plume modelling (Section 5). Some construction activities would be performed concurrently.

Once commissioned, the trunkline is expected to operate for around 25 years.

Table 3-2: Estimated timeframe for key State waters construction activities (base case)

Activity	Earliest start of activity	Estimated duration
Pre, during and post lay surveys	Q1 2023	Intermittent as required, over 24 months
Shore crossing activities (pre and post)	Q2 2023	Nine months (intermittent)
Pre-lay trenching and spoil disposal	Q2 2023	Three months
Trunkline installation, including shore pull	Q3 2023	Three months
Post lay backfill	Q3 2023	Three months
Rock placement	Q3 2023	Four months

Note: Durations are indicative and subject to operational conditions and delays.

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[2] All trenching volumes are based on ‘in situ’ measurement (confirmed by hydrographic survey techniques). All backfill volumes are based on ‘in-hopper’ measurements (confirmed by vessel with onboard measurements). Rock dump tonnage is based on a conversion of 1.8 ton/m^3 bulk density.

[3] All activities in Commonwealth Waters have been assessed separately as part of an OPP by NOPSEMA and relevant secondary approvals.

[4] If sediments dredged from the borrow grounds are tested as not suitable for backfill they may be disposed of at an existing spoil ground. This would lead to an increase in borrow ground material used and dredge spoil placed.

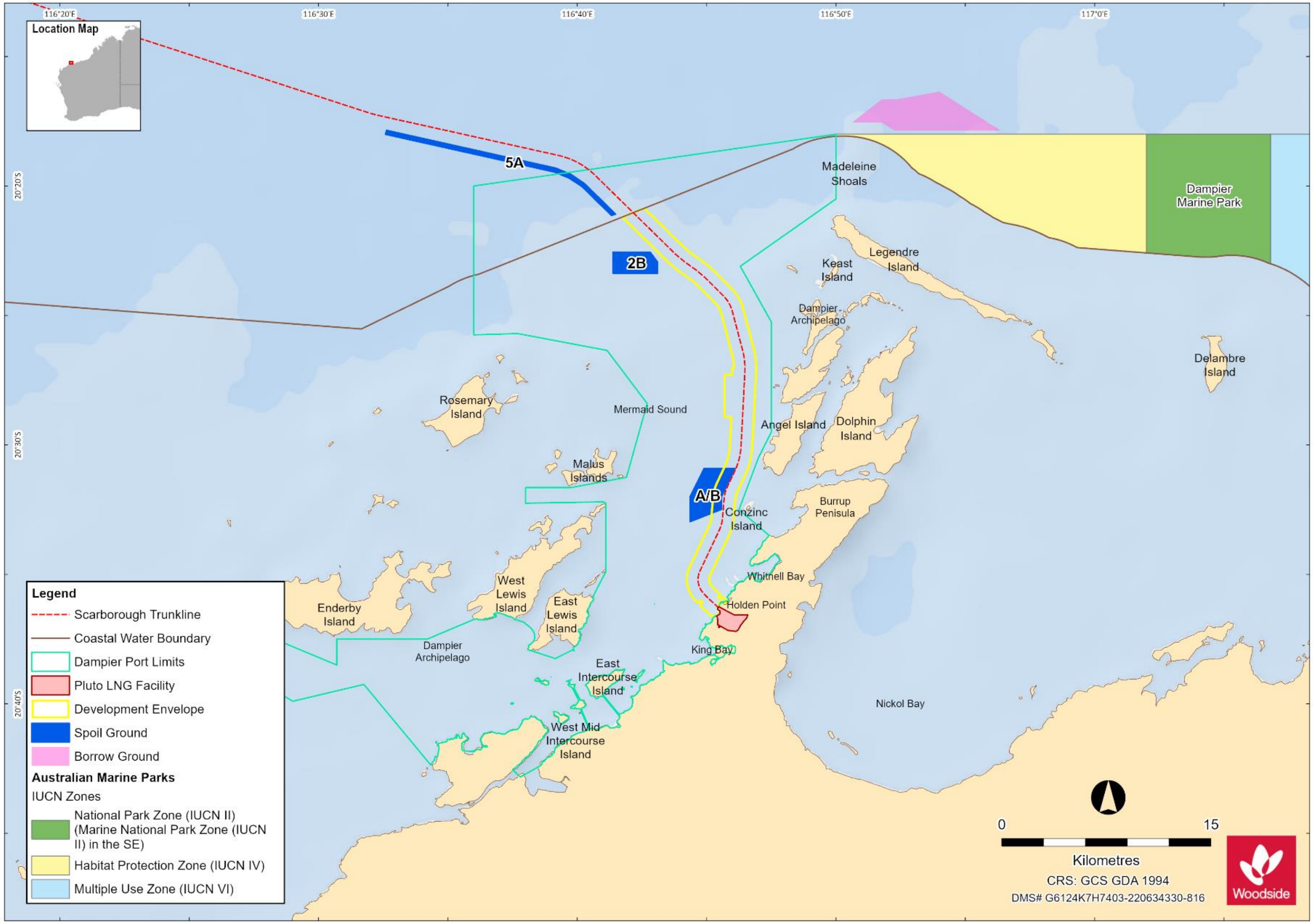

Figure 3-1: Scarborough Project development envelope (State waters component)

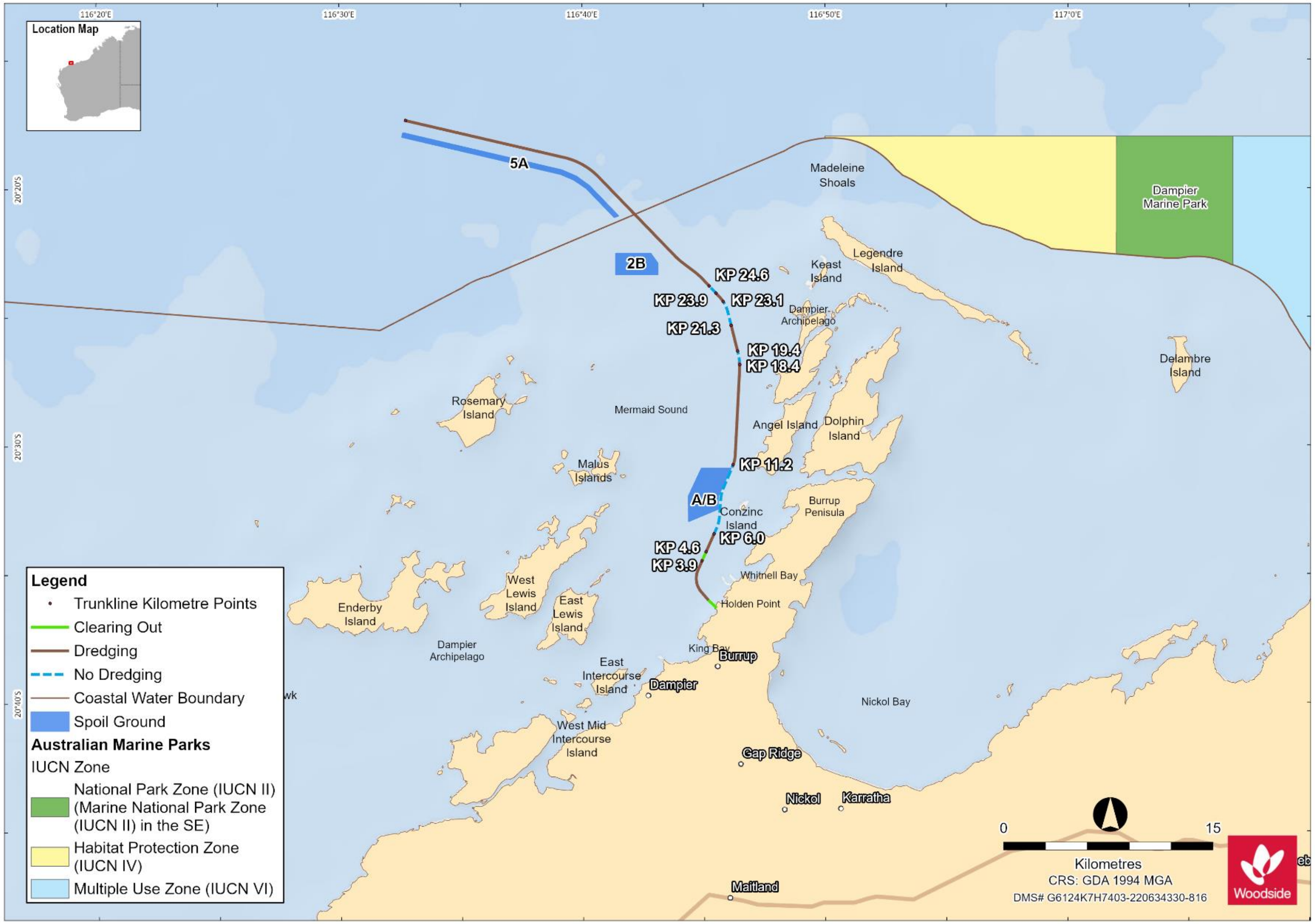

Figure 3-2: Breakdown of proposed dredging activities showing the indicative pipeline kilometre points and locations of the existing spoil grounds (AB, 2B and 5A) that will be used during disposal activities

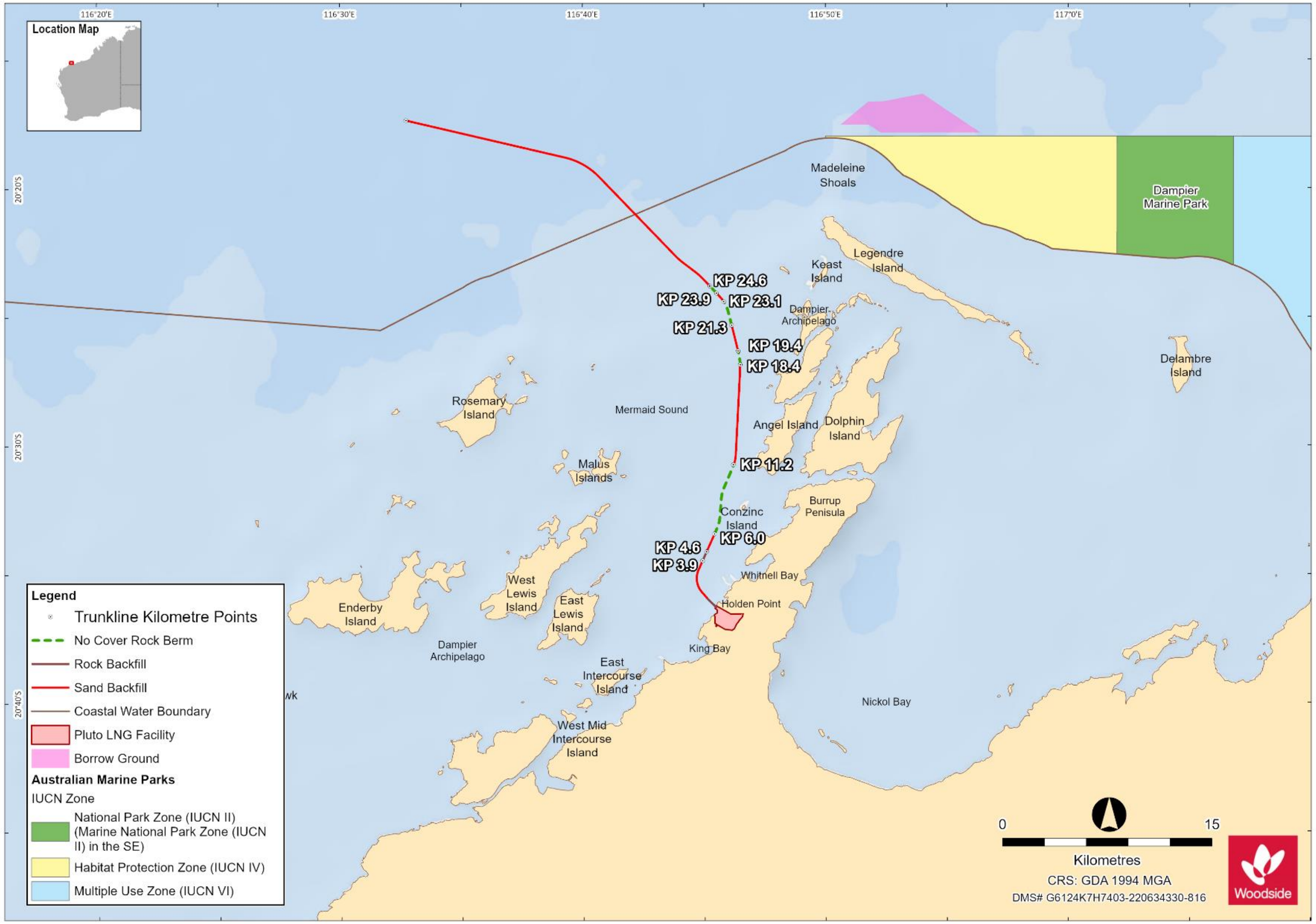

Figure 3-3: Breakdown of proposed backfill activities showing the indicative pipeline kilometre points, the backfill material type to be placed along each pipeline section, and the location of offshore borrow ground where sand backfill material is to be sourced

3.2 Surveys

Survey activities may be performed before commencing seabed intervention and trunkline installation, during scope execution and after the activity is complete. Surveys may collect data to gather information about bathymetry, debris and obstacles, pipeline and infrastructure spoil ground and borrow ground conditions and trunkline position. The survey activities are expected to be undertaken either from a dedicated survey vessel or from the construction vessels themselves (rock installation vessel (RIV) using its ROV for example).

The survey methods for the activities covered by this DSDMP typically include multibeam echosounders (MBES), which are non-intrusive and the equipment, under planned operation, will not disturb the seabed. Survey methods may also include side scan sonar (SSS), pipe trackers, magnetometer and sub bottom profiler (SBP)m as well as long baseline or ultra-short baseline for positioning. The survey methods used will be dependent on seabed soil conditions and required penetration and resolution. Some of the systems act as the transmitter and receiver; others have a separate transmitter and a short hydrophone streamer as a receiver. The majority of the survey activities will be along the proposed trunkline route, spoil grounds, and areas requested by the PPA where declared depths need to be maintained (I.e., the NWS Shelf and Pluto Shipping Channels).

MBES is typically used to perform hydrographic surveys prior to, during and post trenching, material disposal and offshore borrow ground dredging activities. The purpose of the surveys is to establish seabed levels of the dredging areas, monitoring progress during dredging, material disposal and backfill. -MBES, like other sonar systems, transmit sound energy and analyse the return signal (echo) from the seafloor or other objects. The sound waves are transmitted from a transducer mounted on the hull of the survey vessel to produce a fan-shaped coverage of the seafloor. The coverage area on the seafloor depends on the equipment used, the settings of the equipment and the depth of the water.

SSS may be used along the trunkline route as part of the pre-clearance survey for the pipelay barge to support anchoring and any other locations within the operational area where seabed roughness needs to be determined. Pipe tracker may be used to aid in positioning the trunkline once installed and stabilised / trench backfilled. SBP may be used along the trunkline / route corridor to profile the shallow lithology and to confirm depth of burial post stabilisation / trench backfill, should it be required. While magnetometer is included as a contingency should it be required. Additional small-scale geotechnical surveys may be undertaken to support seabed preparation activities. Geotechnical surveys typically involve in-situ testing and piston/push sampling. Following sampling, all equipment is withdrawn from the seabed. A small hole (<0.1 m^2) will remain, which will eventually collapse and infill with the movement of surface sediments in ocean current.

3.3 Dredging work method

3.3.1 Overview

The selection of dredging equipment is influenced by many variables. This includes the volume to be dredged, cost and availability of equipment, dredging and spoil disposal site characteristics, environmental considerations related to the duration of the activity (in other words, directly correlated to the dredging production rate) and the levels of turbidity generated relative to background levels.

The equipment selection also influences the applicability and effectiveness of other (related) management practices (Netzband et al., 2009). Best environmental practice for dredging, spoil disposal and backfill has been implemented throughout the design and planning phase of the project (for example, by reducing overall volumes) and will continue to be implemented throughout the works.

The selection process has ensured the best and latest dredging technologies will be used during the project. These technologies include:

- accurate online positioning and production monitoring technology to improve operational efficiency

- best suited dredging equipment (further described in Section 3.3.2.3)
- application of environmental related controls; for example, turbidity control devices such as ‘green’ valves, and turtle deflection devices.

The dredging activities are summarised in Table 3-3.

Table 3-3: Indicative Trunkline seabed intervention activities[5]

Section	Vessel types – pre-lay works	Vessel types – post -lay works	Disposal Location
Kilometre point (KP)0 to KP0.1	Excavation: BHD; land based long reach excavator	Land based long reach excavator (rock backfill)	Onshore
KP0.072 to KP0.8	BHD and SHB, TSHD	Rock backfill using a BHD and flat top barge (FTB) or RIV to cover over the top of the pipe	BHD to A/B TSHD to 2B
KP0.8 to KP3.9	BHD and SHB, TSHD	Rock backfill using a BHD and FTB Sand backfill using a TSHD to cover over the top of the pipe	BHD to A/B TSHD to 2B
KP3.9 to KP4.6	TSHD, BHD and SHB	Rock backfill using BHD and FTB or RIV to cover over the top of the pipe	BHD to A/B TSHD to 2B
KP4.6 to KP6.0	BHD and SHB, TSHD	Sand backfill using a TSHD to cover over the top of the pipe	BHD to A/B TSHD to 2B
KP6.0 to KP11.2	No dredging Span rectification using BHD and FTB or RIV	Rock berm to stabilise the trunkline using BHD and FTB or RIV	No disposal
KP11.2 to KP18.4	TSHD	Sand backfill using a TSHD to cover over the top of the pipe	2B/5A
KP18.4 to KP19.4	No dredging Span rectification using BHD and FTB or RIV	Rock berm to stabilise the trunkline using BHD and FTB or RIV	No disposal
KP19.4 to KP21.3	TSHD	Sand backfill using a TSHD to cover over the top of the pipe	2B/5A
KP21.3 to KP23.1	No dredging Span rectification using BHD and FTB or RIV	Rock berm to stabilise the trunkline using BHD and FTB or RIV	No disposal
KP23.1 to KP23.9	TSHD	Sand backfill using a TSHD to cover over the top of the pipe	2B/5A
KP23.9 to KP24.6	No dredging Span rectification using BHD and FTB or RIV	Rock berm to stabilise the trunkline using BHD and FTB or RIV	No disposal
KP24.6 to KP32.0	TSHD	Sand backfill using a TSHD to cover over the top of the pipe	2B/5A
KP32.0 to KP38.2	TSHD	Sand backfill using a TSHD to cover over the top of the pipe	5A
KP38.2 to KP50.3*	TSHD	Sand backfill using a TSHD to cover over the top of the pipe	5A

*Contingency only

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[5] These activities are subject to refinement during design and execution. Bed levelling may also be used through-out the program to reach the desired sediment profiles.

3.3.2 Trunkline trenching

The pre-lay works associated with installing the export trunkline involve dredging a 2 m to 4.3 m deep trench along the export trunkline route. The trenching activities are proposed to be performed by a combination of a BHD supported by SHBs and TSHD, as described in Section 3.3.2.1 and Section 3.3.2.2 respectively. Details of the proposed works and locations are provided in Table 3-3.

Note, some of the dredging has already occurred under pre-investment work when installing the Pluto trunkline. Hard rock sections of the proposed trunkline route were previously dredged with a cutter suction dredge as part of the Pluto LNG Foundation project. No nearshore blasting or cutter suction dredge works are required as part of this project. However, it is likely some cleanout of the pre-existing trench section may be required, including removing rock and backfilled materials.

Various support vessels would be used throughout the project for vessel transfers, positioning, construction support, hydrographic surveys and supply replenishment.

3.3.2.1 Backhoe dredge and associated split hopper barges

A BHD is a hydraulic excavator installed on a pontoon with a spud system to control the positioning and stability of the equipment. It uses a bucket mounted on an arm that is hydraulically operated. The BHD is mainly used for dredging in shallow or confined waters. It is especially suitable for working in narrow areas and in the near presence of obstacles, such as jetties, quay walls and pipelines. The BHD will manoeuvre itself using three spud legs. The BHD will be positioned using its spud and can manoeuvre to the required dredging location using its excavator arm or with support tugs (for longer distances).

The BHD will place the dredged material into independent hopper barges. The proposed SHBs will be self-propelled, towed or pushed by tugs. The SHBs will be positioned alongside the BHD under its own propulsion (if self-propelled) or using a tug. Once safely secured, the SHB is loaded by the BHD. Once fully loaded, the SHB will sail to the designated disposal area and discharge its load, opening the hopper by splitting the hopper well or opening the bottom doors, depending on the type of SHB. To ensure a continuous dredging process, at least two SHBs will be employed.

3.3.2.2 Trailing suction hopper dredge

TSHDs are self-propelled vessels with a hopper. They are hydraulic dredges typically used for dredging sand, silts and soft clays via a draghead and suction pipe. Dredged material is then subsequently stored in its cargo hold (the hopper) for transport and disposal afield (Foster et al., 2010).

TSHDs are generally equipped with one or two suction pipes connected to the vessel. A draghead is fitted at the end of the suction pipe. Upon arrival at the dredging area, the TSHD will lower its trailing pipe and attached draghead to the seabed. The vessel will sail slowly forward (typically one to two knots) while dragging the draghead along the seabed. A jet system is typically used to fluidise the coarser material and the draghead teeth provide some cutting and loosening influence. The dredge pumps hydraulically lift the mixture of solids and water up the suction pipe and into the hopper.

The loading of the TSHD will be optimised using overflow. Overflow is the release of predominantly water with some fine sediment, used to maximise the quantity of sediment within the hopper and, as such, dredged material loaded. Overflowing generally starts once the sediment mixture reaches the top of the overflow weir in the hopper. It would typically continue until the hopper is loaded to the dredging mark. Overflow is generally discharged at the keel level rather than above water, to reduce turbidity and dispersal of fine sediments (Netzband et al., 2009).

The overflow funnel/s of the TSHD will be fitted with 'green valves'. These valves restrict the entrainment of air into the overflow mixture, thereby minimising fines dispersal and associated turbidity. Further, the overflow material sinks more rapidly due to density effects, allowing better settlement of overflow material. The green valve is considered most effective when a relatively large portion of fines is within the dredged mixture (Netzband et al., 2009). Optimisation of the overflow process will be an ongoing process throughout the TSHD dredging activities. As the project proceeds, the data available from the monitoring programmes will also be considered in the overflow optimisation process.

Once loaded, the TSHD would sail to the nominated spoil ground and the hopper doors opened to release the sediment within the area.

3.3.2.3 Equipment selection rationale

Equipment selection considered economic, technical feasibility, safety and environmental aspects, with the key drivers for the selection as follows:

- The BHD proposed for the project is specifically designed to operate with large-capacity buckets, enabling high outputs in a large range of materials. This type of equipment has the advantage that the in situ composition of the material is largely kept intact during dredging, resulting in a limited amount of fines being generated during the dredging process. Washout from the bucket during lifting of the bucket through the water column, however, can result in localised elevations of suspended sediments.
- The use of a closed (clamshell) grab has not been further considered due to the size limitations of these types of buckets, which result in moderate to low production rates that would extend the duration of the dredging program. Closed clamshell grabs also have limited application in rocky sediments around the shore crossing area, which may impede the grab from closing and result in higher sediment losses.
- The BHD placing dredged material directly into SHB results in no further rehandling before disposal, which significantly reduces the generated turbidity.
- BHDs generally have lower rates of production compared with TSHDs so will typically lead to increased duration of activities. They are capable of working in very shallow water close to infrastructure, particularly as is the case near the shore crossing. They are, however, limited with regard to workability as sea state increases, being more suited to sheltered environments, unlike TSHDs which are seagoing vessels.
- TSHDs (hydraulic dredges) typically have higher production rates than BHD (mechanical dredges). As a result, the duration of the dredging campaign is likely to be reduced when using a TSHD, which thereby minimises associated effects to environmental, social and cultural values (Netzband et al., 2009).
- Using a large TSHD to transport the material to the disposal site minimises the duration of the works, therefore minimising the temporal extent of the potential impacts related to marine fauna, water quality, light and noise. It also minimises transits to and from the spoil ground and borrow grounds, reducing potential for marine fauna interactions and turbidity associated with propeller wash.
- TSHDs are self-propelled dredges that load sediment directly in their hoppers. Using TSHDs where possible means no other support barges are required for transport. Hence, there is less shipping traffic. It also reduces interference with other shipping operations, recreational users and other users within the Port, as well as a reduction in navigational and safety risks.
- TSHDs activities by virtue of the method (loading and transport) are intermittent, thereby reducing the overall intensity of dredging and spoil-disposal-induced turbidity plumes.
- The geotechnical conditions along the proposed Scarborough Project trunkline route are anticipated to be largely similar to those of the existing Pluto trunkline, given proximity (located between 10 m and 200 m away). The material encountered while dredging the trenches during the Pluto LNG Foundation project was predominantly marine sediments, clays and low strength calcarenite. The dredging and spoil disposal program associated

with the Pluto LNG Foundation project did not result in any indirect mortality to benthic communities using the selected equipment (Mscience 2010).

3.3.2.4 Engineering considerations

The selected management practices are listed in Section 7.4.3. Physical environmental controls such as silt curtains were considered; however, due to the metocean conditions (tidal range, currents and waves) in Mermaid Sound, silt curtains are not feasible and would not contribute to decreased suspended sediment regimes. Further there would be operational constraints given the activity is occurring in an active Port with high shipping traffic. Silt curtains are only effective in certain environmental conditions and dredging work methods (Rachemacher et al., 2013), including:

- small flow velocities (< 0.3 m/s) to ensure the screen stays vertical in the water column and the suspended sediments settle towards the seabed
- uniform flow direction perpendicular to the silt screen in combination with other sheltering structures, such as a breakwater or quay wall
- mild wave and current conditions to prevent damage to the silt screen (high waves and high currents may result in increased durations of elevated turbidity, due to additional mixing induced by turbulence around the silt screen)
- single suspended sediment source
- sufficient depth of silt curtain compared to water depth
- when used in an enclosed configuration around the sediment source to prevent horizontal flow diversion around the silt screen.

In addition, application of silt screens is not technically and practically feasible since multiple dredge operations are occurring in open seas, instead of enclosed areas and by non-stationary vessels, which would require constant relocation of silt screens.

As described in Section 7.4, the dredging, spoil disposal and backfill activities will be managed through the tiered monitoring and management framework (TMMF) informed by water quality, which aims to manage the operations and associated water quality to a level where impacts are not predicted to occur to BCH. This is achieved by ensuring water quality does not exceed the Zone of Moderate Impact thresholds at the receptor based monitoring sites. As such, the environmental benefit of additional mitigative physical controls, coupled with the impracticalities of maintaining silt curtains in open ocean conditions, although considered, is considered disproportionate. Adaptive management of dredge operations through the TMMF is therefore more effective.

3.3.3 Dredge spoil disposal

3.3.3.1 Disposal method and rationale

Dredged material will be disposed at existing spoil grounds within the region (Table 3-4). The placement of spoil within the approved spoil grounds is subject to consultation with relevant stakeholders (PPA and the Port of Dampier Technical Advisory Consultative Committee). A Sea Dumping Permit (SDP2019/3982) has been granted for the disposal of Scarborough Project dredge volumes at existing Spoil Grounds A/B, 2B and 5A.

Direct placement involves releasing sediment from the TSHD or barge by opening the bottom doors or by the SHB ‘splitting’. The sediment is released into the upper part of the water column, from where it rapidly descends as a density current towards the bottom, subsequently settling and depositing on the seafloor of the designated spoil disposal site. The optimal sediment placement method was selected based on environmental, operational and safety considerations. Alternative disposal methods, such as hydraulic placement of materials into the disposal area, have been discarded on the basis that these types of disposal methods would cause further break-up of dredged materials.

Hydraulic placement of materials using a diffuser or tremie pipe would not be advantageous in comparison with conventional bottom placement, as it would require mixing the material with additional water to pump it, resulting in a lower density when disposed and therefore a potential higher resuspension factor. Further, it would require a barge or pontoon to be located at the disposal site from which the equipment would be operated. Given the offshore location and high-energy hydrodynamic conditions, anchoring and use of such equipment would impose unnecessary safety and operational risk. Further, conventional direct placement of material within these spoil grounds have been used routinely with no indirect impacts to BCH. Noting the dredging and spoil disposal program associated with the Pluto LNG Foundation project did not result in any indirect mortality to benthic communities using the selected equipment (Mscience 2010).

Table 3-4: Coordinates of proposed spoil grounds (datum WGS 84)

Spoil Ground	Latitude	Longitude
Spoil Ground A/B	20° 30.912’ S	116° 44.898’ E
	20° 30.912’ S	116° 46.104’ E
	20° 31.998’ S	116° 45.576’ E
	20° 31.998’ S	116° 44.358’ E
	20° 32.491’ S	116° 45.573’ E
	20° 32.963’ S	116° 44.368’ E
Spoil Ground 2B	20° 22.556’ S	116° 41.380’ E
	20° 22.558’ S	116° 42.817’ E
	20° 22.938’ S	116° 43.104’ E
	20° 23.372’ S	116° 43.103’ E
	20° 23.369’ S	116° 41.378’ E
Spoil Ground 5A	20° 18.006’ S	116° 32.584’ E
	20° 17.848’ S	116° 32.624’ E
	20° 19.306’ S	116° 39.158’ E
	20° 19.550’ S	116° 39.756’ E
	20° 19.913’ S	116° 40.286’ E
	20° 21.086’ S	116° 41.483’ E
	20° 21.142’ S	116° 41.321’ E
	20° 20.016’ S	116° 40.172’ E
	20° 19.691’ S	116° 39.669’ E
	20° 19.464’ S	116° 39.118’ E

3.3.3.2 Spoil Ground A/B

Spoil Ground A/B was initially established in 1986 by Woodside for disposing of dredged material from capital dredging activities. The spoil ground has subsequently been used for disposing of maintenance dredging material. The spoil ground has been used by Woodside, PPA and Rio Tinto. Most recently, Spoil Ground A/B has been used as part of two separate maintenance dredging campaigns:

1. Rio Tinto (Five-Year Sea Dumping Permit SD2016/3462) – 500,000 m³ of 1,225,000 m³ (total permitted volume over five years) placed within Spoil Ground A/B

2. Woodside (Sea Dumping Permit SD2016/3262) – 333,400 m³ of 400,000 m³ (total permitted volume) placed within Spoil Ground A/B.

The remaining capacity at Spoil Ground A/B is assumed to be 6.7 Mm³. Under its Long-Term Sea Dumping Permit SD2016/3462, Rio Tinto is permitted to place a further 725,000 m³ of material derived from its maintenance dredging, either wholly within or split between Spoil Grounds A/B and 2B. Additionally, PPA has applied to use the spoil ground to support its maintenance dredging activities. Even if all maintenance dredging material from PPA (450,000 m³) and Rio Tinto was placed in Spoil Ground A/B, there would still be ample remaining capacity to accommodate the entire dredged volume from the Scarborough Project.

Disposal operations will be limited to the disposal of sediments dredged using the BHD at Spoil Ground A/B. Sediments dredged using a backhoe dredger remain more consolidated than those dredged using a TSHD, which limits the quantity of fines mobilised into the water column during disposal.

3.3.3.3 Spoil Ground 2B

Spoil Ground 2B was developed for the capital dredging activities associated with Woodside's Pluto LNG Foundation project. The Pluto LNG Foundation project capital dredging program has been the sole user of Spoil Ground 2B to date. The current capacity of Spoil Ground 2B is 38.5 Mm³, calculated at an agreed ceiling height of -23.5 m chart datum.

Under its Long-Term Sea Dumping Permit SD2016/3462, Rio Tinto is permitted to place the remaining volume of maintenance dredging material (around 725,000 m³) either wholly within or split between Spoil Grounds A/B and 2B.

PPA has also applied to use the spoil ground to support its maintenance dredging activities. Even if all maintenance dredging material from PPA (450,000 m³) and Rio Tinto was placed in Spoil Ground 2B, there would still be capacity to accommodate the entire dredged volumes from the Scarborough Project.

3.3.3.4 Spoil Ground 5A

Spoil Ground 5A in Commonwealth waters was developed for the capital dredging activities associated with the Woodside Pluto LNG Foundation project and has capacity to accommodate dredge volumes from the Scarborough Project.

3.3.4 Borrow ground dredging and backfill

After installation of the trunkline, sand will be needed to help stabilise the export trunkline in some of the sections in shallower water. Stabilisation is anticipated to generally be required in water depths shallower than 40 m, which corresponds to a location about 50 km offshore from the Pluto LNG Plant. Rock may need to be used for stabilisation in some areas; however, sand is preferred due to its local availability, which reduces risk associated with bringing rock from onshore or oversea locations. Woodside considered a range of stabilisation options as presented in Section 3.7 of the accepted Scarborough Project OPP (Woodside, 2019).

The sand for stabilisation is proposed to be obtained from a borrow ground in Commonwealth waters. The location of the pre-identified borrow ground is shown in Figure 3-1. When selecting suitable borrow ground locations, consideration was given to the suitability of stabilisation material, proximity to the pipeline, and the environmental sensitivity of the offshore borrow ground and surrounding area. As described in Section 3.7 of the accepted Scarborough Project OPP, Woodside plans to use sand material sourced from offshore borrow ground, as this location contains substantial amounts of highly suitable material of a quality and quantity required for stabilisation activities for the Scarborough Project scope. A 250 m buffer will be maintained from the Dampier Marine Park (Woodside, 2019).

Consideration was given to potentially reusing materials from existing spoil grounds to negate the requirement to use a new borrow ground. However, this was discounted due to the geotechnical properties of the materials in existing spoil grounds not being suitable for pipeline stabilisation and the high fines content.

The sand would be dredged from the borrow ground using a TSHD, as described in Section 3.3.2.2. Overflow may be required to ensure the particle size distribution specifications for pipeline stabilisation are met.

When on location along the trunkline route, the TSHD will reverse pump the sand backfill material into the trench through a suction pipe, such that material is released close to the seabed. This trench backfill method was used successfully on both the Pluto LNG Foundation project and the Trunkline System Expansion project.

3.4 Rock placement work method

Figure 3-1 and Table 3-3 provide an overview of the trunkline dredging, protection and stabilisation activities, including those trunkline areas planned to be stabilised by rock materials.

Rock materials will be required to assist with trunkline stabilisation and protection. Rock placement will be required at the following locations:

- the shore crossing trench
- the Woodside channel crossing
- the beach ridges near the entrance of Mermaid Sound
- areas where pre-trenching is not cost-effective
- the nearshore area where the TSHD is unable to access shallow areas to place sand backfill (up to around KP 0.8).

Rock Installation from approximately KP 0.072 up to KP 0.550 will be executed with a BHD, positioned on spuds (supported by FTB). The maximum range of the BHD at mean high water springs (MHWS) will allow sufficient overlap with the shore crossing post lay rock placement works. The rock material will be provided to the BHD by a SHB or FTB, collecting the imported material.

In areas further offshore, rock placement will be performed by the BHD (supported by a FTB) or the RIV, the latter which may consist of a large side dump vessel or a combination of a large side dump vessel and a fall pipe vessel. If a fall pipe is used, rock will be transferred by conveyor belts from the hull to the hopper on deck, using a large excavator to feed the hopper. From the hopper, the rock travels through a feeder that controls the flow of rock into the fall pipe. The ROV at the end of the fall pipe is used to manoeuvre the fall pipe and accurately install the rock using survey and positioning equipment.

If a ‘dry’ pre-commissioning method is adopted for the trunkline , additional rock placement may be required to weigh the trunkline down during trench backfill as the trunkline would not be flooded. This may involve the placement of a thin layer of rock over the trunkline or spot placement at selected locations. Alternatively, increased concrete weight coating thickness may be used to achieve sufficient weighting of the trunkline.

Rock material would be obtained from domestic and/or international sources.

3.5 Span rectification

Pre-lay span rectification is expected at several locations within State waters where the trunkline is modelled to have spans in excess of the allowable span length (indicative locations in Table 3-3). The pre-lay span scope is a planned to be covered with a combination of methods depending on the specific requirements of the span location such as pre-lay rock berms, strategic placement of concrete mattresses (typically 6 or 8 m x 3 m) and/or grout bags (typically 200 kg to 2000 kg).

The BHD (support by FTB) or the RIV are proposed for the pre-lay rock berms. Concrete mattresses and/or grout bags are planned to be installed by a construction support vessel with the support of a work class ROV to ensure accurate placement and control of the operation. All the span areas will subsequently be covered with rock material as part of the post-lay rock placement campaign.

3.6 Other shore crossing construction activities

3.6.1 Shore crossing

Trenching of the shore crossing will comprise armour removal from the historically-formed trench from the intertidal area, up to the transition point between onshore and offshore trench construction as accessible from the mainland (around KP0.1), using dry excavation equipment. This rock may be used to reinstate the shore crossing rock berm after trunkline installation or may be disposed offsite. Some minor quantities of hard rock may be removed below previously crushed rock levels to achieve the required design profile. After the shore pull of the trunkline, various gradings of rock backfill will be installed to provide stabilisation and protection.

3.6.2 Temporary rock platform/groyne

A temporary platform/groyne around 30 m long may be constructed on the shoreline between the trunkline trench location and the Pluto LNG Jetty to allow excavating equipment to access and excavate the rock berm currently covering the pre-excavated trench in the nearshore zone.

The platform/groyne is to be constructed from existing rock material recovered from within the trunkline battery limits. The platform/groyne will be designed to include heavy armour (coarse / large rock material) to protect it during weather events. The height of the platform/groyne is such that onshore equipment is planned to be above the waterline at all times. It will be periodically maintained to ensure it remains in serviceable condition. Following trunkline installation and subsequent backfill of the trench, the groyne will be removed.

3.6.3 Bedding layer Installation

A bedding layer may be installed in the bottom of the trench at the shore crossing, before pipelay activities, to reduce the risks of encountering obstruction during the pipe pull operations. The bedding layer material may be provided to the BHD by the SHB or FTB collecting the material from a designated facility. The bedding layer material may also be provided to the long reach excavator by a front-end loader supported with a spread of dumper trucks collecting the imported material from the temporary storage area. Following the shore pull of the trunkline, various gradings of rock backfill will be installed to provide stabilisation and protection.

3.7 Trunkline installation and anchoring

The nearshore section of the trunkline will be installed by a shallow water lay barge (SWLB) where water depth is generally less than 30 m, which is the minimum depth for the dynamically positioned deepwater pipeline installation vessel (PV) installing the remainder of the trunkline. The SWLB constructs the trunkline by welding together nominal 12 m lengths of pipe in its firing line (a series of workstations where welders weld the pipes together) and laying them to the seabed over the ‘stinger’, which supports the trunkline as it transitions from the SWLB to the seabed. As the pipes are 12 m long, the SWLB moves forward 12 m at a time as each pipe joint is welded into the trunkline.

Anchoring will be required to position the SWLB in the nearshore area. The SWLB typically uses an eight- or ten-point anchor mooring spread for station-keeping as it lays the pipe along the trunkline route in State waters. The mooring system consists of a suitable anchor, with chain linked to the working length of high strength synthetic rope or steel wire. Note mooring design is still be conducted and this design will determine what anchors are used where and associated lines.

The SWLB is expected to travel around 300 to 350 m of the pipeline route on one mooring spread before the anchors are re-set to the next location. Anchor spreads may be required within a distance of 750 m from the trunkline centreline, resulting in a development envelope of 50 km², noting only a portion of the increased development envelope will be subject to seabed disturbance. The closest position of the SWLB to shore will be around 750 m from shore (anchors will extend inwards towards the shore) and the SWLB will need to moor for the full extent of its use (potentially up to the State waters boundary at around KP32).

During anchoring, the seabed will be disturbed by the vessel anchor mooring system, through the placement of anchors and chain/wire along the seabed and potential dragging during tensioning and recovery. Activities will predominantly occur in areas that were pre-disturbed during the previous installation campaign for the Pluto trunkline, which is located parallel to and in the vicinity of the proposed Scarborough Project trunkline route. Other pre-disturbed areas within the development envelope include spoil grounds and shipping channel. Anchoring activities will be managed to avoid disturbance of the significant BCH and nearshore area (on request by MAC) as indicated in Figure 3-4.

Anchor holding tests may be performed to ensure anchor requirements of the SWLB can be met. If an anchor is found to be dragging, the tension in the anchor wire will be released and remedial action in the form of redeployment and/or re-tensioning will be undertaken.

The SWLB will be assisted throughout pipelay operations by a spread comprising supporting vessels, specifically:

- two anchor handling tugs for mooring operations
- two shallow-water anchor handling tugs for mooring in shallow-water areas
- support vessel for monitoring of the touch down point of the pipeline
- two pipe supply vessels
- general supply vessel for the SWLB.

Once the pipelay has progressed to deeper waters (more than 30 m), the PV will install the trunkline (around KP31 and KP32.7, although subject to vary). Pipelay will commence with recovery of the trunkline laid by the SWLB at around KP31 in around 30 m water depth. The PV will maintain position during pipelaying operations using dynamic positioning.

Like the SWLB, the PV allows for welding together nominally 12 m lengths of pipe, each new section being welded to the previous section to form the trunkline. To operate at high productivity, the PV includes three firing lines. In two parallel firing lines three 12 m pipes are welded together to form 36 m long triple joints. These triple joints are then transferred into the main firing line where they are welded together to construct the trunkline. Upon completion of welding; inspections and repairs or amendments are carried out as required and field joint coating applied, before the pipe is laid over a “stinger” on the stern of the vessel, down to the seabed. A tensioning system, consisting of three tensioners, holds the trunkline in the PV and allows the trunkline to be laid at the desired rate while maintaining the required tension as each new pipe-section is welded into the trunkline and the vessel moves forward. The PV will be supported by a fleet of support and supply vessels.

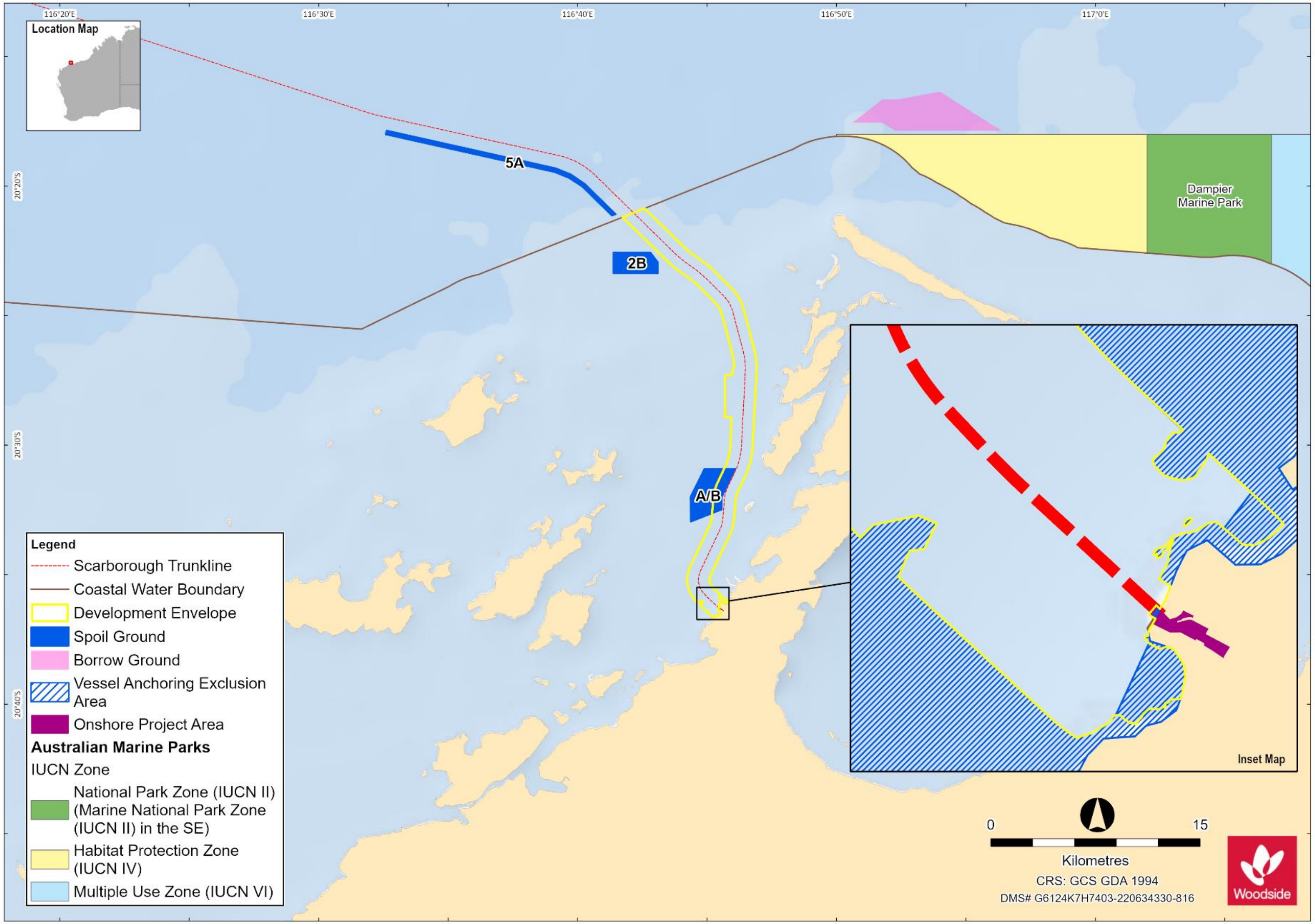


Figure 3-4 Trunkline installation anchoring exclusion zones

3.8 Contingent activities

3.8.1 Span Rectification

The trunkline route has been engineered to reduce the requirement for span rectification. Following installation of the trunkline, locations requiring span rectification may be identified. The options for possible span correction (pre and post lay) and scour mitigation include grout bags, rock installation, seabed levelling and excavation (e.g., dredging using TSHD, mass flow excavators and jetting).

3.8.2 Maintenance of Trenches

In case pre-lay trenches are silting up prior to pipelay (due to a storm/cyclone event, delays to pipelay or other causes) secondary dredging of settled material in trench may need to occur to reprofile the trench to design utilising the TSHD or BHD (in shallow sections), with the associated dredged material placed in Spoil Ground 2B (for TSHD activities) or Spoil Ground A/B (for BHD activities).

3.8.3 Jetting and Mass Flow Excavation

Jetting and/or mass flow excavation may be used during the trunkline installation for span rectification or to assist trunkline lay within the pre-constructed trenches. These activities would be performed from a construction vessel.

3.8.4 Pre-lay Removal of Obstructions

In the event the pre-lay survey of the trunkline route identifies any obstructions that may impact the trunkline installation, these obstructions will need to be removed. This will be performed by a construction vessel using ROVs and heave compensated crane.

3.8.5 Deburial

In case of faults (or suspected faults) found in the as-constructed trunkline in any section where the pipeline has been buried (after sand or rock placement), the burial material may need to be removed to allow inspection and possible repair of the suspect area. Methods considered for this work are typically mass flow excavation (MFE), jetting, grab systems or (partial) re-dredging with the TSHD. Sediment would be placed in the designated Spoil Ground 2B (in case of TSHD intervention) or remain close to the pipeline alignment (all other methods).

3.8.6 Remediation Work

Re-dredging or removing of misplaced sand backfill may be required in case spoil disposal occurred outside the spoil dump area or erroneous placement of rock material and it was decided in coordination with relevant stakeholders that additional intervention is the correct response. Remediation could take the form of application of an MFE attempting to move material away from the offending position, use of a grab system to relocate or re-dredging with the TSHD. A bed leveller / sweep barge may also be used to smooth high spots along the trench profile or within spoil grounds, and existing channels.

4 Description of the environment

4.1 Physical environment

4.1.1 Climate and meteorology

4.1.1.1 Seasonal patterns

The climate within the region is dry tropical, exhibiting a hot summer season from October to April and a milder winter season between May and September (Bureau of Meteorology (BoM), 2019a). There are often distinct transition periods between the summer and winter regimes, which are characterised by periods of relatively low winds (Pearce et al., 2003).

4.1.1.2 Temperature and rainfall

Air temperatures in the region, as measured onshore at the Karratha aerodrome, follow seasonal trends. At Karratha, maximum temperatures during summer reach an average of 36.2 ºC in March, falling to an average maximum of 26.3 ºC in July (BoM, 2019a). Average minimum temperatures range from 26.8 ºC in January to 13.8 ºC in July (BoM, 2019a). Similar temperatures have been recorded at North Rankin Complex. Maximum temperatures during summer reach an average of 40 ºC in January, falling to an average maximum of 26 ºC in July (BoM 2019a). Average minimum temperatures range from 22 ºC in December to 14 ºC in May (BoM 2019a). The region experiences a tropical monsoon climate, with distinct wet (October to April) and dry (May to September) seasons (Pearce et al., 2003). Rainfall in the region is typically at its highest during late summer (BoM, 2019a). This is often associated with passing tropical low pressure systems and cyclones (Pearce et al., 2003). Rainfall outside this period is typically low.

4.1.1.3 Wind

Winds typically vary seasonally, with a tendency for winds from the south westerly quadrant in summer and the south-easterly quadrant in winter. The summer south-westerly winds are driven by high pressure cells that pass from west to east over the Australian continent. The relative position of the high-pressure cells moves further north during winter months, leading to prevailing south-easterly winds blowing from the mainland (Pearce et al., 2003). Winds typically weaken and are more variable during the transitional period between the summer and winter regimes, typically in April and August. Coastal areas may also experience daytime sea breezes and night time land breezes, with wind speeds typically less than 10 m/s in summer and reaching 10 to 15 m/s, and occasionally peaking at 20 m/s further offshore in winter (Pearce et al., 2003).

4.1.1.4 Tropical cyclones

Cyclones are a relatively frequent event in the region, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast. Tropical cyclone activity can occur between November and April and is most frequent in the area during January to March, with an annual average of about one storm per month. Cyclones are less frequent in the area in the months of November, December and April. However, historically the highest category cyclones have occurred in April.

4.1.2 Oceanography

4.1.2.1 Currents and tides

The large-scale ocean circulation of the North West Shelf (NWS) is primarily influenced by the Indonesian Flowthrough Current (Meyers et al., 1995; Potemra et al., 2003) and the Leeuwin Current (Godfrey and Ridgway, 1985; Holloway and Nye, 1985; Batteen et al., 1992; James et al., 2004). Both currents are significant drivers of the region's ecosystems. The currents are driven by pressure differences between the equator and the higher density, cooler and more saline waters of the Southern Ocean. The currents are strongly influenced by seasonal change, and El Niño and La Niña episodes (DSEWPaC, 2012a). The Indonesian Flowthrough Current and Leeuwin Current are strongest during winter and late summer (Holloway and Nye, 1985; James et al., 2004). Flow reversals to the north-east associated with strong south-westerly winds are typically weak and short-lived but can generate upwelling of cold, deep water onto the shelf (Holloway and Nye, 1985; James et al., 2004; Condie et al., 2006).

The Leeuwin Current, which originates in the region, runs southward along the edge of the continental shelf. It is primarily a surface flow (up to 150 m deep) which is strongest during winter (Woodside, 2002). Triggered by metocean processes outside the region to the north, the Holloway Current develops in March flowing southward across the region, and acts as an extension to the Leeuwin Current (Figure 4-1). To the south, the Ningaloo Current flows in the opposite direction to the Leeuwin Current, running northward along the outside of Ningaloo Reef and across the inner shelf from September to mid-April (Figure 4-1).

In addition to the synoptic-scale current dynamics, tidally-driven currents are a significant component of water movement on the NWS. Wind-driven currents become dominant during the neap tide (Pearce et al., 2003). In summer, the stratified water column and large tides can generate internal waves over the upper slope of the NWS (Craig, 1988). As these waves pass the shelf break at about 125 m deep, the thermocline may rise and fall by up to 100 m in the water column (Holloway and Nye, 1985; Holloway, 1988). Internal waves on the NWS are confined to water depths between 70 and 1000 m. The dissipation energy from such waves can enhance mixing in the water column (Holloway et al., 2001).

Tides in the NWS region are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south-east and ebbing towards the north-west (Pearce et al., 2003). Tides within the Dampier Archipelago range up to 5.1 m, and tidal flow direction is influenced by the surrounding islands (Mills, 1985). The region exhibits a considerable range in tidal height, from microtidal ranges (less than 2 m) south-west of Barrow Island to macrotidal ranges (greater than 6 m) north of Broome (Holloway, 1983; Heyward et al., 2006; Brewer et al., 2007). Storm surges and cyclonic events can also significantly raise sea levels above predicted tidal heights (Pearce et al., 2003).

Currents in the Dampier Archipelago are driven by tides, local winds, large-scale ocean circulation, and are strongly influenced by the layout of the islands. On a spring tide, tidally-driven waters generally flow in a south-easterly direction and are channelled through the islands and along Mermaid Sound and Mermaid Strait, converging near the Intercourse Islands at the south of the archipelago (Pearce et al., 2003). During the ebb tide, flows are in the opposite direction at comparable speeds (Pearce et al., 2003).

Tidal current speeds are strongest at the offshore entrances of the Dampier Archipelago and between some of the islands, reaching 0.4 to 0.5 m/s at the seaward reaches of the Mermaid Sound, 0.3 to 0.4 m/s in the channel between Eaglehawk and Enderby Islands and the channel to the south of Rosemary Island (Pearce et al., 2003). The strongest currents (exceeding 2 m/s) occur in the channels connecting Mermaid Sound and Nickol Bay between Angel and Dolphin Islands (Forde, 1985: cited in Pearce et al., 2003). Away from its offshore entrance, tidal currents in Mermaid Sound are in the order of 0.2 m/s during spring tides and 0.1 m/s during neap tides (Pearce et al., 2003). Flows around the islands are complex. Secondary circulation can occur (Pearce et al., 2003).

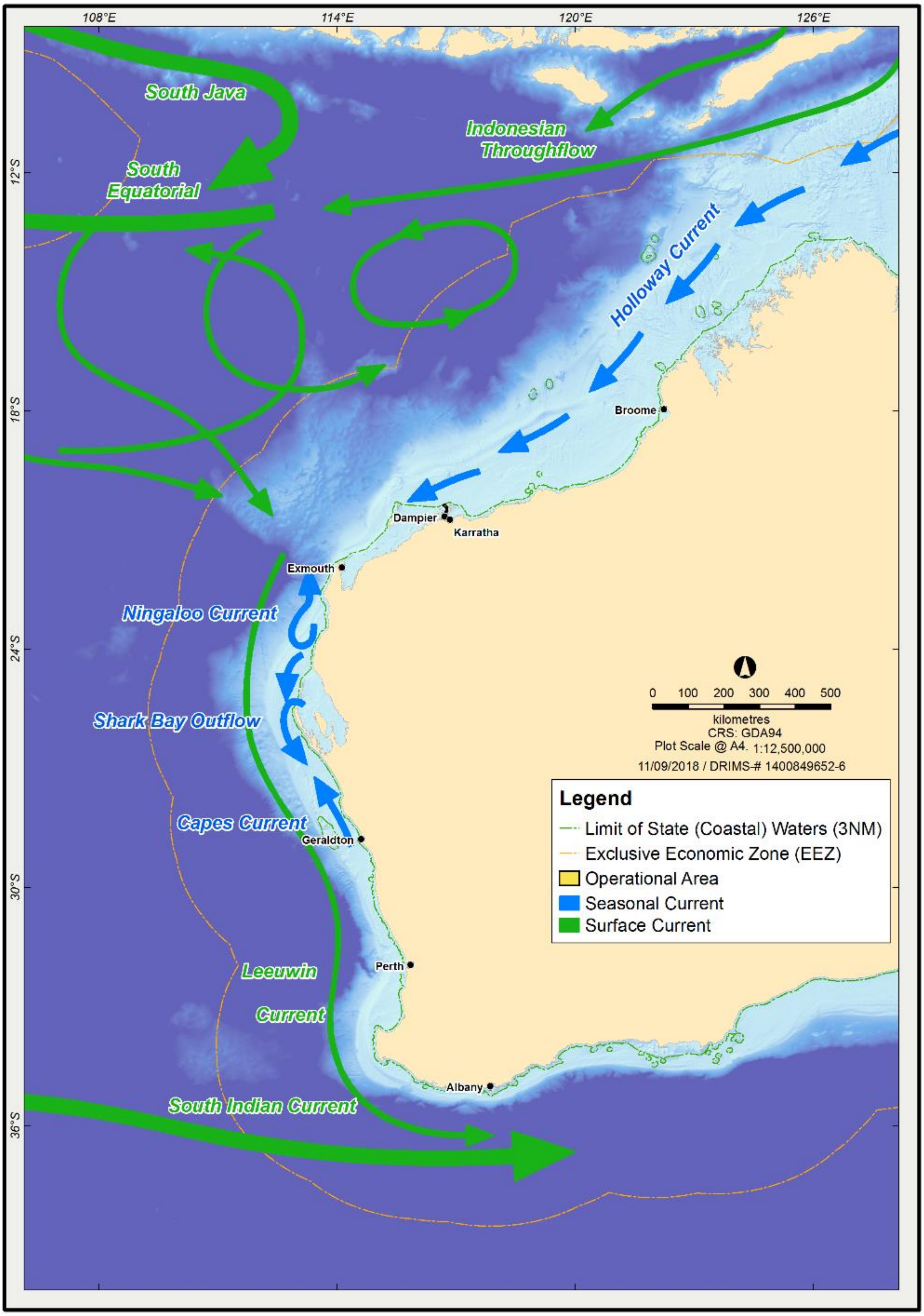


Figure 4-1: Generalised schematic of ocean circulation for the wider North-west Marine Region (Department of the Environment, Water, Heritage and the Arts, 2008a)

4.1.2.2 Waves

Waves on the NWS are predominantly from a south-west direction, with swell height averaging 1 to 2 m and rising to 3 m during the winter months of June to August. During winter, storm events in the lower Indian Ocean generate swell which can attenuate into a low, consistent, long-period wave form as it approaches the Dampier Archipelago (Woodside, 1998). Wave heights typically reduce by at least 50% as they move down Mermaid Sound from the open ocean (Pearce et al., 2003). Waves in the Dampier Archipelago are driven by westerly winds in summer, while the western shores of the Burrup Peninsula and the islands to its north are protected from the persistent winter easterlies (Woodside, 1998). From December to April during cyclone season, intense low-pressure systems and extreme winds can generate swells higher than 8 m.

4.2 Marine environmental quality

'Marine environmental quality' refers to the waters, sediments and biota contained within the marine environment. This includes physical or chemical properties (EPA 2016c).

4.2.1 Marine water quality and characteristics

Water temperature and salinity

Mean temperature of the nearshore waters of the Dampier Archipelago ranges from 22.5 °C in July/August to 30.4 °C in February (Pearce et al., 2003). These nearshore waters are semi-enclosed from the offshore waters by the islands of the Archipelago, resulting in warmer temperatures in summer and cooler temperatures in winter. Monitoring conducted for the Pluto LNG Foundation project found water temperature at locations in the inner and middle of Mermaid Sound remained higher for longer, compared with the sites further offshore over summer periods (Mscience, 2010). Peak summer water temperatures exceeded 32°C at inner and mid Mermaid Sound monitoring locations and exceeded 31°C at outer monitoring locations (Mscience, 2010). High water temperatures are often the cause of coral bleaching events.

Similarly, in contrast to offshore waters where salinity remains relatively uniform, within the Dampier Archipelago salinity is generally vertically stratified, wedging seaward beneath the open waters of the continental shelf. Though typically the nearshore waters are more saline, surface water salinity is diluted during periods of cyclonic activity and heavy rainfall within the Archipelago.

Turbidity and suspended solids

Turbidity is a measure of the degree to which water loses its transparency due to the presence of suspended particulates. Typically, the waters in the inner Archipelago, closer to the mainland, are characterised as having naturally higher levels of turbidity than the clearer offshore environment. This is predominantly related to the continual resuspension of fine sediment material through natural inputs such as winds, tidal currents and wave energy, which is exacerbated in shallow areas where strong tidal flows exist (such as through Flying Foam Passage) or where a high volume of vessel movements occur (such as shipping channel and berthage areas). Periodic events, such as major sediment transport associated with tropical cyclones, may influence turbidity on a regional scale (CSIRO, 2007).

Monitoring at 25 sites (outside dredging periods) spread throughout Mermaid Sound for dredging associated with the Pluto LNG Foundation project found long-term median turbidity (recorded as nephelometric turbidity unit, or 'NTU') ranged from 0.4 to 3.6 NTU. Variations were experienced between locations with higher median turbidity values in the inner archipelago. Baseline data collected for the Pluto LNG Foundation project shows the duration of natural elevations in turbidity is generally quite short, with values above the 80th percentile rarely sustained for longer than one day (Mscience, 2007a)

Additional baseline water quality data is being collected at a suite of sites throughout the Dampier Archipelago to provide a contemporary dataset to supplement the existing Pluto LNG Foundation

Project data. Baseline data will continue to be collected until the commencement of trenching and spoil disposal. Parameters being measured include turbidity (NTU), benthic Light (DLI), temperature (°C) and depth (m). Preliminary analysis of the turbidity data considered representative of normal winter conditions (07/07/2022 to 01/08/2022) was found it was comparable to the Pluto LNG Foundation Project as demonstrated in Table 4-1.

Table 4-1 Preliminary analysis of Scarborough baseline turbidity data (converted to SSC)

Ecological zone	Scarborough 2022 Measured converted to SSC (mg/L)		Pluto LNG Foundation Project Values SSC (mg/L)	
	Mean	80%ile	Mean	80%ile
Zone A	2.3	2.6	1.8	2.3
Zone B	1.3	1.7	1.2	1.6

Turbidity may also influence the attenuation of light through the water column, causing light to be scattered or absorbed (Fearns et al., 2017). Daily light integral (DLI, the sum of moles of photons from within the photosynthetic active radiation spectrum per square metre per day) has previously been measured at two sites in mermaid sound (Angel Island and Conzinc Island) at mean water depth (around 4 to 5 m below surface). Mean DLI recorded was 15.8 mol.m-2.d-1 at Angel Island and 17.3 mol.m-2.d-1 at Conzinc Island. It should be noted water depth also plays a key role in determining light availability.

Trace metals and organics

A study measuring dissolved concentrations of cadmium, chromium, copper, lead, zinc, total mercury, polyaromatic hydrocarbons, phenols, benzene, toluene, ethylbenzene and xylene chemicals and petroleum hydrocarbons, found water quality in the Dampier Archipelago met the guidelines for a ‘very high’ level of ecological protection (99% species protection) based on the recommended guidelines and approaches in Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (2000) (Wenziker et al., 2006). At the time of sampling, all metals measured in King Bay, adjacent to an industrial centre, achieved the national guidelines for 99% species protection. The study (Wenziker et al., 2006) found no detectable levels of organics in the waters of the Dampier Archipelago.

Nutrients

In the Dampier region, intertidal blue-green algal mats have been observed that have the potential to increase nutrient levels in the sediments (Wells and Walker, 2003). These have been studied by Paling (1986) and Paling and McComb (1994). The distribution of algal mats is controlled by tidal height, tidal current, sediment influx and sediment drainage (Wells and Walker, 2003). The algal mat is a cohesive fabric consisting of cyanophyte filaments, stabilising the substrate to resist erosion. The mats are rich in organic matter, storing carbon, nitrogen and phosphorous. The nutrients from the algal mats provide a significant source of nutrient input to mangrove communities in the region (Paling and McComb, 1994). These mats are present in intertidal and mangrove community areas which will not be disturbed as part of the dredging for this proposal.

Sediment sampling of a nearshore subtidal area (cutter suction dredge 1 km south of the trunkline route) with similar sediments to the trunkline route showed nutrient concentrations were generally low (Worley, 2009). These results were consistent with previous surveys in the area completed by Mscience (2007) that showed all nutrient levels were below the limits of detection. Results from testing of chemical and biological oxygen demand (Worley, 2009) also indicated there are low levels of bioavailable nutrients in the seabed sediments.

Waters in the Dampier Archipelago are considered oligotrophic. However, on occasions, blooms of nitrogen-fixing microbes such as *trichodesmium* or mangrove mud-flat cyanobacterium may contribute significant amounts of nutrients into the marine environment. High spatial and seasonal variability are evident in nutrient and chlorophyll-a concentrations within the Dampier Archipelago (Pearce et al., 2003).

As the waters of the Dampier Archipelago are oligotrophic, suggesting a regular supply of nutrient-rich sediment is absent and previous investigations have shown nutrient levels in the sediments close to the proposed trenching activity are low, remobilisation of nutrient-rich sediments is not expected as part of this proposal.

4.2.2 Marine sediment quality and characteristics

Contaminants

Information about sediment quality directly related to the trenching footprint has been assessed as part of a detailed Sampling and Analysis Plan (SAP) for the Project (Appendix B). The approved SAP was implemented in March 2019. Samples were collected from 36 locations along the proposed trunkline route. Total metal concentrations were very low and below the limits of reporting (LOR) for many analytes. Concentrations of organotin compounds were also very low and below the LOR for all locations tested. All results from the Scarborough Project SAP implementation were below the National Assessment Guideline for Dredging (NAGD) screening levels and found the sediments are free from any form of anthropogenic contamination (Appendix B).

Regionally, past studies have rarely found contaminants in sediments of the Dampier Archipelago. This is considered attributable to the lack of riverine inputs and controls on discharges associated with low levels of industrial development (Mscience, 2004). Historically, sediments in Mermaid Sound have been generally clean (in that they were below screening levels of National Ocean Disposal Guidelines for Dredged Material) with tributyltin, which has been used as an anti-foulant on ships, the only contaminant of concern (Woodside, 2006; DEC, 2006) and only found in the upper sediment layer, in areas used by the shipping industry (IRCE, 2003a; 2003b).

More recent studies performed throughout the Archipelago, within Port limits, have indicated surficial sediments (upper 1 m of sediment) were still considered generally clean. From recent sampling (Advisian 2019c; O2 Marine 2021), no hydrocarbons were detected above the respective screening level (ANZG 2018: TPH 280 mg/kgb, NAGD 2009: total PAH 10,000 mg/kg). Recent studies (Advisian 2019; Advisian, 2017; Jacobs, 2015; GHD, 2016) found that the only analytes to exceed NAGD screening levels were nickel and arsenic (only in a subset of studies), and only at a small subset of sampling locations. These elevated levels were considered attributable to the natural geology of the region, which accords with the findings of previous studies (DEC, 2006; Woodside, 2006). Stoddart et al. (2019), found that natural concentrations of nickel routinely occur in sediments off the Pilbara coast at levels above the NAGD (low) screening levels. The GHD study also determined locations with the smallest particle grain size had higher adsorption potential and generally had higher concentrations of metals, metalloids and total organic carbon (GHD, 2016). The good spatial coverage and sampling of recently deposited fine sediments suggests that sediments within the port continue to exhibit low levels of contamination.

Grain size

Seabed sediment grain size in the Dampier Archipelago region is highly variable, due to the presence of strong tidal currents, periodic cyclones, protected embayments and sediment-producing organisms such as coral reefs (Talbot et al., 1985). Analysis of particle size distribution sediment survey for the Pluto LNG Foundation project dredging footprint in January 2006, found sediments adjacent to Holden Point to be predominantly sand (particle size of 0.06 to 2.0 mm). Further offshore, within the navigation channel, the sediments were comprised of sand (particle size of 0.06 to 2.0 mm); silt (0.002 to 0.06 mm) and clay (≤ 0.002 mm) (Woodside, 2006). Similarly, most sites sampled by Jacobs (2015) within Mermaid Sound were dominated by silt and clay.

Particle size diameter (PSD) data within the proposed dredge footprint was collected as part of the Scarborough Project SAP Implementation Study (Appendix B). Sand was the dominant fraction of sediments at all sites within the nearshore zone KP0 to KP3.6 (Appendix B; Figure 4-1). Levels of silt varied a little across sites, though generally comprised <30% of sediments and small fractions of clay were at nine of the 19 sites. Very small amounts of gravel were present at most sites. Between KP3.6 and KP4.6 sediments were much coarser, with higher percentages of gravel and sand and less than 21% silt (Appendix B; Figure 4-3). Between KP11 and KP15, particle sizes were similar to those observed between KP0 to KP3.6, but with a slightly lower proportion of silt (<25%) (Appendix B; Figure 4-4).

PSD data was also collected from a geotechnical survey of the trunkline route (Fugro, 2019). Between KP15 and KP21.3, increasing proportions of clay and coarse sand were observed (on average around 7% clay, 23% silts, 70% sand), trending towards higher proportions of larger particle sizes between KP23 and KP38 (on average around 9% clay, 16% silts, 75% sand), and KP38 and KP50 (on average around 3% clay, 10% silts, 87% sand) (Fugro, 2019).

Data was also collected at the proposed offshore borrow ground, which consists of sand with minimal fines (Fugro, 2019). On average, the material consists of 94% coarse sand and <4% clay and silt.

4.3 Benthic communities and habitat

A review of publicly available reports and papers on the Dampier Archipelago, including the Port of Dampier (Mscience, 2014), identified six key BCHs likely to be present, including mixed communities (including marine invertebrates), corals, macroalgae, mangroves and seagrass. The significant BCH of the Dampier Archipelago, including the Port of Dampier, are discussed in detail in this section, and are shown in Figure 4-2.

Historically, each project within Dampier Port assessed impacts to BCH using differing spatial areas for impact assessment (previously referred to as management zones and more recently referred to as local assessment units). Additionally, each project sought to determine the coverage of benthic communities relative to each project. In 2012, Dampier Port Authority (now PPA) sought to align the way impacts to BCH were assessed within the port boundaries. The assessment included defining a common set of local assessment units (LAUs), identifying the communities that are represented by BPPHs and assessing their historic and present distributions.

The habitat map (Figure 4-2) was subsequently updated in 2017 (Mscience, 2017) and has been used to support the impact assessment presented within the DSDMP. The habitat map is an amalgamation of previous studies and maps. Habitat layers were split into individual habitat types and evaluated for congruence in the extent and placement of habitat features. Based on the data source and agreement of data layers, a confidence value for each feature was assigned (ranging from 1 – data should be rejected to 5 – data is highly reliable, and the extent of the feature was justified based on the survey methods used to describe it and the feature corroborated by two data sources) (Mscience, 2018a).

The final habitat file was produced by grouping individual habitat layers into one spatial file. The final shape file was assessed for conflicts in habitat classification between grouped layers and the feature confidence values were modified accordingly. Once all layer conflicts had been resolved, randomly selected features were checked against high-resolution satellite imagery to confirm their validity. In some cases, the boundaries of features were modified based on the available satellite imagery to increase confidence in their validity. A final assessment of the combined spatial data was performed by incorporating advice from an expert in the BPPH within the Dampier Archipelago and surrounding Cape Lambert. The expert advice was generally used to modify the confidence classification of data layers but, in some cases, the spatial extent of features was modified based on expert assessment of the feature (Mscience, 2017).

Further information was reviewed or collected to determine the presence or absence of benthic communities at the proposed borrow grounds. Due to the limited historical data for the offshore borrow ground location, additional survey work was completed to determine the presence or absence of benthic communities, which is further described in Section 4.3.1.1.

Geophysical and geotechnical survey results in outer Mermaid Sound classed as the offshore ecological zone (Section 5.5) show the seabed is generally flat and featureless, comprising carbonate sand and shell gravel. There are some areas of sorted accumulations of coarser sediments and some small depressions, but these are not expected to support significant benthic communities. As part of the Pluto LNG Foundation project, surveys were completed to determine the presence and extent of any sessile benthic assemblages adjacent to the proposed trunkline route. The survey was completed between the State waters boundary and to a point adjacent to KP50.3 to determine the suitability of the area for an offshore spoil disposal ground (Woodside, 2009). Twenty-nine sites were surveyed with a drop camera. The seabed was characterised as fine to coarse sand with low species abundance and diversity, with sparse sponges and soft corals typical of habitat on the NWS. The seabed substrate observed on the drop camera footage was representative of the area (predominantly fine to coarse sand) and is consistent with the geophysical and geotechnical data collected along the trunkline route. Sparse ascidians, sponges, invertebrate communities, burrowing organisms and octocorals were observed from the drop camera study. This benthos is considered representative of the area and is similar to that observed in other regional studies (Keesing, 2019; Advisian, 2019b).

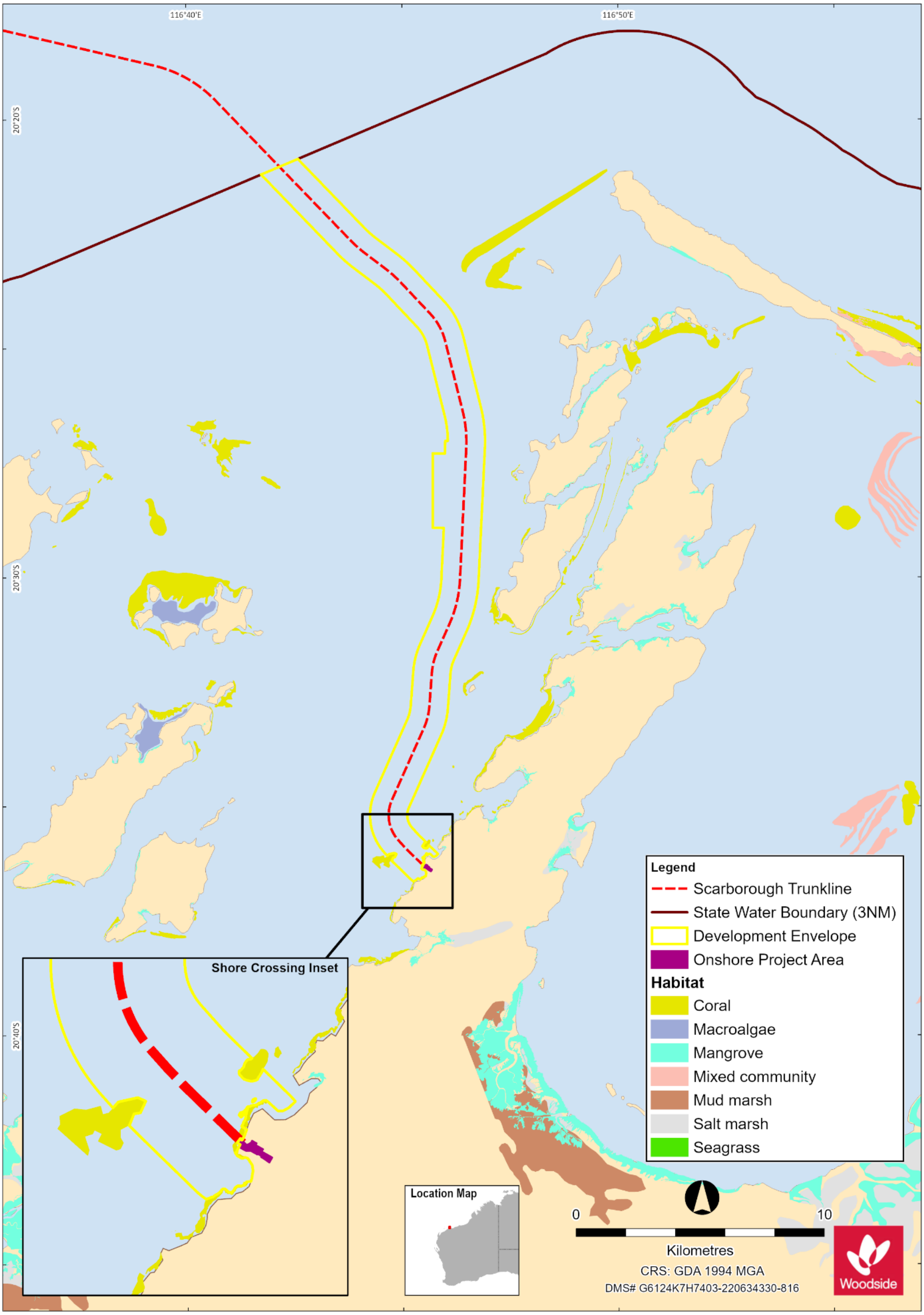


Figure 4-2: Significant benthic communities and their distribution in the Dampier Archipelago (Data source Mscience, 2018a)

4.3.1 Benthic habitats

The Dampier Archipelago contains many various subtidal and intertidal habitats, described below.

4.3.1.1 Soft sediments and sandy beaches

Soft sediment composed of sand and silt is the dominant subtidal habitat within Mermaid Sound (Bancroft and Sheridan, 2000). The SAP implementation survey showed the sediments along the trunkline route were generally silty sands with varying proportions of clay. This is supported by the Woodside Maintenance Dredging SAP Implementation Report (Mscience, 2016) and the Scarborough Trunkline Geotechnical Survey (Fugro, 2019), which recorded silty sands throughout Mermaid Sound and a higher proportion of silts further inshore. The areas where no classification is presented in Figure 4-2 are considered to consist of bare silty sands with no or low abundance areas of benthic communities and habitat. This is supported by previous work completed as part of the Pluto Baseline Marine Habitat Survey (SKM, 2008) and further refined by Mscience (2017) to produce the habitat map presented in Figure 4-2.

The sand habitat may overlay reef platforms or contain patches of another habitat. In the Dampier Archipelago, sand habitats are typically bare, though may contain seasonal vegetation or permanent patches of seagrass, macroalgae and invertebrate infauna. Subtidal soft-bottom communities are recognised as important to Traditional Custodians represented by MAC for their support of invertebrate diversity (MAC, 2021). The silty subtidal habitats of the Dampier Archipelago are in more sheltered areas, such as embayments, and are usually unvegetated. These habitats typically support a rich variety of infauna species such as polychaete worms, molluscs and crustaceans. The intertidal mudflats of the inner Archipelago occur predominantly on the eastern side of the Burrup Peninsula and support significant arid-zone mangrove communities, foraging shorebirds and wading birds. They can also host bacteria important to carbon cycling (Heyward et al., 2000).

Given the dominance of soft sand and silt habitat within the inner Dampier Archipelago (Bancroft and Sheridan, 2000), sedimentary infauna associated with soft unconsolidated sediments is likely to be widespread and well represented. In the context of the contiguous extent of habitats across the region, it is considered of relatively low environmental sensitivity.

Findings from the benthic habitat survey completed in the offshore borrow ground project area and adjacent areas of the Dampier Marine Park suggest the benthic habitat is dominated by sandy bottom with little to no biota (Advisian, 2019a, Appendix C). Data captured included high-resolution still images and video footage at 24 drop camera locations outside the marine park and 51 drop camera locations within the marine park. Within and outside the marine park, little or no invertebrates were observed (< 10% coverage) (Figure 4-3 and Figure 4-4). Where biota was observed, it typically consisted of invertebrates such as anemones and crinoids at densities no greater than 10% and typically less than 5% cover. Of the 24 survey locations within the potential borrow ground, sparse invertebrate cover was observed at only two locations. Of the 51 survey locations within the habitat protection zone of the Dampier Marine Park immediately adjacent to the proposed borrow ground, sparse invertebrate cover was observed at 12 locations.

Additional survey work completed by CSIRO shows benthic cover at the proposed offshore borrow ground and adjacent habitat protection zone is not regionally significant, and benthic cover is lower than that identified regionally (Keesing, 2019).

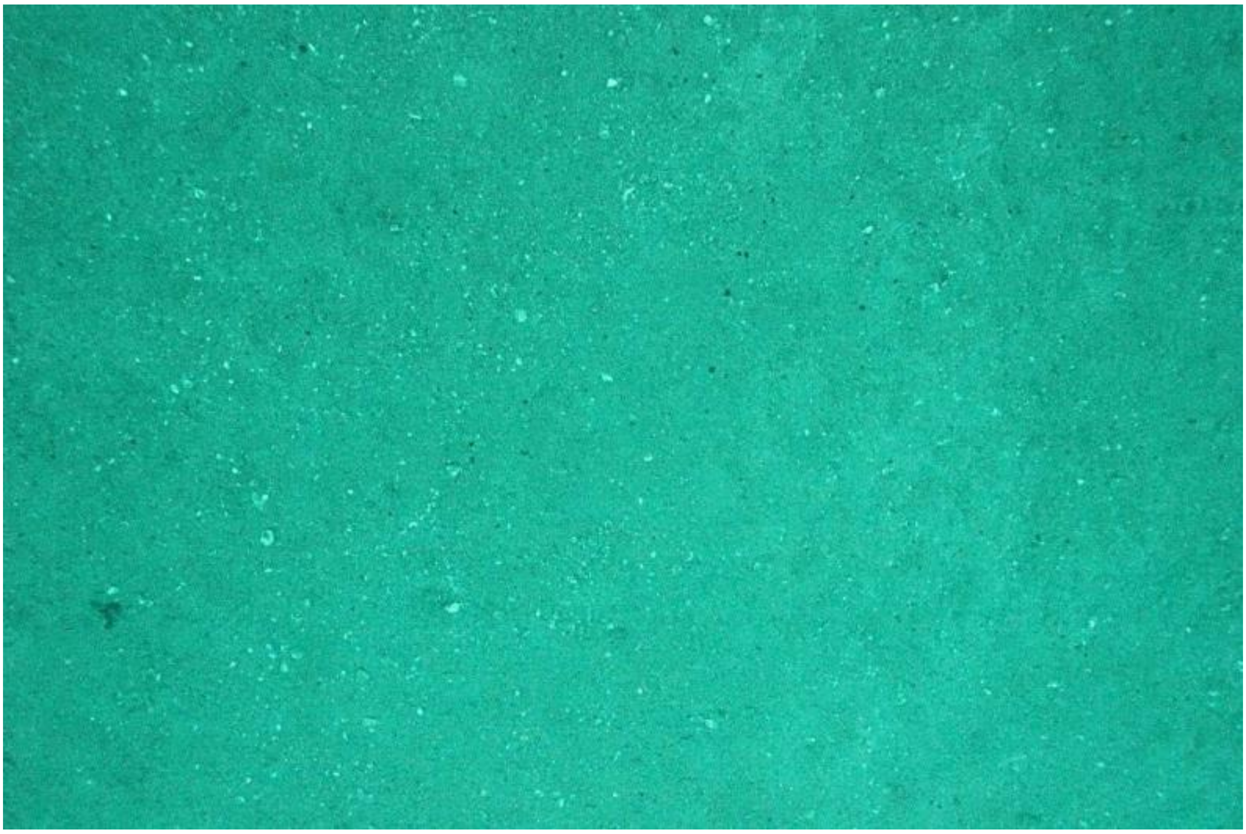


Figure 4-3: Example image of typical sand habitat with no biota observed within the Dampier Marine Park area of interest

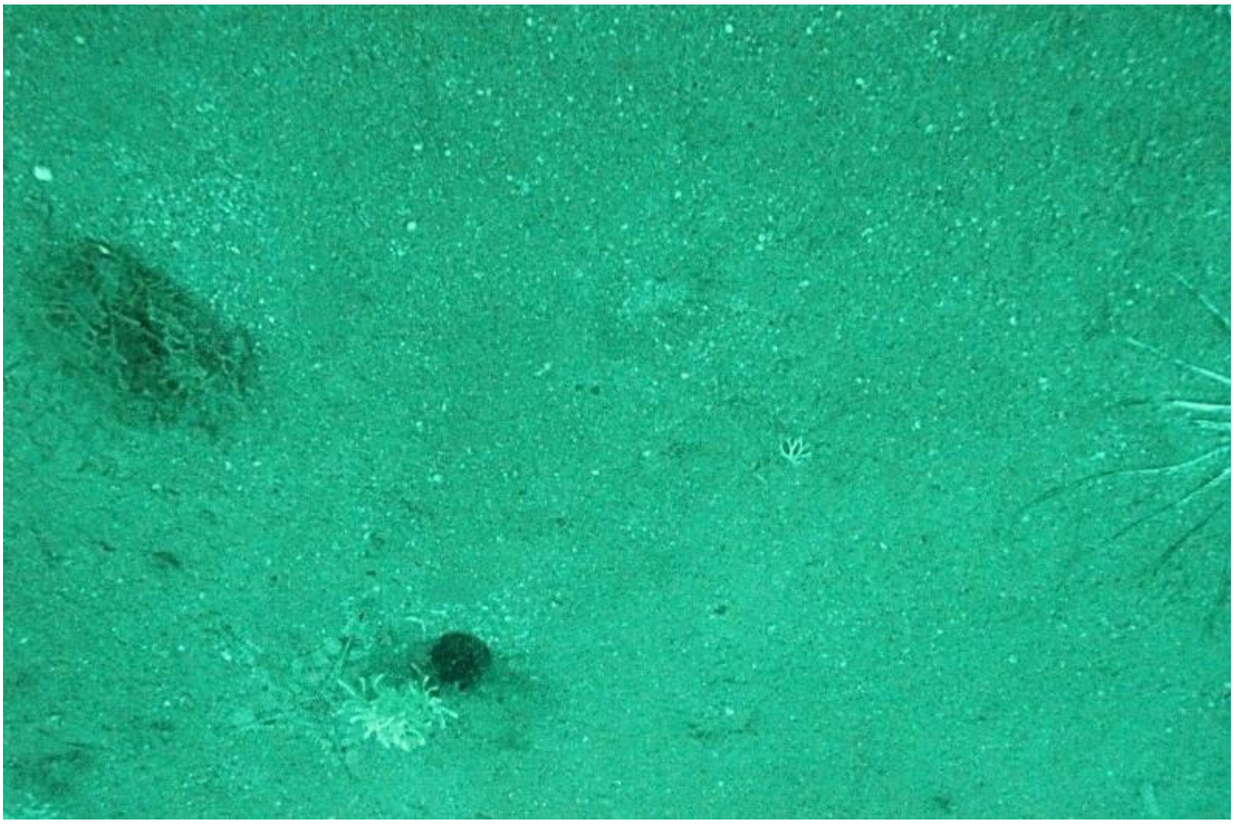


Figure 4-4: Example image of sand habitat with sparse invertebrates (< 10%) observed within the Dampier Marine Park area of interest

4.3.1.2 Rocky shores

Rocky shores are the dominant shoreline habitat associated within the Dampier region (Semeniuk et al., 1982). Wells and Walker (2003) described the fauna of the littoral zone as sparse, comprised predominantly of littorinid snails and grapsid crabs, while the intertidal zones are dominated by a diverse range of species including sponges, oysters, limpets, chitons, crabs and barnacles. The biota becomes increasingly diverse in the lower intertidal zone, with a variety of sessile and motile invertebrates and benthic algae. Corals reach into the lowest portions of the intertidal zone (Jackson et al., 2006). Rocky shores are recognised as important to Traditional Custodians represented by MAC as habitats for intertidal organisms and feeding sites for shorebirds (MAC, 2021).

4.3.1.3 Reefs

Reef habitat is considered as anywhere hard bottom exists in the subtidal environment. Hard bottom substrates have the potential to support a variety of communities and may have a foundation of biota, such as biogenic reefs composed of skeletal remains of hard corals (coral reefs). The coral communities of the Dampier Archipelago have been described below. These communities are mostly present as individual colonies that settle and grow on existing hard substrate (Jones, 2004; Worley, 2009; Mscience, 2014), predominantly located close to shore to a depth of 10 m lowest astronomical tide (Mscience, 2014).

Reef habitat also supports macroalgal and mixed biota communities within the Dampier Archipelago, most of which occur in the lower intertidal areas of the Archipelago. Algal habitats have been previously determined to be essentially all hard substrates within the photic zone (Mscience, 2014). As a result, large macroalgal reef habitats occur in the south-west region of the inner harbour around West Intercourse Island. Furthermore, there are several shallow reef flats on the western and eastern margins of Mermaid Sound that may support seasonal macroalgal assemblages (Mscience, 2014).

A band of reef crosses the entrance to Mermaid Sound; however, towed video footage (Advisian, 2019b) shows the reef is largely devoid of epibenthic communities, with some smaller patches of mixed communities to the west of the proposed trunkline route.

Madelaine Shoals is an igneous monolith to the north of Legendre Island, dominated by soft corals and gorgonians with some hard corals in the shallower areas. The deeper areas are dominated by siltier sediments and sea whips (Hutchins et al., 2007).

4.3.2 Benthic communities

The significant benthic communities using the habitats described above are described in the next sections.

4.3.2.1 *Mixed communities*

Soft corals and sponges are assigned to the mixed community classification presented in Figure 4-2.

The Pilbara region has a very high diversity of marine sponges (Fromont et al., 2016); 275 sponge species have been recorded within the Dampier Archipelago. About 20% of these species are presently known to be limited to WA and are likely to be endemic (Fromont, 2003). While extensive surveys of the WA coastline are limited, there is data to suggest some sponge species have limited distributions. Fromont (2003) suggests the high level of endemism may be the result of a short larval phase and limited dispersal.

Surveys conducted by Fromont (2004) found the highest diversity of sponges in the Dampier Archipelago occurred in sponge communities that were either low relief or pavement habitats, often with a sediment layer with strong tidal currents. High-diversity sponge communities have been observed at the eastern end of Flying Foam Passage, at the western end of Mermaid Strait and between Enderby and West Lewis Islands (Fromont, 2004; Jones, 2004). Generally, the high habitat complexity of the Dampier Archipelago corresponds with high sponge species richness, contributing to the high biodiversity value of the nearshore environment of the Pilbara region (Fromont, 2016).

Mscience (2018a) grouped sponges, soft corals and other such biota occurring together, classifying them as mixed communities. Figure 4-2 shows the distribution of mixed communities as primarily present in confined aggregations around Intercourse Island and between East Mid Intercourse and East Intercourse islands.

4.3.2.2 Coral

Coral communities of the Dampier Archipelago predominantly occur as narrow linear features fringing the shorelines of islands and the Burrup Peninsula, typically between 2 m and 10 m mean lower low water (Blakeway and Radford, 2005; Jones, 2004). The fringing reefs are not true coral reefs; they establish and grow on existing hard substratum (Jones, 2004; Worley, 2009).

Both zooxanthellate and azooxanthellate corals are found throughout the Dampier Archipelago, including 229 species from 57 hermatypic coral genera (Woodside, 2006; Griffith, 2004), representing a large proportion of the 318 hermatypic species from 70 genera known to occur in WA (URS, 2004). Distribution of coral communities shows a strong gradient in which nearshore or inner harbour reefs are dominated by sediment tolerant species, that shift to wave-tolerant clear water species further offshore in the outer port harbour (Wilson, 1994).

It is widely recognised that coral communities provide high ecological value to the marine environment. Thus, coral communities within the Dampier Archipelago have been researched to identify community ecological structure and manage impacts associated with port development and other anthropogenic impacts. Historically, taxonomic surveys and ecological research have concentrated on the outer Archipelago (Griffith, 2004), while studies associated with monitoring potential impacts on coral from industrial development and port expansion have focused on nearshore areas (Blakeway & Radford, 2005). The coral communities along the mainland Burrup Peninsula coast show little evidence of reef development; rather, they grow by encrusting solid substrata such as Precambrian rock (URS, 2004; Jones, 2004). Corals are recognised as important to Traditional Custodians for attracting fish and other marine organisms, the potential for symbiotic relationships between fish and corals, and for their aesthetic values (MAC, 2021). Coral communities at Withnell Bay, Conzinc Bay and south-west of Legendre Island were specifically noted by Traditional Custodians (MAC, 2021).

An initial baseline assessment of the status of coral communities within Mermaid Sound was completed in May 2019 (Mscience, 2019a) (Appendix D). Coral cover measured in this survey was very similar to historic cover levels. Although most sites reported similar coral coverage estimates between surveys, there were a few exceptions. Sites ANG2, GIDI and SUP2 showed significantly more coral cover in the 2019 survey when compared to the 2007 and 2010 surveys. Coral cover increases at ANG2 appear to be driven by the abundance of corymbose and tabular *Acropora* colonies relative to previous surveys. Increases at GIDI and SUP2 do not appear to be due to any species-specific changes, rather a general increase in cover of all corals across the monitoring site, although there was some evidence to suggest a disproportionate increase in *Pavona* coral species at SUP2.

The only site to show a significant reduction in coral cover in the survey (Mscience, 2019a) (Appendix D) was LEGD. While this site has shown historically low cover relative to the other monitoring sites, cover in the current survey has shown further reductions from the historic coverage estimates of about 10% down to around 6% coral cover. The reduction in coral cover appeared to occur across all coral species present on the reef. It is unclear as to what has caused this decrease in coral cover, though the offshore location of the monitoring site suggests it was unlikely to be due to anthropogenic effects arising from activities in the Dampier Harbour.

Levels of bleaching in the recent survey (Mscience, 2019a) (Appendix D) were relatively low; 1 to 3% at SUP2, INTI and CONI, and <0.5% at the remaining sites. This is consistent with mid-year surveys previously conducted in the Pilbara, when the thermal bleaching effects of high summer water temperatures have usually resolved, either in recovery or mortality (Depczynski et al., 2013). The low proportion of recently-dead standing coral observed in the current survey suggested mortality due to thermal bleaching over the 2018–2019 summer was minimal.

Diversity of corals at monitoring sites was evaluated using the six hard coral categories. Proportional representation of each category was found to be relatively consistent over time, indicative of diverse and mature coral communities. While there was a relatively consistent proportional representation of categories, there were some obvious differences in the community composition between sites. *Acropora* corals were nearly absent from inshore sites KGBY and SUP2, while outer harbour communities at MAL2, ANG2 and GIDI showed higher proportional representation of *Acropora*, consistent with previous reports at Dampier (Blakeway and Radford, 2005; Mscience, 2007). MAL2, CONI and COBN sites showed a high proportion of *Porites*, while KGBY was unique in its very high proportion of Faviid corals.

The nearshore coral communities at KGBY and SUP2 experience elevated levels of natural turbidity and suspended sediment most of the year and appear to be relatively resilient in terms of the persistent turbidity (Blakeway & Radford, 2005). The *Turbinaria* and mixed coral assemblages found in this area are considered less sensitive to turbidity and sedimentation compared with the *Pavona*, *Porites* and *Acropora*-dominated assemblages found further offshore (Blakeway & Radford, 2005). Figure 4-2 shows the distribution of hard coral communities within the Dampier Archipelago (Mscience, 2018a).

Coral recruitment and spawning

The ecology, particularly reproductive ecology, of corals in the Dampier Archipelago has been extensively studied (Simpson, 1985a; Simpson, 1985b; Simpson, 1988; Heyward et al., 2000; Baird et al., 2011). Communities in the Pilbara spawn predominantly during autumn, but there is also some participation in a spring spawning; periods of reproduction through these seasons may be more protracted than on the northern reefs and species common to the Pilbara display distinct cycles of reproduction (Gilmour et al., 2017).

Most of the major coral species are broadcast spawners and have their major peak of reproductive activity between March and April, about seven to ten nights after the full moon. A second, though less pronounced, peak occurs in October and November, coinciding with the major spawning on the Great Barrier Reef in eastern Australia, though it is considered possible that sampling during the spring-time event in the Dampier Archipelago has occurred during periods when corals are experiencing environmental stress, and is therefore an underestimate of participation of some species (Gilmour et al., 2017).

As a general rule in the Pilbara, spawning that is predicted to occur between 8 and 24 March in any year is considered likely to result in a major spawning in March, with smaller contributions in February and April. If spawning is predicted to occur between 1 and 7 March, spawning is likely to be split between March and April, with one month having a greater participation rate than the other. If spawning is predicted to occur between 25 and 31 March, spawning is likely to be split between February and March, with one month having a greater participation rate (Gilmour et al., 2017).

4.3.2.3 Seagrass

Seagrasses in the Dampier Archipelago are generally sparse, occurring in low abundance on shallow sandy sediments in sheltered areas and interspersed with other BCH (CALM, 2005; Jones, 2004; Mscience, 2014) (Figure 4-2). Surveys and studies of the region have identified nine species: *Cymodocea angustata*, *Enhalus acoroides*, *Halophila decipiens*, *Halophila minor*, *Halophila ovalis*, *Halophila spinulosa*, *Halodule uninervis*, *Thalassia hemprichii* and *Syringodium isoetifolium* (McMahon et al., 2017; Woodside, 2006). However, *Halophila* is the predominant species and is typically restricted to the 6 m (chart datum) depth contour (Mscience, 2014).

Surveys conducted by Bertolino (2006) reported seagrass in Conzinc and Withnell Bays, southern side of East Lewis Island and between the causeways connecting East Intercourse Island and Mistaken/East Mid Intercourse Islands (Mscience, 2014). Sparse patches of seagrass have also been recorded throughout Mermaid Strait and in the nearshore environments of the bordering islands (Mscience, 2014; Huisman and Borowitzka, 2003; Waycott et al., 2004). MAC have reported seagrass beds to exist near Conzinc Island and between Angel and Gidley Islands (MAC, 2021).

Seagrasses are recognised as important to Traditional Custodians represented by MAC as refuges for small marine fauna (MAC, 2021).

The most significant areas of seagrass In the Dampier Archipelago are found between Keast and Legendre islands to the north of the Burrup Peninsula, and between West Intercourse Island and Cape Preston. Recorded occurrences of *Halophila* species in the Dampier Archipelago fluctuate, depending on various factors such as salinity, success of seed set and colonisation, temperature and grazing by dugongs (Woodside, 2006). Furthermore, this fluctuation may indicate the presence of transitory communities, which are annual meadows that develop from the seed bank, grow flower, set seed and die back each year (McMahon et al., 2017).

During the Pluto LNG Foundation project, monitoring sites for seagrasses were difficult to locate due to the very low coverage of seagrasses. Monitoring showed there were no detectable impacts to seagrasses. Abiotic was the dominant substrate recorded (more than 90% of community composition) at all monitoring sites, with very low coverage of seagrasses (less than 10% coverage before dredging and <15% cover after dredging). Seagrasses were dominated by *Halophila Ovalis* and *Halophila Decipiens* which are both ephemeral (Short et al., 2006) increasing in biomass over the summer months.

4.3.2.4 Macroalgae and microphytobenthos

Macroalgal communities of the north-west of Western Australia are relatively poorly understood and surveyed compared to other regions of Australia (Huisman, 2004; Huisman and Borowitzka, 2003). Macroalgae generally require a hard substrate, sufficient light and water clarity to survive, so are generally limited to shallow water. Macroalgal assemblages in the Pilbara region display an ephemeral growth pattern and may not be present year-round, despite the presence of suitable habitat. Previously, macroalgal habitats were determined to be essentially all hard substrates within the photic zone. As a result, large algal habitats occur around West Intercourse Island and a number of shallow reef flats on the western and eastern margins of Mermaid Sound. In nearshore areas, macroalgae are most commonly found on shallow limestone pavements located on the northern and western portions of West Intercourse, West Lewis and Malus islands (Figure 4-2). More broadly, large expanses of macroalgae are prevalent along the seaward side of West Intercourse Island, extending south-west along the coast to Cape Preston and beyond.

The most abundant group of algae in the region is brown algae; particularly, species from the genus *Sargassum*, *Dictyopteris* and *Padina* are very common (Woodside, 2006). The most common species of green algae in the Dampier Archipelago include *Caulerpa* species and calcareous *Halimeda* species (CALM, 2005; Jones, 2004). A variety of red algae are also found in the Dampier Archipelago, including corallines, calcified red algae and algal turf (Jones, 2004).

Macroalgal communities are recognised as important to Traditional Custodians as primary production sites, habitats and food sources (MAC, 2021). Subtidal sandy seabed areas that support benthic algae or microphytobenthos (MPB) are recognised as one major contributor to overall benthic primary productivity of ecosystems, as well as providing habitat for short-range endemic fauna (Murrell et al., 2009). With the dominance of subtidal sandy habitat and the relatively shallow bathymetry of Mermaid Sound, it is likely MPB occurs throughout the area, although its abundance and distribution has not been previously described. In Mermaid Sound, the more environmentally significant MPB habitat is likely to occur in shallower areas, where more light is available on the seabed. Regular fluctuations in biomass indicate MPB responds rapidly to environmental variation. Monitoring in Port Phillip Bay, for example, has shown MPB biomass is highly dynamic and capable of rapid recovery in shallow waters (Beardall et al., 1997; AME, 2006).

In the Dampier region, many areas of the otherwise bare substrate contain intertidal blue-green algal mats (Wells and Walker, 2003). These have been studied by Paling (1986) and Paling and McComb (1994). The distribution of algal mats is controlled by tidal height, tidal current, sediment influx and sediment drainage (Wells and Walker, 2003). The algal mat is a cohesive fabric consisting of cyanophyte filaments, stabilising the substrate to resist erosion. The mats are rich in organic matter, storing carbon, nitrogen and phosphorous. The nutrients from the algal mats provide a significant source of nutrient input to mangrove communities in the region (Paling and McComb, 1994).

4.3.2.5 Mangroves

Mangroves are an important part of the coastal ecosystem, contributing to primary productivity and providing habitat for fauna species including fish, seasnakes, turtles and birds (Wells et al., 2003). The significance of tropical arid zone mangroves along the Pilbara coastline is recognised. Specific guidance documentation has been established by EPA (2001) to protect these communities, habitats and dependant habitats from development pressures.

Six species of mangrove occur in the Dampier region: *Avicennia marina*, *Aegialitis annulata*, *Aegiceras corniculatum*, *Bruguiera exaristata*, *Ceriops tagal* and *Rhizophora stylosa*. Most mangrove communities contain many species, and a variety of structures of zonation persist, dependent on the underlying sediment type, tidal height and wave and current action (Semeniuk et al., 1987). *Avicennia marina* is the most abundant species, existing in some monospecific stands that range from forests down to stunted shrubs. Regionally significant areas of mangroves that occur in the Dampier Archipelago include communities at West Intercourse Island, Enderby Island Complex and Searipple Passage/Conzinc Bay (EPA, 2001). MAC also reports mangrove populations in Flying Foam Passage and the north-east bay of West Lewis Island, which are important for shelter, crab and shellfish resources and possible turtle nurseries (MAC, 2021).

The nearest mangrove community to the Proposal is a stand of *Avicennia* and *Rhizophera* located at the north-east pocket of the sandy beach at No Name Bay (Figure 4-2). This stand has been studied as part of a long-term Chemical and Ecological Monitoring Program of Mermaid Sound initiated by Woodside in 1985. The most recent survey by Advisian (2017) recorded very little to no decline in the health of this stand over time, indicating very little impact to this mangrove community from existing industrial activities. The next closest, and considerably larger, mangrove community exists at King Bay (Figure 4-2). That community was the subject of studies by the WA Department of Conservation and Environment in the early 1980s, when the main Burrup access road was constructed through its upper reaches (Semeniuk et al., 1982). A comparison of aerial photography from 1957 and 2001 shows the distribution of individuals and species within the Hamersley Lease has changed little over the intervening 44 years (mScience, 2004).

4.4 Marine fauna

4.4.1 Protected species

The Dampier Archipelago is an important area for protected species listed under the EPBC Act and/or the *Biodiversity Conservation Act 2016* (BC Act). Protected species that may occur within the vicinity of the development envelope have been identified by searching the:

- EPBC Act Protected Matters Search Tool for the development envelope (with a 10 km buffer)
- Western Australian DBCA NatureMap tool for the development envelope (with a 20 km buffer) within State waters.

The searches identified protected species of mammals, birds, reptiles and fish that may be within the vicinity of the Proposal; these are summarised in the next sections. Table 4-2 summarises the protected, threatened and migratory species under both the EPBC Act and BC Act likely to be present within the development envelope or zone of influence.

Table 4-2: Listed threatened and migratory species likely to be present within the development envelope and/or zone of influence; species highlighted in green have biologically important areas that intersect the development envelope

Species	Status EPBC Act	Status BC Act
Mammals		
Dugong dugon Dugong	Migratory	Other Protected Fauna
Megaptera novaeangliae Humpback Whale	Migratory	Conservation-Dependent
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory	
Tursiops aduncus Spotted Bottlenose Dolphin	Migratory	
Birds		
Ardenna pacifica Wedge-tailed Shearwater	Migratory	Migratory
Hydroprogne caspia Caspian Tern	Migratory	Migratory
Onychoprion anaethetus Bridled Tern	Migratory	Migratory
Pandion haliaetus Osprey	Migratory	
Sterna dougallii Roseate Tern	Migratory	Migratory
Sternula nereis nereis Australian Fairy Tern	Vulnerable	Vulnerable
Thalasseus bergii Crested Tern	Migratory	Migratory
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake	Critically Endangered	Critically Endangered
Caretta caretta Loggerhead Turtle	Endangered, Migratory	Endangered
Chelonia mydas Green Turtle	Vulnerable, Migratory	Vulnerable
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered, Migratory	Vulnerable
Eretmochelys imbricata Hawksbill Turtle	Vulnerable, Migratory	Vulnerable
Natator depressus Flatback Turtle	Vulnerable, Migratory	Vulnerable
Fish		
Anoxypristis cuspidate Narrow Sawfish, Knifetooth Sawfish	Migratory	
Carcharias Taurus Grey Nurse Shark	Vulnerable	Vulnerable

Species	Status EPBC Act	Status BC Act
Carcharodon carcharias White Shark, Great White Shark	Vulnerable, Migratory	Vulnerable, Migratory
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred’s Ray, Resident Manta Ray	Migratory	
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory	
Pristis clavata Dwarf Sawfish, Queensland Sawfish	Vulnerable, Migratory	P1
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable, Migratory	Vulnerable

4.4.2 Biologically important areas

Biologically important areas (BIAs) are particularly important for conserving protected species and where aggregations of individuals display biologically important behaviour such as breeding, foraging, resting or migration. The presence of the observed behaviour is assumed to indicate the habitat required for the behaviour is also present. Using expert scientific knowledge about species' distribution, abundance and behaviour in the region, BIAs have been identified for the EPBC Act listed species with a potential to occur within the Dampier Archipelago, specifically:

- humpback whales
- loggerhead, green, hawksbill and flatback turtles
- wedge-tailed shearwater, Caspian tern and roseate tern.

More details about the BIAs are included in the next sections.

4.4.3 Marine mammals

Cetaceans (whales and dolphins) and dugongs may occur within the vicinity of the Proposal, including species classified as 'threatened' and 'migratory' under the EPBC Act or specially protected under the BC Act (Table 4-2).

Cetaceans within the region include those that are predominantly found in shallow coastal waters (such as Indo-Pacific humpback dolphin). Furthermore, the North-West Marine Region is thought to be an important migratory pathway between feeding grounds in the Southern Ocean and breeding grounds in tropical waters for several cetacean species (Department of the Environment, Water, Heritage and the Arts (DEWHA), 2012a). Whales and dolphins are recognised as important to Traditional Custodians represented by MAC as totems (MAC, 2021).

The following summary focuses on the subset of species that have been identified as having ecologically significant interactions (such as migration BIA) in the area or are considered 'iconic' (such as dolphins and dugongs).

4.4.3.1 Dugong

Dugongs (*Dugong dugon*) are associated with tropical and sub-tropical coastal waters, particularly shallow, protected waters such as sheltered bays, mangrove channels and in the lee of large inshore islands (United Nations Environment Program, 2002). Dugongs are herbivores that feed on seagrass. The dugong's reproductive cycle is sensitive to food availability; with breeding delayed if sufficient food is unavailable (United Nations Environment Program, 2002).

The distribution of dugong in the Pilbara region is widespread, including Barrow Island and the Montebello Islands, the Dampier Archipelago and the mainland coastal waters. They have been recorded near various islands including Rosemary Island, East Lewis Island, West Lewis Island, Keast Island, Legendre Island and Little Rocky Island (CALM, 2005; URS, 2000). Dugongs have also been sighted in shallow, sheltered bays of the Burrup Peninsula and mainland such as Regnard Bay and Nickol Bay (CALM, 2005). MAC reports dugongs may be seen in seagrasses near Gidley Island and are important as a food resource (MAC, 2021).

4.4.3.2 Humpback whale

Humpback whales are listed as migratory under the EPBC Act, and conservation dependent under the BC Act (Table 4-2). The WA population of humpback whales is genetically distinct from the eastern Australian population.

Breeding and calving grounds occur between Broome and the northern end of Camden Sound, with breeding typically occurring between August and September (DEWHA, 2012a). Feeding occurs primarily during summer in Antarctic waters, with krill forming the major part of the diet (DEWHA, 2012a). A BIA for migration has been identified on the inner shelf, including within the vicinity of the proposed trunkline (Figure 4-5). Although the north- and south-bound migratory routes for most whales are further offshore than the Dampier Archipelago waters (up to 70 nm from the coast), during the south-bound migration it is likely most individuals, particularly cow/calf pairs, stay closer to the coast than the northern migratory path (Double et al., 2010). During the south-bound migration, it is likely some whales may travel through Dampier Archipelago waters, either passing the open outer waters or travelling into the Mermaid Sound proper and continuing westwards, likely through the channel bounded by West Lewis Island and Enderby Island to the south and Rosemary Island to the north (with reference to Jenner et al., 2001). The southern migration in proximity to the Dampier Archipelago extends from August to October inclusive (Double et al. 2012). Humpback whales are recognised as culturally significant to Traditional Custodians represented by MAC (MAC, 2021).

4.4.3.3 Indo-Pacific humpback dolphin

In Australia, humpback dolphins are thought to be widely distributed along the northern Australian coastline from about the Queensland–New South Wales border to western Shark Bay, WA (Parra & Cagnazzi, 2016). While coastal waters are arguably the primary habitat of Australian humpback dolphins, most survey work has been conducted close to the coast; thus, the extent to which humpback dolphins use offshore waters is not yet fully understood. Aerial surveys over the western Pilbara have recorded humpback dolphins more than 60 km from the mainland in shallow shelf waters (i.e. <30 m deep) near Barrow Island and the western Lowendal Islands (Hanf, 2015). The species has also been recorded in fringing coral reef and shallow, sheltered sandy lagoons at the Montebello Islands (Raudino et al., 2018).

4.4.3.4 Bottlenose dolphin

Bottlenose dolphins are distributed continuously around the Australian mainland. Indian Ocean bottlenose dolphins have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia (Hale et al., 2000; Möller & Beheregaray, 2001; Ross & Cockcroft, 1990). In Australia, the Indian Ocean bottlenose dolphin is restricted to inshore areas such as bays and estuaries, nearshore waters, open coast environments, and shallow offshore waters including coastal areas around oceanic islands (Hale et al., 2000; Kogi et al., 2004; Möller & Beheregaray, 2001; Wang et al., 1999).

4.4.3.5 Snubnose dolphin

Snubnose dolphins are endemic to the waters of northern Australia and southern Papua New Guinea. In WA, the species is most commonly found in shallow waters (less than 21 m deep) that are close to freshwater inputs (Bouchet et al., 2021). Snubfin dolphins have been recorded in relatively high numbers in the waters of the Kimberley, with Roebuck Bay and Cygnet Bay being known hotspots. The species has been recorded as far south as the Pilbara and the North West Cape; however, sightings that far south are rare (Bouchet et al., 2021).

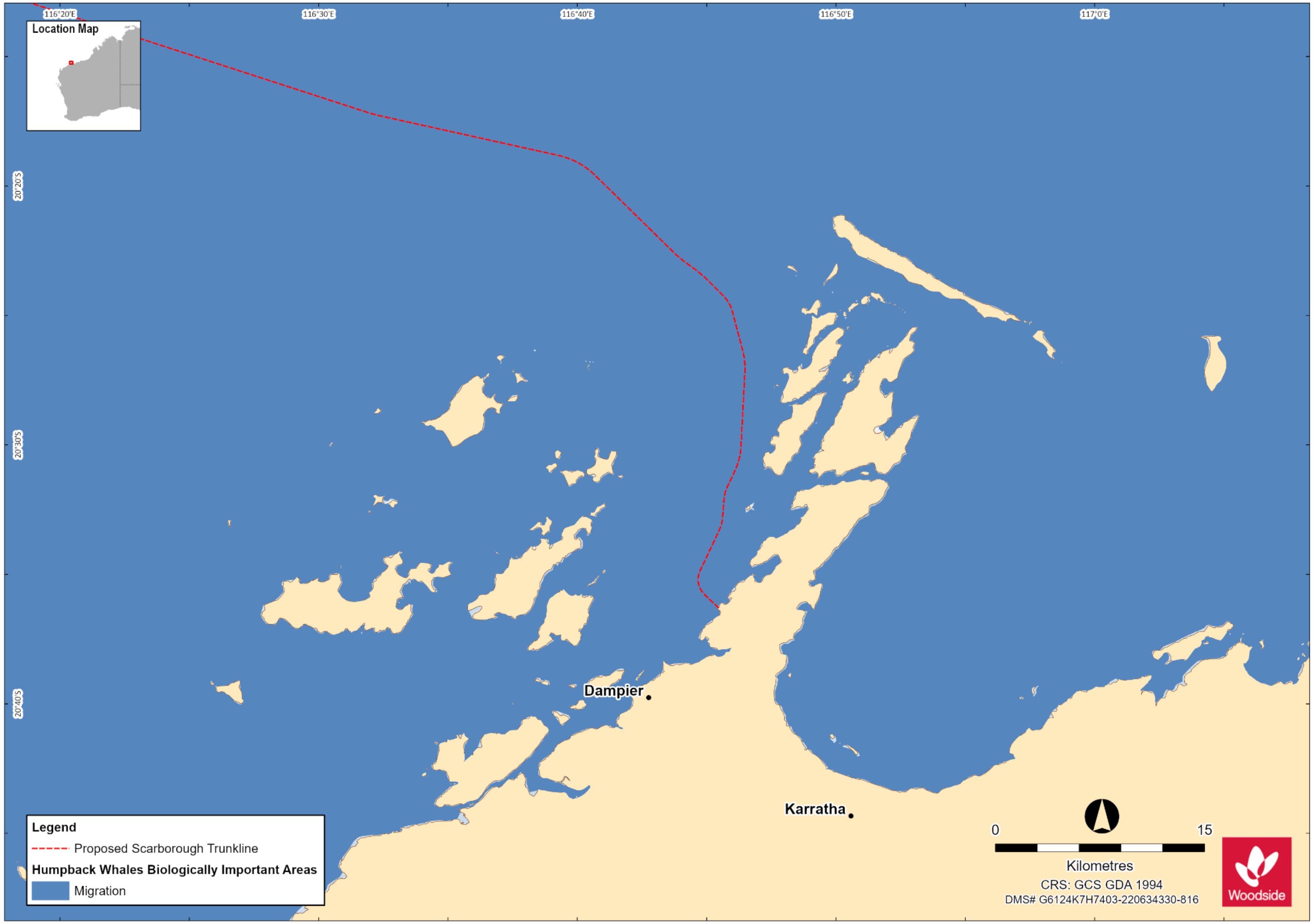


Figure 4-5: Biologically important areas for humpback whales

4.4.4 Marine reptiles

Seasnakes and turtle species may occur within the vicinity of the Proposal (Udyawer et al., 2020). This includes species classified as 'threatened' and 'migratory' under the EPBC Act (Table 4-2). The following summary focuses on the subset of species that have been identified as having ecologically significant interactions (such as foraging, nesting, internesting BIAs) in the area. Seasnakes and turtles are reported by MAC as culturally important species, with a turtle songline reaching Withnell Bay from Fortescue (MAC, 2021).

The Recovery plan for marine turtles (Commonwealth of Australia, 2017) outlines habitat critical to the survival of a species ("habitat critical") for marine turtle genetic stocks. All marine turtle BIAs were inclusive of areas identified as habitat critical. One key difference between BIAs and habitat critical is the size of the internesting buffer around flatback nesting beaches; BIAs include an 80 km buffer whereas habitat critical is 60 km. For all other species, the internesting buffer is 20 km for both habitat critical and BIAs.

4.4.4.1 Loggerhead turtle

Loggerhead turtles are defined as 'endangered' and 'migratory' under the EPBC Act and 'endangered' under the BC Act and are the most common marine turtle breeding in the North-west Marine Region (DEWHA, 2012). The Western Australia stock is found Shark Bay to North West Cape and as far north as Muiron Islands and Dampier Archipelago. The major nesting are principally from Dirk Hartog Island in the south, along the Gnaraloo and Ningaloo coast to North West Cape and the Muiron Islands in the north. There have been occasional records from Varanus and Rosemary islands and Ashmore Reef. Late summer nesting recorded for Barrow Island, Lowendal Islands and Dampier Archipelago. There is limited data on Australian loggerhead turtles however, literature indicates internesting habitat for this species is generally within 20 km of nesting beaches (DAWE, 2020b). Internesting BIA overlaps the development envelope at Cohen Island and Dampier Archipelago (islands to the west of the Burrup Peninsula). BIAs (Figure 4-6) and habitat critical (Figure 4-7) for the green turtles have been identified intersecting the development envelope.

4.4.4.2 Green turtle

Green turtles are listed as 'vulnerable' and 'migratory' under the EPBC Act and 'vulnerable' under the BC Act and are the most common marine turtle breeding in the North-west Marine Region (DEWHA, 2012c). Three distinct breeding stocks of green turtles occur in the region: the North West Shelf stock, the Scott Reef stock and the Ashmore stock. Principal near-coastal rookeries include the Lacepede Islands, some islands of the Dampier Archipelago, Barrow Island, the Montebello Islands, and North West Cape and the Muiron Islands (DEWHA, 2012c, Ferreira et al., 2020). The nesting period for the NWS stock is expected to begin in November, peak in January to February, and end in April (DEWHA, 2012c). Green turtles forage for seagrass and algae in estuarine, rocky and coral reef and seagrass habitats. BIAs (Figure 4-6) and habitat critical (Figure 4-7) for the green turtles have been identified intersecting the development envelope.

4.4.4.3 Leatherback turtle

Leatherback turtles are listed as 'endangered' and 'migratory' under the EPBC Act and 'vulnerable' under the BC Act. They have the broadest distribution worldwide but are uncommon within their Australian range (DEWHA, 2012c). Leatherback turtles are rarely recorded breeding within Australia; however, are known to regularly forage within continental shelf waters. The leatherback turtle is an oceanic, pelagic species that feeds primarily on jellyfish, sea squirts and other soft-bodied invertebrates (DEWHA, 2012c). They do not have BIAs or habitat critical intersecting the development envelope.

4.4.4.4 Hawksbill turtle

Hawksbill turtles are listed as 'vulnerable' and 'migratory' under the EPBC Act and 'vulnerable' under the BC Act and are generally associated with rocky and coral reef habitats, foraging on algae, sponges and soft coral (DEWHA, 2012c). There is a single breeding stock in the region, the Western Australian stock, which is centred on the Dampier Archipelago. The most significant breeding areas include Rosemary Island in the Dampier Archipelago, Varanus Island in the Lowendal group, and some islands in the Montebello group (DEWHA, 2012c). Hawksbill turtles nest in the region all year round with a peak between October and January. BIAs (Figure 4-6) and habitat critical (Figure 4-7) for the hawksbill turtles have been identified intersecting the development envelope.

4.4.4.5 Flatback turtle

Flatback turtles are listed as 'vulnerable' and 'migratory' under the EPBC Act and 'vulnerable' under the BC Act and are endemic to the northern Australia/southern New Guinea continental shelf. There are two breeding stocks within the North-west Marine Region, one of which (the NWS stock) has significant rookeries on Thevenard Island, Barrow Island, the Montebello Islands, Varanus Island, the Lowendal Islands, islands of the Dampier Archipelago (Fosette et al., 2021), and coastal areas around Port Hedland or along the Kimberley coast where suitable beaches occur (DEWHA, 2012c). Nesting begins in late November to December, peaks in January, and finishes by February to March. Flatback turtles differ from other marine turtles in that they do not have a pelagic phase to their lifecycle; instead, hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches. BIAs (Figure 4-6) and habitat critical (Figure 4-7) for the flatback turtles have been identified intersecting the development envelope.

4.4.4.6 Turtle nesting

Dampier Archipelago

Table 4-3 summarises records of nesting behaviour of green, flatback and hawksbill turtles on islands of the Dampier Archipelago.

Within the Dampier Archipelago, Rosemary Island has the most significant nesting beaches, determined as mean number of hawksbill, green and flatback turtle tracks per day (Pendoley et al 2016) and is recognised as an internationally significant rookery for hawksbill turtles (Limpus, 2009). On Rosemary Island, the majority of hawksbill nesting occurs on the north-western beaches (Gee et al. 2020) with lower density flatback and green nesting occurring at beaches on the eastern end of the Island. An analysis of turtle track data from these beaches on Rosemary Island between 1990 and 2017 has been undertaken (Whiting, 2018). The analysis concluded that nest counts were dominated by hawksbill turtles (9860 nesting events, or 92.1%), with flatback and green nest counts at 366 (3.4%) and 478 (4.5%), respectively. These results corroborate other conclusions that the nesting population of hawksbill turtles at Rosemary Island is one of the largest populations in Australia and globally (Limpus, 2009).

Other islands also with moderate nesting activity for all three species, include Delambre Island, Enderby Island, Eaglehawk Island and Angel Island (Pendoley et al 2016). Although track data confirmed presence of flatback turtles only at Legendre Island (Pendoley et al., 2016), a tagging program conducted in 2008 demonstrated that flatbacks, hawksbill and green turtles nested in notable numbers at this island (Biota, 2009). Of these, Delambre and Angel Islands are located within 20 km of the Project Area. Although Delambre Island is located 20 km SE of the borrow ground, the area within 20 km comprises rocky coastline unsuitable for turtle nesting.

Seasonality of nesting differs between flatback, green and hawksbill turtles. Table 4-4 provides a summary of the generalised seasonality across the North West Shelf region. A study by Whiting (2018) provides defined seasonality specific nesting data for Rosemary Island and found that hawksbill turtles having a much earlier peak (October/November) compared to flatback turtles (December/January peak). Seasonality for green turtles was not well defined from the available data

(Whiting, 2018). Given the discrete duration of surveys at Legendre Island (Biota, 2009), insufficient data is available to refine seasonality for this location.

Table 4-3: Records of nesting behaviour of green, flatback and hawksbill turtles on islands of the Dampier Archipelago (CALM, 1990; Pendoley et al., 2016; Biota, 2009)

	Angel	**Burrup Peninsula**	**Conzinc**	**Delambre**	**Dolphin**	**Eaglehawk**	**East Goodwyn**	**East Intercourse**	**Elphick Nob**	**Enderby**	**Hauy**	**Intercourse**	**Keast**	**Lady Nora**	**Legendre**	**Rosemary**	**West Intercourse**	**West Mid Intercourse**
Trunkline Corridor distance (km)	1.6	0	1.6	31	5	32	22	7.5	15	17	19	12	6.3	15	8.7	16	14	13
Offshore borrow ground distance (km)	21	26	28	20	16	57	41	42	32	43	14	45	10	28	6.6	40	48	46
Flatback	X	X	X	M	X	L	X	X	X	M	X	X	X	X	L	M	X	X
Green	-	X	-	L	X	L	-	X	-	L	X	-	-	-	X	M	X	-
Hawksbill	L	-	-	L	-	L	X	-	X	M	-	-	-	-	X	H	-	-

Key	
■	Island is within 20 km of the Project Areas plus nesting at ‘Low’ or above
▨	Island is within 20 km of the Project Areas, but nesting is less than ‘Low’
□	Island is more than 20 km from Project Areas
-	Absent
X	Present
L	Low: 1 – 10 tracks per day
M	Moderate: 11 – 100 tracks per day
H	High: 101 – 500 tracks per day

Table 4-4 Peak activity of nesting females and emerging hatchlings of green, flatback and hawksbill turtles in the NWS region

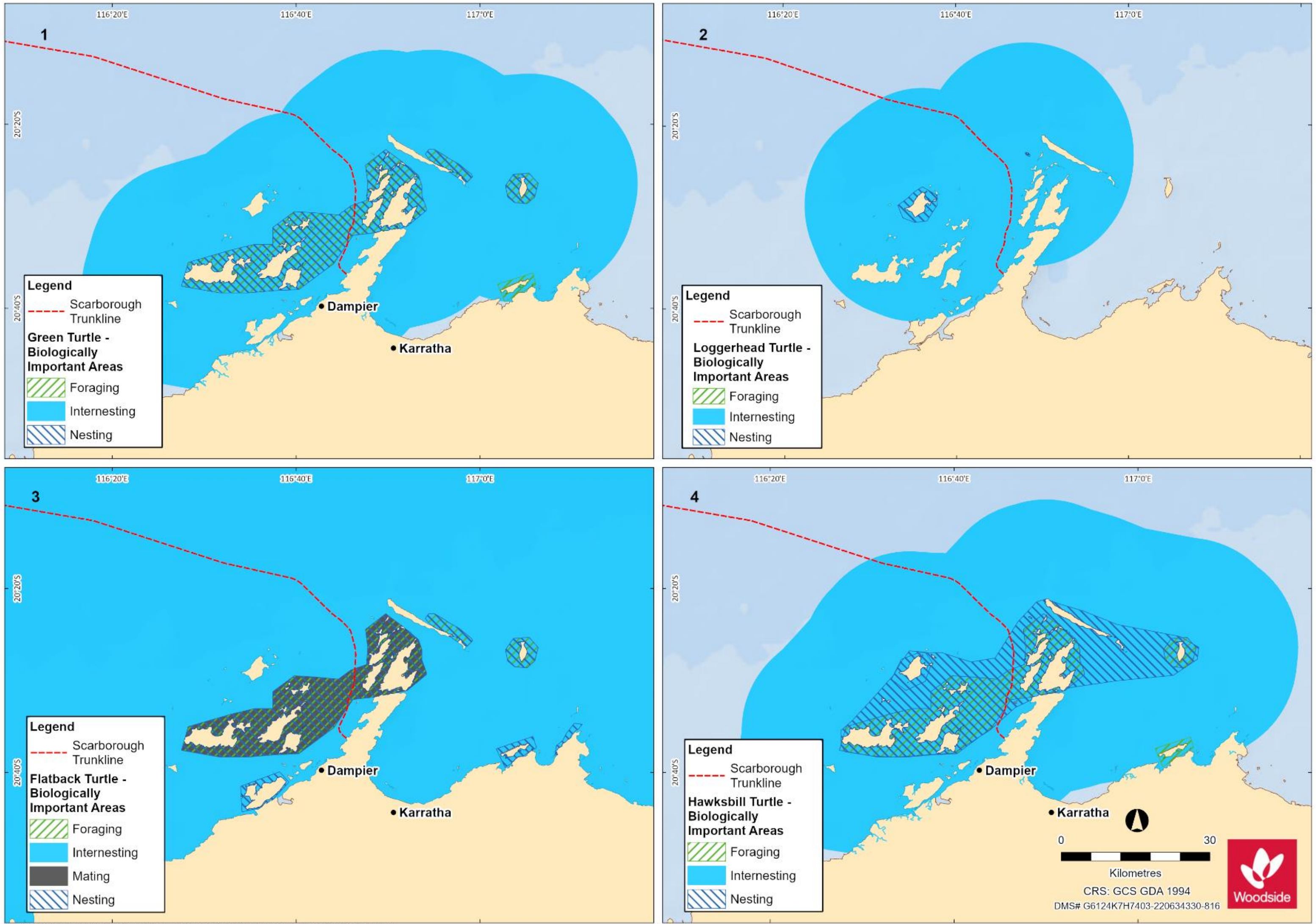
Species	**Activity**	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sept**		**Oct**		**Nov**		**Dec**	
Green turtle	Nesting	*	*	*	*	▨	▨	▨	▨												▨	*	*	*	*
	Emergence	*	*	*	*	*	*	▨	▨	▨	▨													▨	▨
Hawksbill turtle	Nesting	▨	▨															▨	▨	*	*	*	*	*	*
	Emergence	*	*	▨	▨																	▨	▨	*	*
Flatback turtle	Nesting	*	*	▨	▨	▨																▨	▨	*	*
	Emergence	*	*	*	*	▨	▨	▨	▨															▨	▨

*Peak nesting and peak turtle hatchling emergence period (Pendoley 2022)

Holden Beach

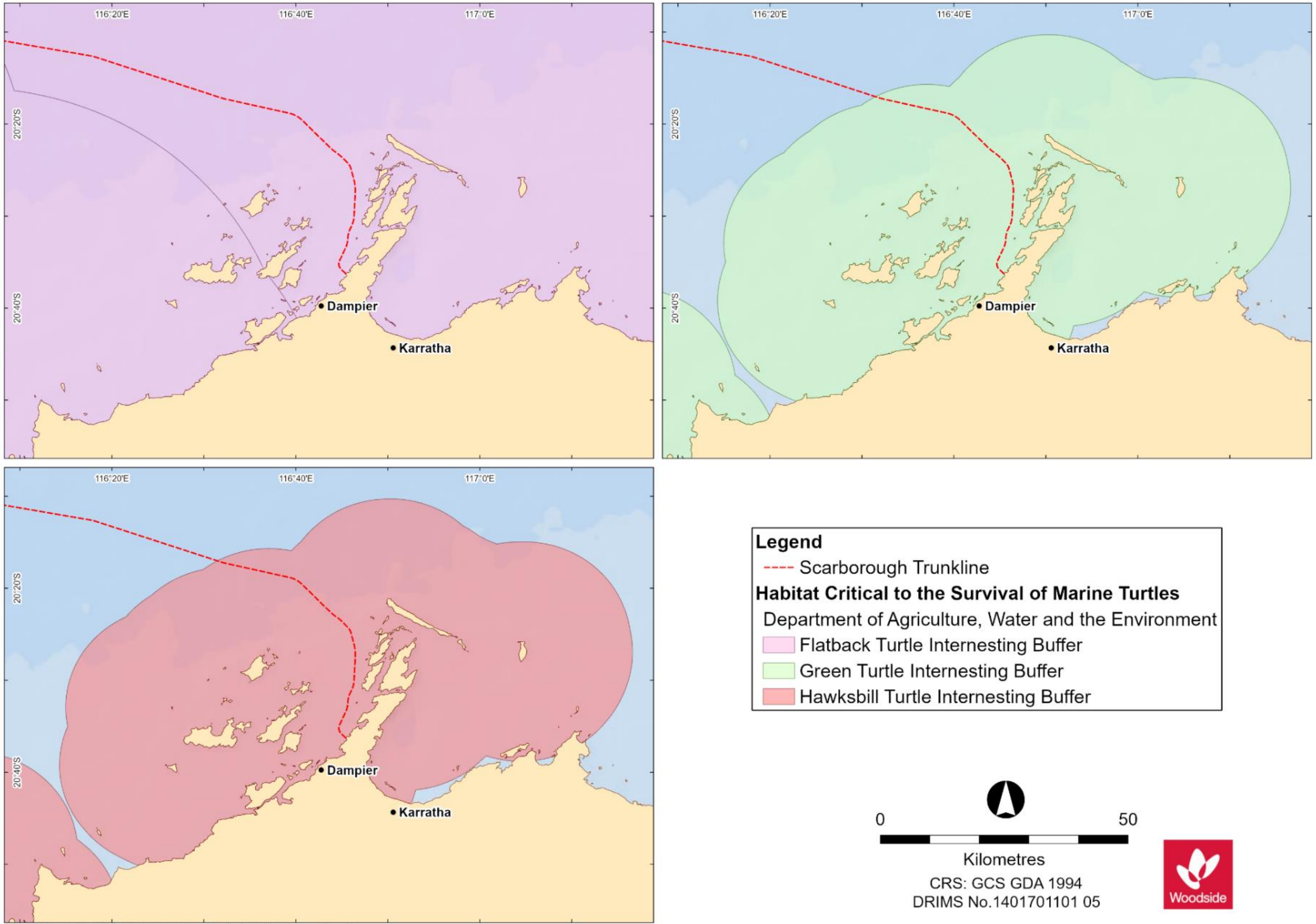
The nearest turtle nesting beach to the Proposal is Holden Beach to the south-west of the shore crossing location. Systematic turtle monitoring has been performed on Holden Beach adjacent to Site A of the Pluto LNG Plant throughout the construction and operational phases between 2007 to now. The key findings from a ten-year review of the monitoring are as follows (Pendoley, 2017):

- Holden Beach is a north-west facing beach, about 590 m long, situated immediately south of the existing Pluto LNG jetty, on the western coast of the Burrup Peninsula. The beach is split into two beaches by a rocky outcrop, which extends into the intertidal zone. Surveys conducted in the 2005–2006 and 2006–2007 seasons by Pendoley Environmental (Pendoley, 2005; 2006) suggested body pits observed on Holden Beach were characteristic of flatback and green turtles.
- Multiple existing and external sources of light are located close to Holden Beach, including lighting from the Pluto LNG jetty, Pluto LNG Site A infrastructure and other nearby facilities.
- A total of 63 turtle tracks have been identified on Holden Beach since monitoring began, creating 73 body pits which resulted in 35 successful nests. Turtle track activity on Holden Beach peaked between November and January during the 2007 to 2017 seasons.
- A total of 822 hatching tracks were observed between the 2007 and 2017 seasons. Hatchling emergence on Holden Beach peaked between December and February during the 2007 to 2017 seasons.
- The results indicate Holden Beach is not a major sea turtle rookery, supporting Pendoley (2010) which proposed key sea turtle nesting locations are located towards the outer Dampier Archipelago on Rosemary and Legendre Islands.



Basemap Esri, HERE, Garmin, FAO, METI/NASA, USGS, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue

Figure 4-6: Biologically important areas for marine turtles



Esri, HERE, Garmin, FAO, METI/NASA, USGS, GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue

Figure 4-7: Habitat Critical to the survival of marine turtles

4.4.5 Seabirds and shorebirds

A diverse assemblage of bird species is known to occur in and around the Dampier Peninsula, including species classified as vulnerable and migratory under the EPBC Act (Table 4-2).

The following summary focuses on the subset of species that have been identified as having ecologically significant interactions (such as breeding and foraging BIAs) in the area.

4.4.5.1 Wedge-tailed shearwater

The wedge-tailed shearwater (*Ardenna pacifica*) is listed as 'migratory' under the EPBC Act and the BC Act. It is a pelagic marine bird, usually recorded off the continental shelf of north-west Australia (Collins & Jessop, 1997). The species is a common visitor to the Pilbara region (Johnstone et al., 2013) and has been recorded breeding on several islands of the Dampier Archipelago. Breeding occurs during early November, with eggs incubated for around 53 days. A known breeding colony occurs on Conzinc Island. BIAs for the wedge-tailed shearwater have been identified as intersecting the development envelope and zone of influence.

4.4.5.2 Caspian tern

The Caspian tern (*Hydroprogne caspia*) is listed as 'migratory' under the EPBC Act and the BC Act. The species favours sheltered seas, flooded coastal samphire flats, brackish pools in the lower reaches of rivers, and saltworks (Johnstone et al., 2013) and is likely to forage in the waters of the Dampier Archipelago. The Caspian tern breeds between July and October. Eggs are incubated for around 22 days, with chicks fledging after around 35 days after hatching (Commonwealth of Australia, 2019). A known breeding colony occurs on Conzinc Island.

4.4.5.3 Bridled tern

The bridled tern (*Onychoprion anaethetus*) is listed as 'migratory' under the EPBC Act and the BC Act. The species is known to feed on a range of fish species, crustaceans and cephalopods, often feeding on fish forced to the surface by other predators (Dunlop, 1997). The species has been reported breeding on islands of the Dampier Archipelago, Montebello Islands, Lowendall Islands, Passage Islands and islands off Onslow between December and February (Johnstone et al., 2013). Populations of the species in WA are known to migrate north of the equator during winter (Johnstone et al., 2013).

4.4.5.4 Osprey

The osprey (*Pandion haliaetus*) is listed as 'migratory' under the EPBC Act. The species has a broad range throughout Australia, often occurring in coastal areas and on offshore islands. The osprey breeds between April and February, with individuals inhabiting northern regions of Australia tending to breed early in the season (Clancy, 2006). Nests are established on a broad variety of surfaces, including on cliffs, rocks, rock stacks and on the ground on rocky headlands and deserted beaches (Clancy, 2006; Dennis, 2007). The species feeds primarily on marine species, favouring fish but occasionally taking molluscs and crustaceans (Smith, 1985). Foraging is likely to occur within the zone of influence, with the highest level of foraging activity occurring during the breeding season.

4.4.5.5 Australian fairy tern

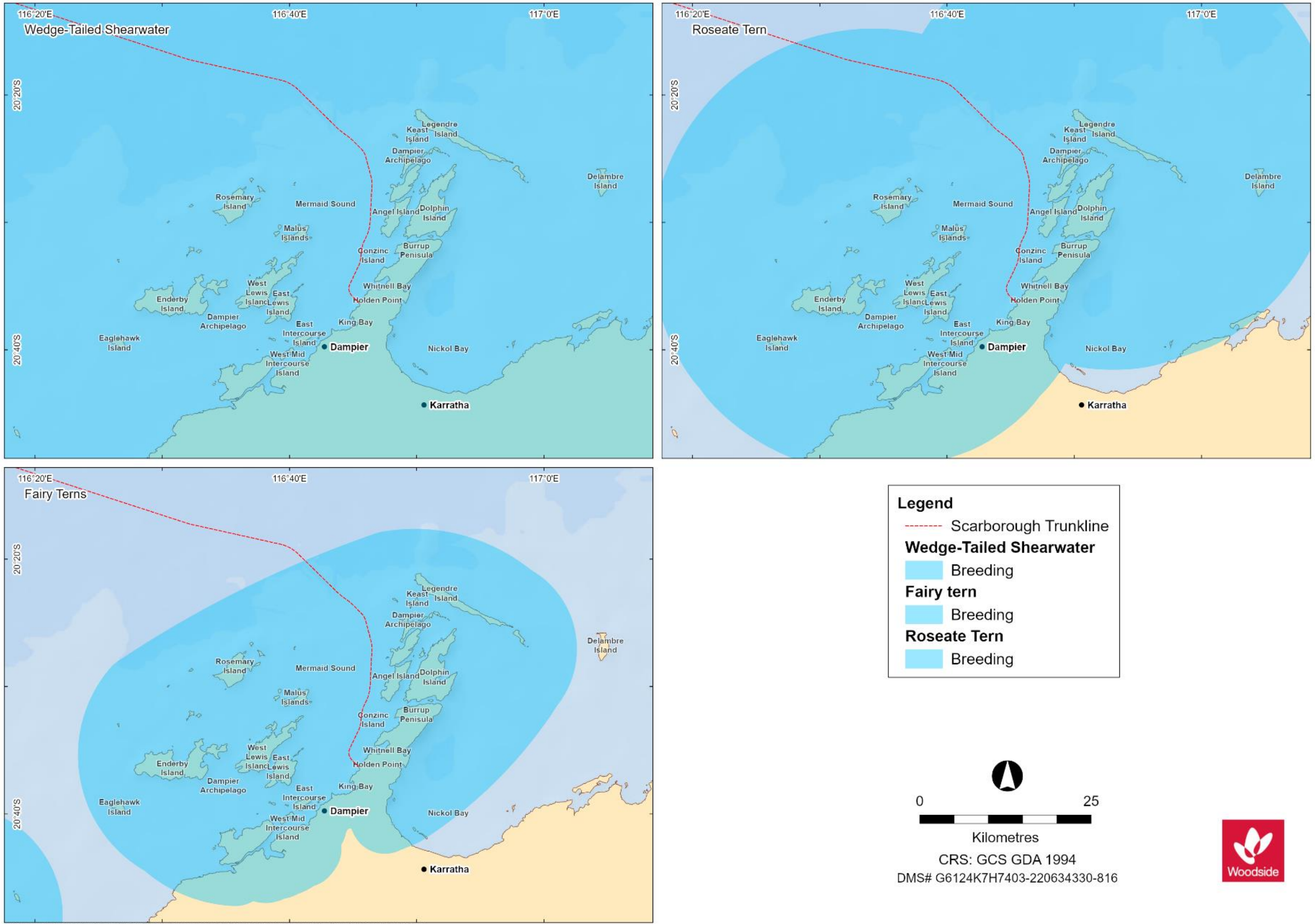
The Australian fairy tern (*Sternula nereis nereis*) is listed as 'vulnerable' under the EPBC Act and the BC Act. The species has been recorded breeding on several islands of the Dampier Archipelago, tending to favour sheltered in shore waters during non-breeding periods, remaining present in the vicinity of breeding sites throughout the year (Johnstone et al., 2013). The Australian fairy tern lays eggs between late July and early September (Johnstone et al., 2013), with eggs incubated for around 18 days (Higgins & Davies, 1996). In the event breeding fails in an area, the species has been known to move to new locations, attempting to relay within the same season (Higgins & Davies, 1996). BIAs for the Australian fairy tern have been identified as intersecting the development envelope and zone of influence.

4.4.5.6 Roseate tern

The roseate tern (*Sterna dougalli*) is listed as ‘migratory’ under the EPBC Act and the BC Act. The species has been recorded breeding on Goodwyn Island (Higgins & Davis, 1996), is generally associated with coral reefs and may also forage around islands on the continental shelf. Foraging in shallow, sheltered inshore waters is rarely recorded, with the species usually only venturing into these areas when breeding islands are nearby (Higgins & Davies, 1996). In WA, the species lays eggs between April and November, with hatching occurring around 25 days later (Higgins & Davies, 1996). The species is known to move away from breeding colonies after breeding; however, its non-breeding range is not well defined (Higgins & Davies, 1996). BIAs for the roseate tern have been identified as intersecting the development envelope and zone of influence.

4.4.5.7 Crested tern

The crested tern (*Thalasseus bergii*), also known as the greater crested tern, is listed as ‘migratory’ under the EPBC Act and the BC Act. The species occurs commonly along coastlines of the NWS (Johnstone et al., 2013), with breeding colonies established on islands, including some as far offshore as Bedout Island, the Montebello Islands and the Lowendal Islands (Johnstone et al., 2013). Breeding occurs between late March and May (Johnstone et al., 2013) and the species tends to forage within around 5 km of colonies during the breeding period (McLeay et al., 2010). Given the preference for foraging close to breeding colonies, foraging is likely to occur within the zone of influence.



Sources: GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue, GeosciencesAustralia, Esri, DeLorme, NaturalVue

Figure 4-8: Biologically important areas for seabirds and shorebirds

4.4.6 Fish

There are more than 650 species of fish that occur within the waters of the Dampier Archipelago. This includes species classified as 'threatened' and 'migratory' under the EPBC Act (Table 4-2). Fish are reported by MAC as culturally important species in Mermaid Sound and surrounds, with Thalu ceremonies associated with increasing fish stocks. Further fish traps in Conzinc Bay, and others would have/do exist in coastal areas of islands (e.g., Angel and Gidley Islands), as well as harvesting of squid from the ocean around Conzinc Island are also important aspects of the marine environment to Traditional Custodians represented by MAC (MAC, 2021).

The following summary focuses on the subset of species that may be considered 'iconic', such as sawfishes, sharks and rays.

4.4.6.1 Sawfishes

Sawfishes generally inhabit inshore coastal, estuarine and riverine environments (Commonwealth of Australia, 2015b). Important areas for sawfishes adjacent to the North-west Marine Region include the Pilbara coast, King Sound, and lower reaches of the Fitzroy, May and Robinson rivers for the dwarf sawfish; and Cape Keraudren for the green sawfish (DEWHA, 2012b).

4.4.6.2 Grey nurse shark

The grey nurse shark (west coast population) has a broad inshore distribution, primarily in sub-tropical to cool temperate waters (Last & Stevens, 1994). The population of grey nurse shark (west coast population) is predominantly found in the south-west coastal waters of WA (Environment Australia, 2002a) and has been recorded as far north as the NWS (Stevens, 1999; Pogonoski et al., 2002). Grey nurse sharks are often observed hovering motionless just above the seabed, in or near deep sandy-bottomed gutters or rocky caves, and near inshore rocky reefs and islands (Pollard et al., 1996). It is therefore unlikely to be present near the development envelope but may occur around the Dampier Archipelago islands.

4.4.6.3 Great white shark

In Australia, great white sharks have been recorded from central Queensland around the south coast to north-west WA but may occur further north on both coasts (Bonfil et al., 2005; Bruce et al., 2006; Last & Stevens, 2009; Paterson, 1990). They have been sighted in all coastal areas except in the Northern Territory. Within Australian waters, most recorded great white shark movements occur between the coast and the 100 m depth contour. Great white sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski et al., 2002 in DEWHA, 2009). Great white sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA, 2009). They were identified as potentially occurring within the development envelope, but given the migratory nature of the species, its low abundance, broad distribution in temperate waters across southern Australia and absence of preferred prey (pinnipeds), great white sharks are unlikely to occur in large numbers.

4.4.6.4 Manta rays

The reef manta ray is commonly sighted inshore but also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al., 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations (Deakos et al., 2011; Marshall et al., 2009).

The giant manta ray is broadly distributed in tropical waters of Australia. The species primarily inhabits nearshore environments along productive coastlines with regular upwelling, but appear to be seasonal visitors to coastal or offshore sites, including offshore island groups, offshore pinnacles and seamounts (Marshall et al., 2011).

4.4.7 Planktonic communities

In the North-west Marine Bioregion, productivity is typically greater during the wet season when the weakening of surface currents allows for increased upwelling (DEWHA, 2008a; Brewer et al., 2007). Areas of enhanced production are also observed at the interface between stable waters warmed by solar heating and unstable waters mixed by tidal turbulence, which is more prevalent in nearshore environments where depths are greater than 40 m (Heyward et al., 2000). Productivity is greater in shallow nearshore environments within State waters than in the offshore waters. During the warmer months, extensive blooms of *trichodesmium* occur on a regional scale, including within the Dampier Archipelago. Its role in the trophic system and the nutrient cycle is not well understood, though it may contribute significantly to the nitrogen budget. There have been no known deleterious water quality impacts caused by toxic algal blooms in the region (Heyward et al., 2000).

A study by Jones (2001) determined a total of 22 zooplankton species and 45 other planktonic taxa, including crustaceans, molluscs, polychaete worms, arrow worms, sea squirts and coelenterates, have been introduced into the Dampier Archipelago via vessel ballast water.

4.5 Social surroundings

4.5.1 Land use

The Proposal is located within the Pilbara region in the Port of Dampier limits managed by PPA. Dampier Port is a major industrial port in the north-west of Western Australia. It is one of the world's largest bulk export ports by tonnage and services, including petrochemical, salt, iron ore and natural gas export industries.

The shoreline crossing and the State waters component of the trunkline are within the Dampier Port boundary. The closest residential township is Karratha, which lies 15 km south-east of the shoreline crossing. Existing surrounding land uses include:

- The North West Shelf project, one of the world's largest LNG producers supplying oil and gas to the WA and international markets from offshore gas and condensate fields located 135 km north-west of Karratha in the Carnarvon Basin
- Pluto LNG Foundation project, a major LNG gas project with onshore facilities that process gas from the Pluto and Xena gas fields located 190 km north-west of Karratha in the Carnarvon Basin
- Rio Tinto Iron Ore operations, a major iron ore producer that excavates iron ore from inland mines for export from its facilities at Parker Point and East Intercourse Island
- Rio Tinto Dampier Salt operations, the world's largest exporter of salt
- Yara Pilbara Fertilisers operations, one of the world's largest ammonia producers.

4.5.2 Shipping

The region supports significant commercial shipping activity, mostly associated with the mining and oil & gas industries. Major shipping routes in the area are associated with vessels entering the ports of Dampier and Barrow Island. The relevant port authority for Dampier Port is PPA.

Commercial shipping activities in the region include:

- international bulk freighters and tankers arriving and departing from Dampier, including mineral ore, hydrocarbons (LNG, liquefied petroleum gas, condensate) and salt carriers
- domestic support and supply vessels servicing offshore facilities and the Barrow Island development
- construction vessels, barges and dredges
- offshore survey vessels.

AMSA has introduced a network of commercial shipping fairways on the NWS to reduce the risk of vessels colliding with offshore infrastructure. The fairways are not mandatory, but AMSA strongly recommends commercial vessels remain within the fairway when transiting the region.

Sea access to the Port is via three major and three minor shipping channels (Table 4-5).

Table 4-5: Shipping channels within Port waters (Dampier Port Authority, 2014)

Channel	Declared depth (chart datum)	Provides access to
NWS Project Channel	12.2 m	North West Shelf Venture LNG and liquefied petroleum gas jetties
Rio Tinto Iron Ore Channel	15.4 to 15.5 m	East Intercourse Island, Parker Point and Mistaken Island wharves
Pluto Channel	12.5 m	Pluto LNG Foundation project jetty
Mermaid Marine Australia Supply Base Channel	5.2 m	Mermaid Marine Australia Supply Base wharves
King Bay Supply Base Channel	6.0 m	King Bay Supply Base tug pens, Pluto Supply Base berths
Dampier Bulk Liquids Berth Channel	11.0 m	Dampier Cargo Wharf, Dampier Bulk Liquids Berth, Heavy Load Out Facility, Alternate Load Out Facility, Floating Deck Transhipment System

4.5.3 Tourism

Charter fishing, cruising, diving, snorkelling, whale watching, and marine turtle and dolphin watching are the main commercial tourism activities in and adjacent to the North-west Marine Region. Except for offshore charter fishing, most marine tourism activities occur in State waters, including in the Dampier Archipelago (DEWHA, 2008a).

Recreational fishing tends to be concentrated in State waters adjacent to population centres, with the highest records typically documented in areas such as Point Samson, Coral Bay and Carnarvon (DEWHA, 2008a). The Dampier Archipelago is also a popular recreational fishing area.

4.5.4 Recreational fishing

Around one third of Western Australians, or about 600,000 people, regularly participate in recreational fishing activities (CALM, 2000). In 2003–2004, the Pilbara and Kimberley regions accounted for 5% of the state's recreational fishing effort (Penn et al., 2005), and in 1999–2000, an estimated 300 tonnes of scalefish were taken recreationally throughout the region from Onslow to Broome, excluding Thevenard Island and Barrow Island charter vessel catches (Williamson et al., 2006).

The popularity of recreational fishing has grown substantially in the Pilbara region over recent years, with a distinct seasonal peak in winter when significant numbers of metropolitan and interstate tourists travel through the area and visit the Dampier Archipelago. The high tidal range in the area means beach fishing is limited to periods of flood tides and high water (Penn et al., 2005). Consequently, much of the angling activity is boat-based. The Pilbara region has the highest boat ownership per capita in Australia (CALM, 2000).

Licenced fishing tours in the region are also a popular tourist attraction. At the end of 2003, the Pilbara and Kimberley regions had 97 licenced fishing tour operators providing 2846 recreational fishing tours (Penn et al., 2005).

Several methods of recreational fishing are used throughout the Dampier Archipelago, including line fishing, netting and spear fishing, with line fishermen targeting deepwater large pelagic species and trolling for smaller fish within the Archipelago nearshore areas. Creek systems, mangroves, rivers and beaches also support a variety of recreationally targeted species, including blue-lined emperor (*Lethrinus laticaudis*), spangled emperor (*Lethrinus nebulosus*), sweetlip emperor (*Lethrinus* *miniatus*), red emperor (*Lutjanus sebae*), estuary cod (*Epinephelus coioides*), sea perches such as mangrove jack, trevally species (*Gnathanodon speciosus*, *Caranx ignobilis* and *Caranx sexfasciatus*), sooty grunter, threadfin salmon species (*Eleutheronema tetradactylum*, *Polydactylus macrochir* and *Polydactylus plebius*), and mud and blue manna crabs.

Offshore islands, coral reef systems and continental shelf waters provide species of major recreational interest, including sharks, tunas, billfish, trevally species, mackerel (*Scomberomorus* spp.), tuskfish (*Choerodon* spp.), coral trout (*Plectropomus leopardus*), coronation trout (*Variola louti*) and bar-cheeked coral trout (*Plectropomus maculatus*) (Penn et al., 2005).

Offshore areas containing coral and subtidal rocky reefs are targeted. Artificial habitat created by existing gas trunklines is also popular.

4.5.5 Fisheries

4.5.5.1 Commonwealth and state fisheries

Many Commonwealth and State fisheries are located within and in proximity of the development envelope. Table 4-6 provides further detail about the fisheries that have been identified through desktop assessment, and are shown in Figure 4-9, Figure 4-10 and Figure 4-11.

Table 4-6: Commonwealth and State fisheries

Fishery	Description
Commonwealth Managed Fisheries	
Southern Bluefin Tuna Fishery	**Description:** The Southern Bluefin Tuna Fishery Management Area encompasses the entire Australian Fishing Zone. The Fishery targets a single, migratory stock that spawns in the north-east Indian Ocean and migrates throughout the temperate southern oceans, including a southbound migration past Western Australia. The Fishery employs both longlining and purse seine net fishing methods, with the majority of fishing in Australia by purse-seine (Patterson, et al., 2021). **Potential for interaction:** While there is an overlap with the fishery management area and the development envelope, no fishing effort has occurred within or nearby to the development envelope for at least the last ten years (Patterson et al., 2021). Accordingly, there is considered to be no potential for interaction with this fishery given the current distribution of fishing effort is focused in the Great Australian Bight, Tasmania and along the New South Wales coast. **Fishery boundary distance from development envelope:** Overlaps the Zone of Influence (ZoI) (Section 5.6). **Licences/vessel s:** Seven active purse seine vessels and 31 active longline vessels (Patterson et al., 2021).
Western Skipjack Fishery	**Description:** The combined Western and Eastern Skipjack Tuna (*Katsuwonus pelamis*) Fisheries encompass the entire Australian Exclusive Economic Zone, including the development envelope. The target species has historically been used for canning, and with the closure of canneries at Eden and Port Lincoln, effort in the fishery has declined and there have been no active vessels operating since 2009 (Patterson and Bath, 2014). No fishing effort for the Western Skipjack Tuna Fishery has been recorded since the 2008–2009 fishing season as a result of the natural variability of skipjack tuna stocks in Australian waters and low unit price for this species (ABARES, 2021). **Potential for interaction:** Given the fishery has been inactive for many years and the distribution of fishing effort when the fishery was active, there is considered to be no potential for interaction with this fishery. Should the fishery commence efforts in the area in the future, fishing effort in the development envelope and surrounding area is considered unlikely, given the historical fishery was concentrated off southern Australia. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Not applicable (fishery inactive).

Fishery	Description
Western Tuna and Billfish Fishery	**Description:** The West Tuna and Billfish Fishery is currently active, running throughout the year. The fishery zoning extends to the Australian Exclusive Economic Zone boundary, starting from the Gulf of Carpentaria and extending westward to the South Australia-Victoria border., overlapping the development envelope. The fishery targets four pelagic species, which are all highly mobile (ABARES, 2019), being: • broadbill swordfish (*Xiphias gladius*) • bigeye tuna (*Thunnus obesus*) • yellowfin tuna (*T. albacares*) • albacore tuna (*T. alalunga*). The number of vessels operating in the fishery has declined in recent years, with less than five vessels operating since 2005 (Patterson and Stephan, 2016; Williams et al., 2016). Fishery effort is concentrated in western and south-western Australia, from offshore Point Cloates to Augusta (ABARES, 2021). The methods used by the fishery are mainly pelagic longline and some minor-line fishing. No significant effort near the development envelope has been documented. **Potential for interaction:** While there is an overlap with the fishery management area and the development envelope, no fishing effort has occurred within or nearby to the area for at least the last ten years (Patterson et al., 2020). Accordingly, there is considered to be no potential for interaction with this fishery given the current distribution of fishing effort is concentrated south-west of the development envelope from Exmouth to Augusta. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Three vessels (two pelagic longline, one minor longline) (Williams et al., 2016).
State Managed Fisheries	
Pilbara Line Fishery	**Description:** The Pilbara Line Fishery encompasses all of the ‘Pilbara waters’, extending from a line commencing at the intersection of 21°56’S latitude and the boundary of the Australian Fishing Zone and north to longitude 120°E (Newman et al., 2014). The Pilbara Line Fishery targets tropical demersal scalefish. There are no stated depth limits and the western extent of the fishery is the boundary of the Australian Fishing Zone (AFZ) (Newman et al., 2015b). The Pilbara Line Fishery is managed under the Prohibition on Fishing by Line from Fishing Boats (Pilbara Waters) Order 2006 with the exemption of nine fishing vessels for any nominated 5-month block period within the year. Fishing in Area 3 has also been a closed to line fishing since 1998 (Newman et al., 2015b). **Potential for interaction:** There have been six active vessels within the 60 NM CAES block (ref. 20160) that overlaps the development envelope from 2011-2020, inclusive (DPIRD, 2021). Therefore, there is considered to be a potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Five active line vessels in 2019 (Newman et al., 2020a).

Fishery	Description
Pilbara Trap Managed Fishery	**Description:** The Pilbara Trap Managed Fishery covers the area from Exmouth northwards and eastwards to the 120° line of longitude, and offshore to approximately the 200 m isobath. The Pilbara Trap Managed Fishery targets a range of species including red emperor, goldband snapper, spangled emperor, flagfish, threadfin bream, jobfish and Rankin cod. The fishery is managed by the use of input controls in the form of individual transferable effort allocations monitored with a satellite-based vessel monitoring system (VMS). Traps are limited in number with the greatest effort in waters greater than 50 m depth. **Potential for interaction:** The development envelope is partially located within a permanently closed portion of the fishery inside of the 50 m isobath. The northern portion of the development envelope overlaps the larger area where fishing activities are permitted. There have been three active vessels within the 60 NM CAES block (ref. 20160) that overlaps the development envelope from 2011-2020, inclusive (DPIRD, 2021). Therefore, there is considered to be a potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Three active trap vessels in 2019 (Newman et al., 2020a).
Pilbara Fish Trawl (Interim) Managed Fishery	**Description:** The Pilbara Fish Trawl (Interim) Managed Fishery operates between the 50 m and 200 m isobath of the Pilbara coast, northwards of 21°S and between 114°E and 120°E (Newman et al., 2020a). The Pilbara Fish Trawl (Interim) Managed Fishery uses trawl nets to target a variety of scalefish species including tropical demersal fish. **Potential for interaction:** The development envelope is located within an area of the fishery that is closed to trawling. The closest area where trawl fishing is permitted is located approximately 15 km north of the development envelope. Therefore, there is considered to be no potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Two trawl vessels active in 2019 (Newman et al., 2020a).
West Coast Deep Sea Crustacean Managed Fishery	**Description:** The West Coast Deep Sea Crustacean Managed Fishery extends north from Cape Leeuwin to the Western Australia/Northern Territory border in water depths greater than 150 m within the Australian Fishing Zone. The West Coast Deep Sea Crustacean Managed Fishery targets crystal (snow) crabs (*Chaceon albus*), giant (king) crabs (*Pseudocarcinus gigas*) and champagne (spiny) crabs (*Hypothalassia acerba*) using baited pots operated in a long-line formation in the shelf edge waters (>150 m but mostly in depths of 500–800 m) (WAFIC, n.d.). **Potential for interaction:** The West Coast Deep Sea Crustacean Managed Fishery operates in the West Coast and Gascoyne Bioregions, outside of the development envelope (How et al. 2015; DPIRD, 2021). Therefore, while there is an overlap with the West Coast Deep Sea Crustacean Managed Fishery management area, there is considered to be no potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Four vessels operating in 2019 (How & Orme, 2020).

Fishery	Description
Specimen Shell Managed Fishery	**Description:** The Specimen Shell Managed Fishery can operate in Western Australian waters. The Specimen Shell Managed Fishery collects specimen shells for display, collections, cataloguing and sale. Specimens are predominantly collected by hand when diving or wading in shallow coastal waters, though a deeper water collection aspect to the fishery has been initiated by employing ROVs operating at depths up to 300 m (Hart and Crowe, 2015). **Potential for interaction:** The fishery encompasses the entire Western Australian coastline but effort is concentrated in areas adjacent to the largest population centres such as Broome, Karratha, Shark Bay, Mandurah, Exmouth, Capes area, Albany and Perth (Hart and Crowe, 2015). There have been three active licences within the CAES blocks the overlap the development envelope from 2011-2020, inclusive (10 NM CAES blocks: 202164 and 203164 (DPIRD, 2021)). Therefore, there is considered to be potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** In 2019, around 9 licences recorded consistent activity (Hart et al, 2020b).
Onslow Prawn Managed Fishery	**Description:** The Onslow Prawn Managed Fishery encompasses a portion of the continental shelf off the Pilbara region. The fishery targets western king prawns (*Penaeus latisulcatus*), brown tiger prawns (Penaeus esculentus) and endeavour prawns (Metapenaeus spp.) using demersal trawl gear. Strict seasonal fishing and voluntary closure periods for three days around the full moon period applies (Sporer et al. 2014). Total prawn catches in 2015 were about 10.1 tonnes, considerably lower than other prawn fisheries (total north coast prawn landings in 2015 were 175 tonnes) (Sporer et al., 2017). **Potential for interaction :** Only 28 days (308 hours) of fishing effort was undertaken by one boat in 2019 (Kangas et al. 2020a), and there have been no active vessels within the CAES blocks that overlap the development envelope from 2011-2020, inclusive (DPIRD, 2021). Therefore, it is considered that there is no potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** One vessel in 2019 (Kangas et al., 2020a).
Nickol Bay Managed Prawn Fishery	**Description:** The Nickol Bay Prawn Managed Fishery extends from the Dampier Archipelago to Eighty Mile Beach, including nearshore waters within the development envelope. The Nickol Bay Prawn Managed Fishery targets penaeid prawns (primarily banana prawns) using trawl gear. The target species typically inhabits sandy and muddy substrate in < 45 m water depth. About 87 tonnes were landed in 2015, comprised largely of banana prawns (Sporer et al., 2017). The season for this fishery extends from March to November, with several specific areas restricted to May to September to protect nursery areas (Sporer et al., 2014). Trawling has been reported to occur at several locations along the Pilbara coast to the east of the Burrup Peninsula, including within the waters of Nickol Bay (Fletcher & Santoro, 2014). **Potential for interaction:** There have been up to 11 vessels active within the CAES blocks that overlap the development envelope from 2011-2020, inclusive (10 NM CAES blocks: 202164, 203164 (DPIRD, 2021)). Therefore, it is considered that there is potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** The precise number of vessels is unreported, though fishing effort increased to 353 boat days in 2019 and produced a catch of 254 t, the highest catch since 2006 (Kangas et al., 2020a).

Fishery	Description
Pilbara Crab Managed Fishery	**Description:** The Pilbara Crab Managed Fishery operates under exemption basis to explore the commercial viability of crabs along the Pilbara coastline. The management boundary includes waters between 114°06'E (approximately Onslow) to 123°45'E (Eighty Mile Beach) and extends to approximately the 200 m isobath. The fishery targets blue swimmer crabs using hourglass traps within inshore waters around Nickol Bay. **Potential for interaction:** The development envelope is partially located within a closed portion of the fishery that encompasses the Dampier Archipelago. The northern portion of the development envelope overlaps the larger area where fishing activities are permitted. There have been three active vessels within the 60 NM CAES block (ref. 20160) that overlaps the development envelope from 2011-2020, inclusive (DPIRD, 2021). Therefore, there is considered to be potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** two active vessels in 2019 (Johnston et al., 2020).
Pearl Oyster Managed Fishery, Pearling Leases	**Description**: The Western Australian Pearl Oyster Managed Fishery is the only remaining significant wild-stock fishery for pearl oysters in the world. The development envelope overlaps the Pearl Oyster Zone 1, which extends from North West Cape (including Exmouth Gulf) (119°30´E) to Cape Thouin (118°20´E). The fishery targets the Indo-Pacific silver-lipped pearl oyster (Pinctada maxima), the primary spawning of which occurs from mid-October to December. A smaller secondary spawning occurs in February and March (Hart et al., 2014). The fishery collects pearl oyster in shallow coastal waters along the North West Shelf using divers, and are mainly used to culture pearls. Fishing in Zone 1 has occurred as a low proportion (<1%) of the total annual catch after a hiatus from 2008–2013 (Hart et al., 2018a), and in 2017 there was no fishing undertaken in Zone 1 (Hart et al., 2020a). **Potential for interaction:** No fishing effort from the Pearl Oyster Managed Fishery occurs within or adjacent to the development envelope (DPIRD, 2021). Therefore, there is considered to be no potential for interaction with Pearl Oyster Managed Fishery fishers. No aquaculture leases occur within the development envelope. The closest lease is located about 13 km west of the development envelope, on the western side of West Lewis Island.. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels**: Five active vessels fin 2019 (Hart et al. 2020a) **Divers:** 14,022 diver hours and 611,816 shells in 2019 (Hart et al., 2020a).
Marine Aquarium Managed Fishery	**Description:** The Marine Aquarium Managed Fishery can operate in all State waters, with effort typically concentrated around the Capes region, Perth, Geraldton, Exmouth and Dampier (Department of Climate Change, Energy, the Environment and Water 2022). The landed catch is predominantly ornamental fish but also includes seahorses, invertebrates, corals and live rock (Newman et al., 2020b). The fishery is primarily a dive-based fishery that uses hand-held nets to capture target species operating from boats up to 8 m in length. The fishery is typically active from Esperance to Broome, with popular areas including the coastal waters of the Capes region, Dampier and Exmouth. **Potential for interaction:** There have been up to seven active vessels within the CAES blocks that overlap the development envelope from 2011-2020, inclusive (10 NM CAES blocks: 202164 and 203164 (DPIRD, 2021)). Therefore, there is considered to be potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** 11 active licences in 2019 (Newman et al., 2020b).

Fishery	Description
West Australian Abalone Fishery	**Description:** The Western Australian abalone fishery includes all coastal waters from the Wester Australian/South Australia border to the Western Australia/Northern Territory border. The abalone fishery targets the greenlip abalone (*Haliotis laevigata*), brownlip abalone (*H. conicopora*) and Roe's abalone (*H. roei*) (DoF, 2004). The fishery is concentrated on the south coast (greenlip and brownlip abalone) and the west coast (Roe's abalone). Abalone are harvested by divers, limiting the fishery to shallow waters (typically < 30 m). **Potential for interaction:** No commercial fishing for abalone north of Moore River (Zone 8 of the managed fishery) has taken place since 2011–2012 (Strain et al., 2017). While there is an overlap with the Abalone Fishery management area, there is considered to be no potential for interaction with fishers within the development envelope. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** 21 commercially fishing for Roe's abalone (Strain et al., 2020).
Western Australian Mackerel Managed Fishery	**Description:** The Mackerel Managed Fishery targets Spanish mackerel (*Scomberomorus commerson*) using near-surface trawling gear from small vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel (*S. semifasciatus*), with other species from the genera *Scomberomorus* (Molony et al., 2015). The commercial fishery extends from Geraldton to the Northern Territory border. There are three managed fishing areas: Kimberley (Area 1), Pilbara (Area 2), and Gascoyne and West Coast (Area 3). Most of the catch is taken from waters off the Kimberley coast (Lewis and Jones, 2017), reflecting the tropical distribution of mackerel species (Molony et al., 2015). Most fishing activity occurs around the coastal reefs of the Dampier Archipelago and Port Hedland area (Area 2), with the seasonal appearance of mackerel in shallower coastal waters most likely associated with feeding and gonad development before spawning (Mackie et al., 2003). The fishery operates to a depth of about 90 m. The commercial fishery takes place over about six months from May – November, when Spanish mackerel are abundant in coastal areas (Lewis et al. 2020). **Potential for interaction:** There have been less than three active vessels within the CAES blocks that overlap the development envelope in the last 10 years, inclusive (10 NM CAES blocks: 203164 and 202164 (DPIRD, 2021)). During this time the Western Australian Mackerel Managed Fishery was active within these blocks in 2018, 2019 and 2020; therefore, there is considered to be potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** 15 active vessels during the 2019 mackerel fishing season, primarily from May to November (Lewis et al. 2020).
South West Coast Salmon Managed Fishery	**Description:** The South West Coast Salmon Managed Fishery operates on various beaches south of the metropolitan area and includes all Western Australian waters north of Cape Beaufort except Geographe Bay. This fishery uses beach seine nets to take Western Australian salmon (*Arripis truttaceus*). No fishing occurs north of the Perth metropolitan area, despite the managed fishery boundary extending to Cape Beaufort (WA/Northern Territory border). **Potential for interaction:** While the South West Coast Salmon Managed Fishery boundary extends to the WA / Northern Territory border, the fishery operates in the West Coast Bioregion, over 950 km south of the development envelope (WAFIC, n.d.). Therefore, while there is an overlap with the South Coast Salmon Managed Fishery management area, it is considered that there is no potential for interaction with fishers within the development envelope. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Six commercial fishers (DPIRD, 2019).

Fishery	Description
Beche-de-mer Fishery	**Description:** The sea cucumber or 'Beche-de-mer' Fishery is a hand harvested fishery that can be conducted within all Western Australian waters (Hart et al., 2019). This nearshore fishery is predominantly a single species fishery with 99% of the catch being sandfish (*Holothuria scabra*). Collection methods are limited to shallow, coastal waters (methods principally by diving or wading). **Potential for interaction:** While there are specific areas closed to this fishery including parts of the Dampier Archipelago, the development envelope is located within an area that may be fished by the Beche-de-mer Fishery. There have been less than three licences active within the CAES blocks that overlap the development envelope from 2011-2020, inclusive (10 NM CAES blocks: 202164, 203164 (DPIRD, 2021)). The licence holder(s) were active within these blocks in 2014 and again in 2016. Therefore, there is considered to be potential for interaction with fishers. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** Less than three licences active within the CAES blocks that overlap the development envelope from 2011-2020. The total number of licence holders is not reported in the Status of the Fisheries Reports.
WA North Coast Shark Fishery	**Description:** The WA North Coast Shark Fishery management boundary includes waters between 114°06'E (approximately Onslow) to 123°45'E (Eighty Mile Beach) and extends to approximately the 200 m isobath. **Potential for interaction:** In 2008, the WA North Coast Shark Fishery's Wildlife Trade Operation approval under the EPBC Act was revoked because a formal management plan had not been finalised (Patterson et al., 2019). Therefore, no vessels are active in the fishery. While there is an overlap with the WA North Coast Shark Fishery management area, there is considered to be no potential for interaction with fishers within the development envelope. **Fishery boundary distance from development envelope:** Overlaps the ZoI. **Licences/vessels:** N/A

4.5.5.2 Aquaculture

Aquaculture development in the north coast bioregion is dominated by the production of pearls from the species *Pinctada maxima* (Gaughan and Santoro, 2018). Many pearl oysters for seeding are obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and around the Dampier Peninsula (Gaughan and Santoro, 2018).

The know aquaculture leases are shown in Figure 4-12. MAC is assisting with the Pilbara Rock Oyster Research and Development Project being conducted by the Pilbara Development Commission and the Fisheries Research Development Corporation on behalf of the Australian Government, City of Karratha and Maxima Pearling Company. A pilot project to grow rock oysters in Flying Foam Passage is being performed by Maxima Pearling and the Pilbara Development Commission, in collaboration with MAC. The aim of the trial is to test a range of equipment and locations and assess growth rates to determine the best setup for a commercial operation in the Pilbara. This aquaculture lease is around five kilometres east of the development envelope and the ZoI does not intersect this lease.

Maxima Pearling Company also has additional aquaculture exemption application sites in flying foam passage, and aquaculture exemption application sites Searipple Passage, Withnell Bay and off West Lewis Island as illustrated in Figure 4-12.

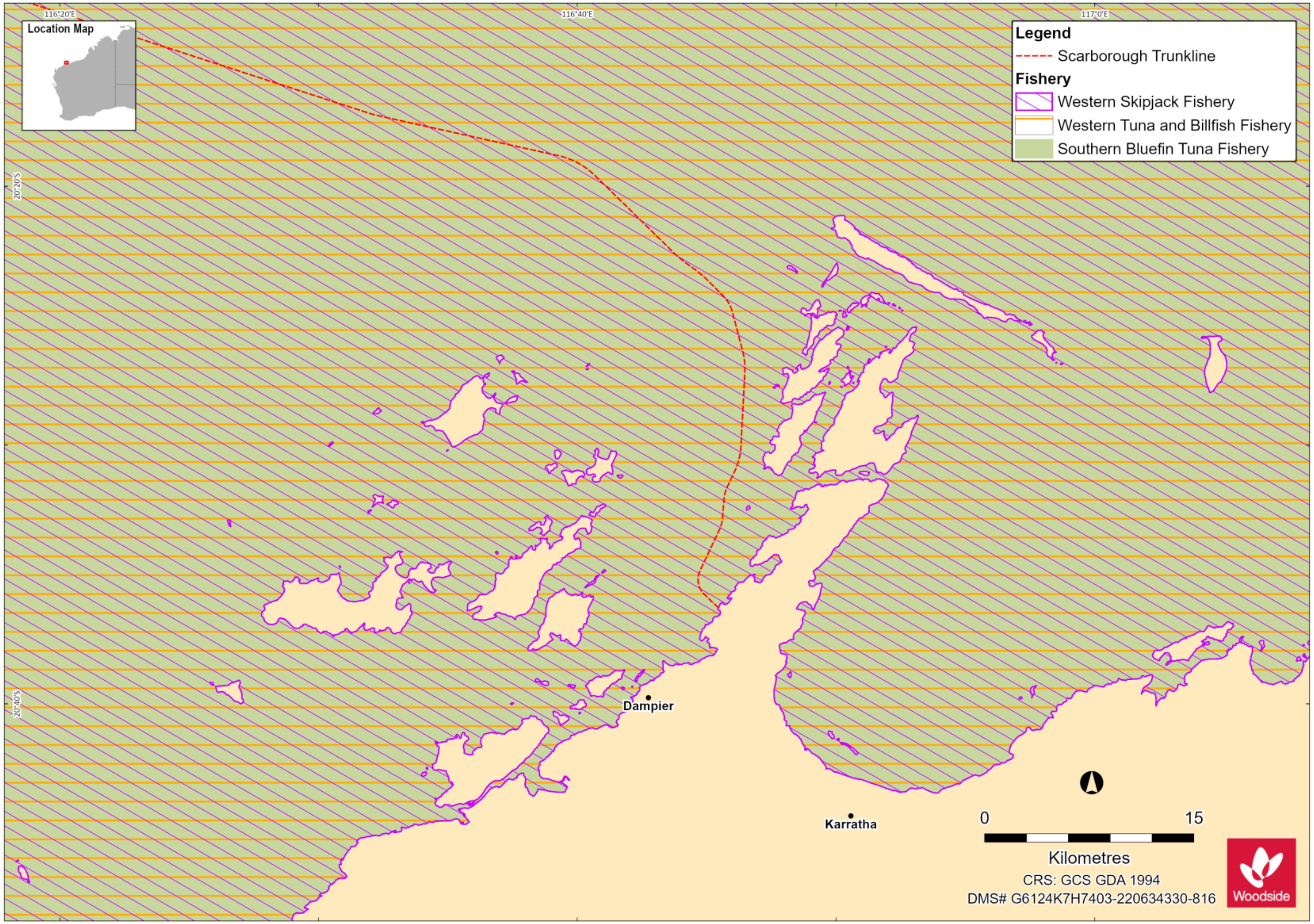
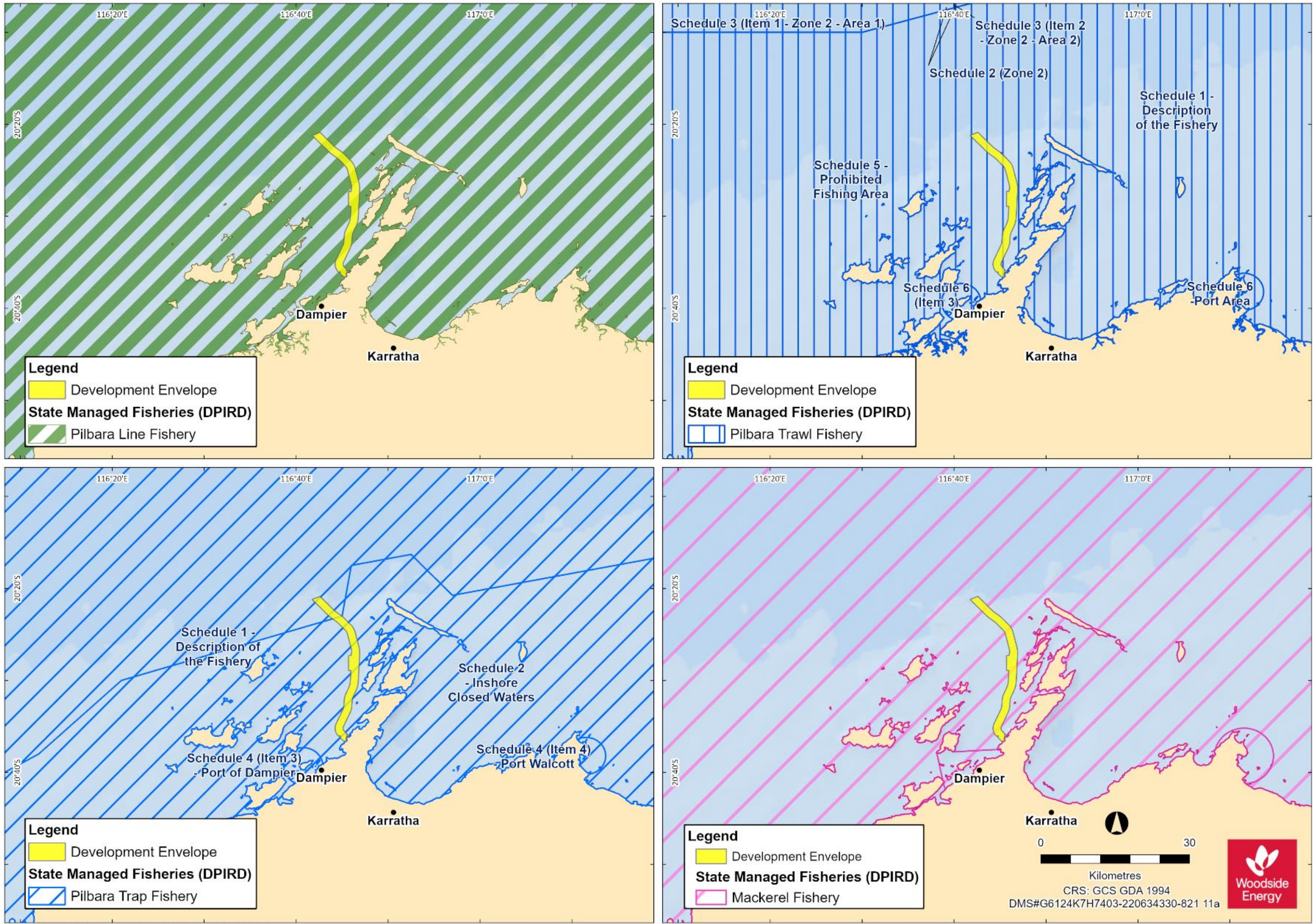


Figure 4-9: Designated Commonwealth fisheries management areas



Basemap sources: GeosciencesAustralia, Esri, GEBCO, DeLorme, NaturalVue

Figure 4-10: Fisheries that have been active within the Development Envelope within the last five years

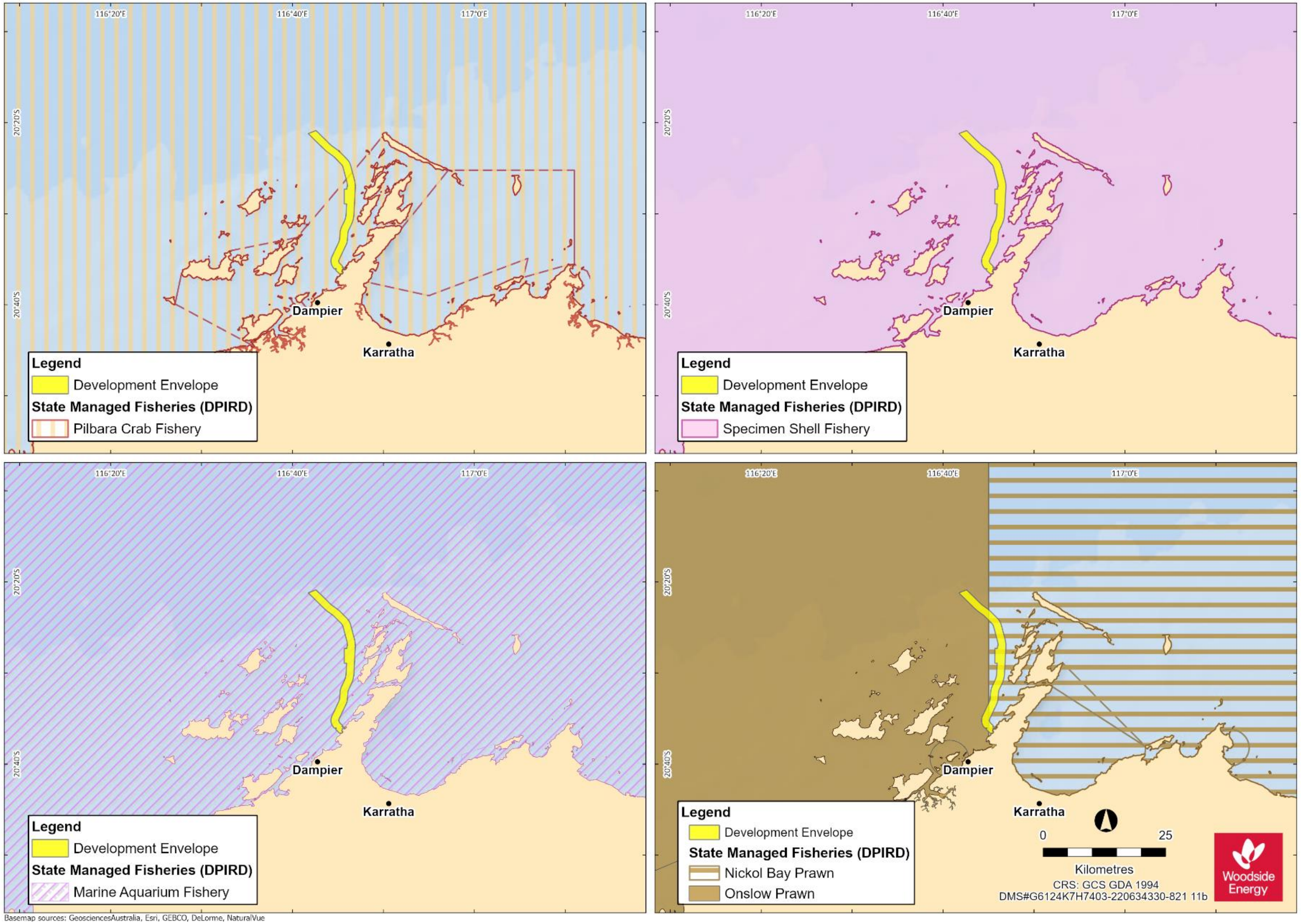


Figure 4-11: Fisheries that have been active within the Development Envelope within the last five years

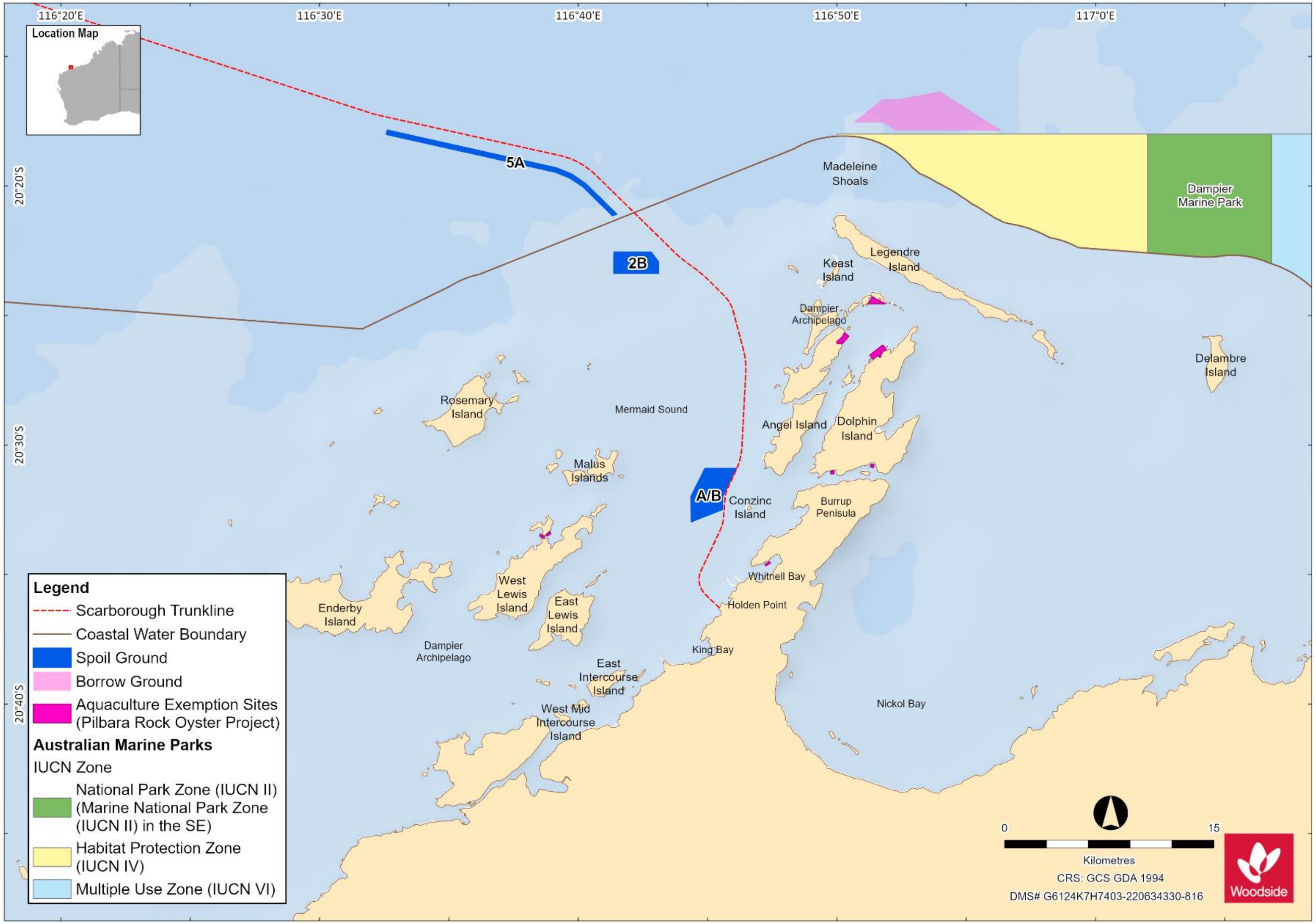


Figure 4-12: Pilbara Rock Oyster Project map of aquaculture exemption sites

4.5.6 Cultural heritage

The Dampier Archipelago (including Burrup Peninsula) is an Indigenous class feature on the National Heritage List.

Murujuga is the traditional Aboriginal name for the Dampier Archipelago and surrounds, including the Burrup Peninsula and Murujuga National Park. The Traditional Custodians of Murujuga are the Ngarda-Ngarli people, a collective term for the Ngarluma, Yindjibarndi, Yaburara, Mardudhunera and Wong-Goo-Tt-Oo people. NgardaNgarli people have an ongoing connection to Murujuga's cultural and spiritual landscape which his understood to date back tens of thousands of years. The Dampier Archipelago (including Burrup Peninsula) is included on Australia's National Heritage List for its values relating to petroglyphs and stone structures. MAC and the state are pursuing World Heritage listing for the Murujuga Cultural Landscape.

A description of the heritage values of Murujuga's cultural landscape are provided in the CHMP (SA0006GH1401311448). Potential impacts and controls for the project relating to heritage matters are also set out in the CHMP.

To understand the key cultural values of the marine environment as relevant to this DSDMP, Woodside has engaged in detailed consultation with MAC (Section 2.3.2.1). In a report by MAC on the spiritual and cultural values of Mermaid Sound, Elders were clear that all living things in Mermaid Sound are connected and Mermaid Sound and Dampier Archipelago (Murujuga) are considered one place where the entire environment and all ecosystems hold both cultural and environmental value, with these types of values (cultural and environmental) intrinsically linked (MAC, 2021). Specific locations of importance are shown Figure 5-12. Key values identified include:

<u>Environmentally and culturally important marine fauna:</u>

- Dolphins and whales:
    - A whale Thalu is an increase at a totemic site that brings whales in to beach.
    - Whales and other species of totemic importance need to be protected, including their populations, biodiversity, and migration patterns.
    - Whales are culturally important species that migrate through Mermaid Sound. Humpback whales in particular.
    - There are cultural ceremonies associated with communicating with dolphins.
- Dugongs:
    - Dugongs are a food source.
    - They are seen in seagrasses near Gidley Island.
- Fish: Specific mentions of fish included Yhere are Thalu ceremonies associated with increasing fish stocks.
- Sea snakes: Sea snakes were specifically mentioned as culturally important species.
- Flatback, green, hawksbill, loggerhead and leatherback turtles:
    - They are culturally important species that moves through Mermaid Sound.
    - Turtles are most often seen in shallower areas and where there are seagrasses.
    - The songline associated with the turtle comes from Fortescue to Withnell Bay. This song is sung by four or five tribes for day and night without consuming food or water.
    - Most beaches are nesting sites for turtles, including those on Gidley and Legendre Islands.

Environmentally and culturally important benthic communities:

- Coral:
    - Fish are attracted to areas with coral.
    - Concerned about coral bleaching because corals are important. Beautiful colours. They also attract a lot of other things.
    - Fish carry coral spawn like bees pollinate flowers. If fish were looked after, the corals would get brighter and brighter (by transmitting nutrients and performing other ecosystem services, fish can be symbiotic with corals).
    - Spawning events should be avoided (associated with full moon).
    - Locations identified during consultation include Withnell Bay; Conzinc Bay; south-west of Legendre Island.
- Seagrass beds:
    - Seagrasses provide protection for animals.
    - Locations identified during consultation include Conzinc Island; between Angel and Gidley Islands.
- Mangroves:
    - Mangroves would have provided shelter, crabbing, digging for shellfish, could be turtle nurseries.
    - Locations identified during consultation include Conzinc Bay north end; Flying Foam Passage; Searipple Passage; north-east bay of West Lewis Island.
- Other habitat not explicitly mentioned:
    - Macroalgal communities, which are important primary production sites, habitats and food sources (Bancroft and Sheridan, 2000; CALM, 2005).
    - Subtidal soft-bottom communities, which support invertebrate diversity (Bancroft and Sheridan, 2000; CALM, 2005).
    - Intertidal sand and mudflat communities, which are important primary production sites, support invertebrate diversity and provide food for shorebirds (Bancroft and Sheridan, 2000; CALM, 2005).
    - Rocky shores, which are habitats for intertidal organisms and provide food for shorebirds (Bancroft and Sheridan, 2000; CALM 2005).

Other areas of Mermaid Sound that are important:

- Fish traps: there are known fish traps in Conzinc Bay, and others would have or do exist in coastal areas of islands, such as Angel and Gidley Islands. People still use the Conzinc Bay fish traps regularly for catching mangrove jack, trevally and other fish.
- Squidding (harvesting of squid from the ocean) around Conzinc Island.

Figure 4-13 Specific locations of importance identified through consultation with Elders (extract from MAC 2021)

5 Dredge plume modelling

5.1 Purpose

Sediment dispersion modelling has been completed to predict the potential magnitude, intensity and spatial distribution of suspended sediment concentrations (SSC) associated with the trenching and spoil disposal and borrow ground dredging and backfill activities (Appendix E). The predicted outcomes are used to assess the unmitigated[6] potential for impact on significant BCH in the region associated with a deterioration in water quality.

This information has also been used to inform the marine environmental quality management framework and associated tiered monitoring and management framework described in Section 7.

5.2 Peer review

To support the modelling a two-stage peer review was completed, with Stage 1 being a review of the appropriateness of the model inputs and process for the Scarborough Project dredge dispersion modelling study, and Stage 2 a review of the modelling outcomes and interpretation. The expert peer review concluded that:

- Stage 1: Satisfied in regard to the modelling approach and the assumptions. Noting that while a level of uncertainty will always exist with modelling studies, the uncertainty has been managed through detailed review of relevant information in the literature, extensive past project experience, adoption of well-established models, adherence to suggested best practice as outlined in the WAMSI Dredging Science Node reports and adoption of conservative values for input parameters where deemed necessary.
- Stage 2: the interpretation and conclusions are considered appropriate, with due consideration to dredging science and guidance.

Details of the peer review can be found in Appendix F.

5.3 Model overviews

5.3.1 Hydrodynamic model

Modelling of the potential sediment dispersion from trenching and spoil disposal, offshore borrow ground dredging and backfill required temporal and spatial representation of the hydrodynamic and wave conditions within the project area.

The hydrodynamic and wave modelling was conducted using the Delft3D suite of software, which can simulate the interaction of flows, waves, sediment transport, morphological developments, water quality and aquatic ecology. The configuration of the current and wave models was in line with recommendations of best practice for sediment dispersion modelling (Sun et al., 2016), such as:

- the inclusion of mesoscale ocean currents which have a significant influence in the net drift of suspended material over the time scales of dredging operations (days to weeks) and are therefore important to predictions of sediment transport.
- the use of three-dimensional current modelling with a series of interconnected grids of progressively finer resolution.
- coupling of the current and wave models and validation of current predictions against measured data.

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[6] Note, unmitigated loss is not expected to eventuate through the implementation of the tiered monitoring and management framework (Section 7.4).

A calibrated and validated hydrodynamic and wave model framework for the Mermaid Sound area used. The model was validated through a comparison of predicted (modelled) currents and waves against measured data from an acoustic wave and current profiler. Good correlations with field measurements and independent model predictions were achieved and the accuracy of the hydrodynamic model is considered suitable for the prediction of impacts. Refer to Appendix E for more information.

5.3.2 Sediment transport model

The predicted dispersion of sediments suspended by trenching, disposal, borrow ground dredging and backfill operations have been derived for the full duration of the activities using an advanced sediment fate model, Suspended Sediment FATE (SSFATE), operating within the RPS DREDGEMAP model framework. This model computes the advection, dispersion, differential sinking, settlement and resuspension of sediment particles and allows for the three-dimensional predictions of SSC, which is in line with best practice for sediment dispersion modelling (Sun et al., 2016).

This modelling relied upon specification of sediment discharges over time for each of the expected sources of sediment suspension and predicted the evolution of the combined sediment plumes via current transport, dispersion, sinking and sedimentation. The model allowed for the subsequent resuspension of settling sediments due to the erosive effects of currents and waves. Thus, the fate of sediments was assessed beyond their initial settling.

When assessed against empirical evidence from the monitoring completed as part of the Pluto LNG Foundation project, the model results presented in this section are considered conservative in their prediction of sediment dispersion and impacts. Refer to Appendix E for more information.

5.4 Modelling approach

5.4.1 Modelling scenarios

To provide for flexibility in the dredging schedule for the purpose of environmental impact assessment, two modelling scenarios have been run, with construction work commencing in the summer season and the winter season.

Analysis of wind data in the region from 1993 to 2017 has shown the period of 2016–2017 is likely to be representative of typical conditions. The dredge modelling was simulated using hydrodynamic and wave data taken from this period, with nominal start dates for model simulation purposes being chosen as 1 July 2016 (winter) and 1 January 2017 (summer). Two scenarios were modelled. It should be noted these scenarios are all mutually exclusive in terms of time.

Table 5-1: Summary of modelling scenarios

Activity	Scenario 1 (Winter start date)	Scenario 2 (Summer start date)
TSHD dredging and disposal operations	Modelled activities completed between 1 July 2016 and 22 August 2016	Modelled activities completed between 1 January 2017 and 22 February 2017
BHD dredging and disposal operations	Modelled activities completed between 7 July 2016 and 4 August 2016	Modelled activities completed between 7 January 2017 and 4 February 2017
Simulations run-on period[7]	Modelled to occur between 22 August 2016 and 1 December 2016	Modelled to occur between 22 February 2017 and 1 June 2017

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[7] Modelled to account for suspended sediments that may remain in the water column following the completion of dredging activities. Sediments suspended in the water column during previous operations were subject to settlement and progressively reducing levels of resuspension during this time.

Activity	Scenario 1 (Winter start date)	Scenario 2 (Summer start date)
TSHD backfill activities	Modelled activities completed between 1 December 2016 and 3 March 2017	Modelled activities completed between 1 June 2017 and 1 September 2017
Rock backfill using a rock installation vessel	Modelled activities completed between 3 March 2017 and 24 March 2017	Modelled activities completed between 1 September 2017 and 22 September 2017
Further simulation run on period[7]	Modelled to occur between 24 March 2017 and 23 May 2017	Modelled to occur between 22 September 2017 and 21 November 2017

5.4.2 Geotechnical inputs

The critical geotechnical information required as input to the modelling is the particle size distribution data for the sediments to be dredged along the pipeline route, the sediments to be dredged from offshore borrow ground and for the quarry rock material.

The PSDs used in the modelling for each pipeline zone to be dredged were determined based on the average PSD of all samples taken within each zone during site investigations (Advisian, 2019c; Fugro, 2019). PSD for each pipeline section have been redistributed in the model to match the material size classes used in the DREDGEMAP model.

The PSD data for offshore borrow ground can be characterised mainly as coarse sand with a low fines fraction, with coarseness and layer thickness increasing towards the eastern part of the borrow ground. For modelling purposes PSDs from a geotechnical site survey (Fugro, 2019) have been used.

For the rock backfill operations, in the absence of grading information it has been conservatively assumed the fraction of material within the quarry rubble classified as ‘fines’ in this context (diameters less than 100 mm) will be 5% of the total volume.

In addition to PSD information, dry bulk density information from the geotechnical site survey (Fugro, 2019) and a previous geotechnical survey (Coffey, 2008) was used. The Fugro (2019) investigation presented ‘low-estimate’, ‘best-estimate’ and ‘high-estimate’ dry bulk density values along the trunkline and within the borrow ground. The high-estimate values were adopted as input to the modelling, as these values are most conservative in terms of sediment mass and also lie within the range of values presented in the earlier Coffey (2008) report. The dry bulk density values applied to each zone are outlined in Table 5-5.

For the quarry rock material, a conservative dry bulk density value of 1950 kg/m³ was assumed based on learnings from the Pluto LNG Foundation Project, which used rock from the Nickol Bay quarry (located between Dampier and Karratha, WA).

Table 5-2: In situ particle size diameters broken down into DREDGEMAP material classes for each pipeline section to be dredged

Sediment Size Class	Size Range (μm)	KP0.072-KP0.8 (%)	KP0.8-KP3.9 (%)	KP3.9-KP4.6 (%)	KP4.6-KP6.0 (%)	KP11.2-KP18.5 (%)	KP19.3-KP21.3 (%)	KP23.0-KP23.8 (%)	KP23.8-KP38.2 (%)	KP38.2-KP50.3 (%)
Clay	<7	4.58	4.58	0.97	6.80	0.51	7.33	11.00	8.80	2.75
Fine Silt	7 to 34	8.51	8.51	8.89	7.63	11.52	6.33	9.50	5.40	2.00
Coarse Silt	35 to 74	18.31	18.31	28.37	11.94	25.94	16.33	21.00	10.80	7.75
Fine Sand	75 to 130	32.70	32.70	18.04	23.71	32.19	13.67	20.00	20.70	18.00
Coarse Sand	>130	35.90	35.90	43.73	49.92	29.84	56.34	38.5	54.30	69.50

Table 5-3: In situ particle size diameters broken down into DREDGEMAP material classes for the offshore borrow ground[8]

Sediment Grain Size Class	Size Range (µm)	Offshore borrow ground (%)
Clay	<7	1.13
Fine Silt	7-34	1.13
Coarse Silt	35-74	1.13
Fine Sand	75-130	3.00
Coarse Sand	>130	94.0

Table 5-4: In situ particle size diameters broken down into DREDGEMAP material classes for the rock backfill material

Sediment Grain Size Class	Size Range (µm)	Rock backfill material (%)
Clay	<7	0.5
Fine Silt	7-34	0.5
Coarse Silt	35-74	0.5
Fine Sand	75-130	0.5
Coarse Sand	>130	98.0

Table 5-5: Dry bulk density classes

Zone	KP0.072-KP50.3(%)	Offshore borrow ground
Dry Bulk Density (t/m³)	1.54	1.78

5.4.3 Pipeline trenching and spoil disposal inputs

The dredging operations for the pipeline route are described and illustrated in Section 3. The description below provides details assumed for the purposes of modelling.

5.4.3.1 BHD inputs

The BHD uses a large excavator arm fitted with an open bucket. The assumed BHD bucket size was in the range of 20 m³ (rock) to 30 m³ (general purpose). The excavator will lift material in the bucket and deliver it to the SHB alongside. The two SHBs are modelled to have 3800 m³ capacity for transport to Spoil Ground A/B for disposal.

Past observations have shown soft, non cemented material is suspended due to the initial grab at the seabed. Further suspension is generated as sediment overflows from the bucket as it is lifted through the water column. Overflow also occurs as the bucket breaks free of the water surface and drains freely. Only sediments larger than 130 µm in diameter are considered 'lost' (suspended into the water column), because the coarser material spilled from the bucket while being lifted to the surface will fall rapidly to the bottom, where it will be re-dredged during subsequent grabs. As such, the distribution of material suspended by the overflow for the bucket was assumed to be distributed across the four smaller sediment size classes in the model.

5.4.3.2 TSHD trenching inputs

The model assumes a TSHD with a capacity of 12,000 m³ will be used for dredging the pipeline route and associated spoil disposal.

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[8] PSD data used as an input to the modelling is considered conservative in the estimation of fines content. Samples collected within the Borrow Grounds show a lower fines content than modelled.

Sources of sediment associated with TSHD operations include:

- hydraulic disturbance of the seabed by the TSHD drag head
- propeller-wash generated as the vessel maneuverers
- overflow of the on-board hoppers, resulting in the discharge of water and entrained sediments.

The characteristics of these SSC sources varies; however, the overflow source term is dominant, being typically an order of magnitude greater than the drag-head and propeller wash source terms. During overflow periods, an increase in the rate of release of fine sediments, and hence initial turbidity, is observed (Anchor Environmental, 2003). The overflow water contains a high proportion of fines because the coarse material settles rapidly in the hopper while the fine material remains in suspension. After the hopper begins overflowing, PSDs heavily weighted towards finer particles has been assumed based on previous field measurements of hopper barge overflow (OPR, 2010), with the proportion greater than 75 μm removed and the remaining distribution normalised to 100% by scaling up the proportions in the three remaining size classes.

The estimated cycle times for TSHD dredging of the pipeline section are described in Appendix E.

5.4.3.3 Spoil ground disposal inputs

The model considered that all material dredged by the BHD will be placed into a waiting SHB and transported by tugs to the spoil grounds, while all material dredged by the TSHD will be transported directly to the spoil grounds in the hopper of the vessel.

Modelling has assumed the BHD will be accompanied by two SHBs, with a capacity of about 3800 m³. The SHBs were modelled to be pushed or towed by a harbour tug. The potential for sediment mobilisation by tug and TSHD propeller-wash effects has been considered along all relevant pipeline sections.

Material discharges from the SHBs were assumed to occur between depths of 5.8 m and 1.5 m below mean sea level, while the TSHD bottom doors, from which discharge will occur, are modelled to open at a depth of around 12.75 m below mean sea level. For modelling purposes, it was considered the spoil is evenly distributed over each spoil ground area. These inputs are further described in the modelling report in Appendix E.

5.4.4 Borrow ground dredging and backfill inputs

5.4.4.1 TSHD borrow ground dredging inputs

The model assumes a TSHD with a capacity of 12,000 m³ will be used for dredging the offshore borrow ground and backfilling the pipeline route. The same sources of sediment associated with TSHD trunkline trenching applies (Section 5.4.3.2); however, notably, dredging of backfill material from the borrow ground locations is largely sandy sediments with minimal fines.

The estimated cycle times for TSHD dredging within the offshore borrow ground and placement of material within each pipeline section are considered and described in the modelling report in Appendix E. The potential for sediment mobilisation by TSHD propeller-wash effects has also been considered.

5.4.4.2 Pipeline route backfill

Pipeline route backfill operations have been modelled to account for sand backfill from a TSHD and rock backfill from a rock installation vessel.

The model assumes a TSHD with a capacity of 12,000 m³ (emptied at a rate of about 90 m³/min), with sand discharged through the suction pipe at an elevation of about 5 m above the pipeline. The potential for sediment mobilisation by TSHD and rock placement vessel propeller-wash effects has been considered along the relevant pipeline sections.

The rock installation vessel has been modelled to have a capacity of 4500 tonnes, with an average installation rate of about 2250 tonnes/hr, and rock dumped from a fixed height at the sea surface.

5.5 Modelling thresholds

Modelled predictions of suspended sediment concentrations (SSC) (combination of excess SSC generated by dredging and assumed background) for each scenario were assessed against a series of water quality thresholds (as relevant to the most sensitive BCH) to categorise the modelled outcomes into management zones of influence and impact. The approach is described below, with further details regarding how the modelling thresholds were derived provided in Appendix G and how they were applied in modelling in Appendix E.

5.5.1 Impact zonation scheme

Thresholds for three zones were defined in accordance with the *Technical Guidance – Environmental Impact Assessment of Marine Dredging Proposals* (EPA, 2021b). The definition of these zones are as follows:

1. Zone of High Impact (ZoHI) – is the area where serious damage to benthic communities is predicted or where impacts are considered to be irreversible. The term serious damage means ‘damage to benthic communities and/or their habitats that is effectively irreversible or where any recovery, if possible, would be unlikely to occur for at least 5 years’. Areas within and immediately adjacent to proposed dredge and disposal sites are typically ZoHI.
2. Zone of Moderate Impact (ZoMI) – the area within which predicted impacts on benthic organisms are recoverable within a period of five years after completing the dredging activities. This zone abuts, and lies immediately outside of, the ZoHI. The outer boundary of this zone coincides with the inner boundary of the next zone, the Zone of Influence.
3. Zone of Influence (ZoI) – the area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the dredging operations, but where these changes would not result in a detectable impact on benthic biota. These areas can be large, but at any time the dredge plumes are likely to be restricted to a relatively small portion of the ZoI. The outer boundary of the ZoI bounds the composite of all the predicted maximum extents of dredge plumes under a range of possible metocean conditions and represents the point beyond which dredge generated plumes should not be discernible from background conditions at any stage during the dredging campaign. Furthermore, this provides transparency for the public about where visible plumes may be present, albeit only occasionally, if the Proposal is implemented.

5.5.2 Ecological zones

The criteria associated with each management zone is also varied across three ecological zones, which are defined based on the sensitivity of benthic receptors. The ecological zones are named as follows and shown in Figure 5-1:

- Offshore – the trunkline area beyond KP25, and generally all areas north of a boundary line containing Rosemary Island, Legendre Island and Delambre Island. In developing the thresholds, it is considered benthic communities will be sparse and made up largely of sponges and filter feeders without corals.
- Zone B – the trunkline area between KP8 and KP25, adjacent coral and macroalgae habitats within Mermaid Sound, and generally all coral, macroalgae and mixed community habitats between Dolphin Island and Bezout Island, including Madeleine Shoals.
- Zone A – the trunkline area between the shoreline and KP8, adjacent macroalgae and mangrove habitats within Mermaid Sound, and generally all mangrove, marsh and seagrass habitats between Nickol Bay and Point Samson. Water quality within Zone A is

more turbid and coral communities comprise more sediment-tolerant or resilient species (Blakeway and Radford, 2005).

The proposed management zones are not based directly on the presence or absence of receptors, but on the receptors likely to be encountered within an ecological zone. For instance, the ZoMI and ZoHI threshold may be applied where no coral occurs due to the reefs of Mermaid Sound being spatially confined. Sponges and filter feeders in Zones A and B occur among corals. This mixed community is best evaluated using coral thresholds which present the most conservative thresholds.

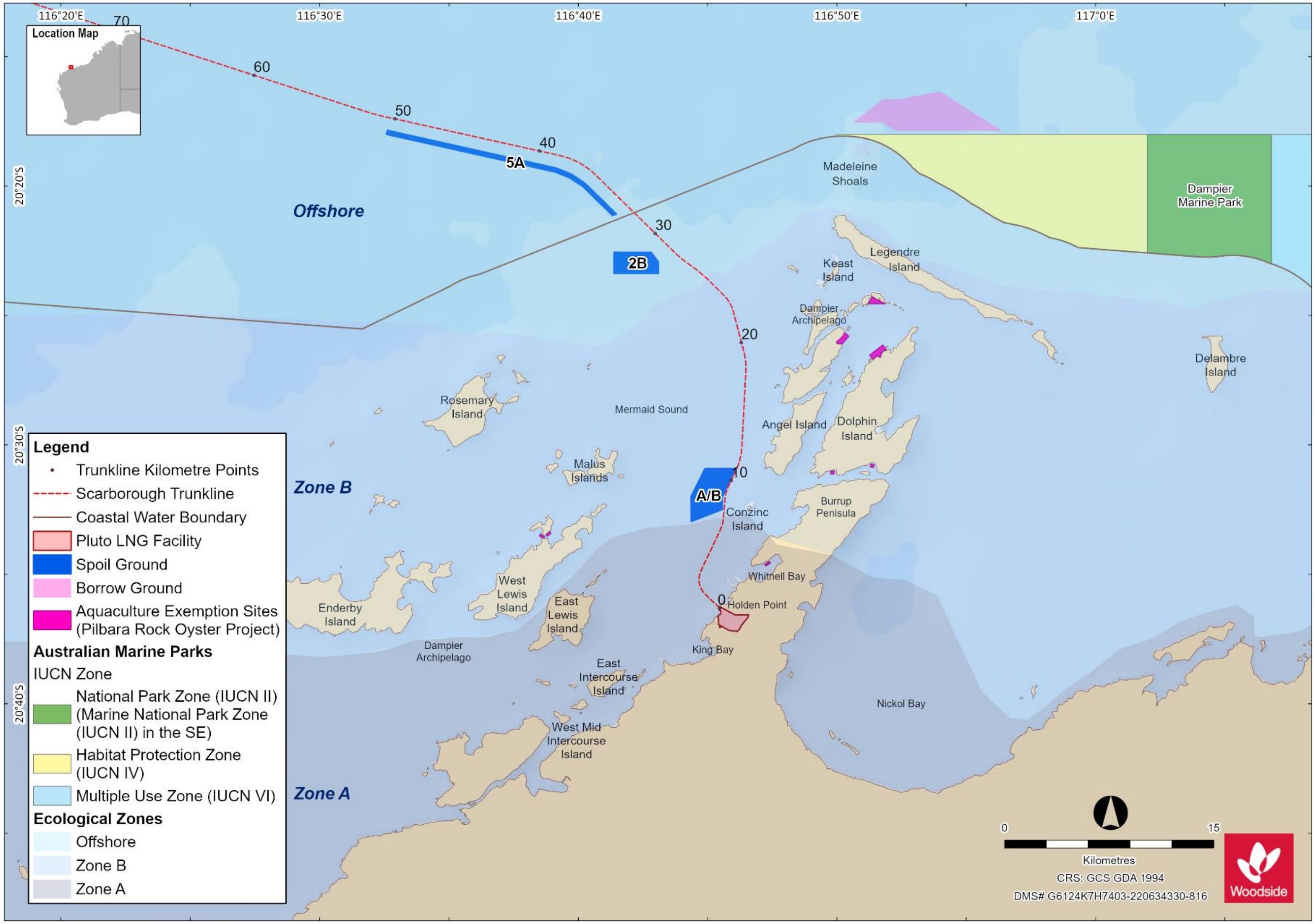

Figure 5-1: Ecological zones

5.5.3 Background water quality

Background water quality was calculated for each ecological zone (Table 5-6) to allow total SSCs (background plus dredge-induced) to be assessed in the model.

An extensive water quality monitoring program was completed as part of the Pluto LNG Foundation project (2007 to 2010)[9]. This dataset represents the only dataset in Mermaid Sound that covers the three ecological zones with multiple sites (six within ecological Zone A and 17 within ecological Zone B). Data from the project was split into two seasons: summer (November to March) and Winter (April to October). Mean SSCs were then calculated for sites in the relevant ecological zones (Zones A and B) across the three years of monitoring data (mScience, 2010). For the Offshore zone, data from the seaward reef at Legendre Island was used.

The summary report (mScience, 2010) for the Pluto LNG Foundation project showed that dredging was likely to have elevated turbidity by 0.7 NTU (0.98 mg/l SSC) in Zone A and 0.3 NTU (0.42 mg/l SSC) in Zone B; therefore, summary statistics have been reduced by these values to provide a background water quality value in Zones A and B. The offshore data from Legendre has not been reduced.

Table 5-6: Mean and 80th percentile of suspended sediment concentration (mg/l) background water quality for summer and winter months for each of the three ecological zones

Ecological Zone	Season	Mean SSC (mg/l)	80th percentile (mg/l)
A	Summer	4.1	5.0
	Winter	1.8	2.3
B	Summer	2.5	2.7
	Winter	1.2	1.6
Offshore	Summer	1.8	1.8
	Winter	0.6	0.9

The data collected between 2007 and 2010 are not expected to have significantly changed since collection. The sites most at risk of altered water quality from increased vessel movements, anthropogenic sources of dust from stockpiles and new developments are those within Ecological Zone A. However, there has been no significant port construction within this period except the Dampier Marine Services Facility. This facility is around 1 km away from the nearest site (SUP2). Changes to the regional hydrodynamics associated with constructing this project were not predicted beyond 1 km, with changes to current velocities expected to be highly localised (Worley, 2011). Thus, the construction of this facility is not expected to have altered water quality at this site or across Ecological Zone A.

The site at Legendre Island was used to predict baseline water quality for the Offshore ecological zone. Given the geographical location of this site, it is not expected to have been influenced by construction activities within Mermaid Sound and the data collected up to 2010 is still considered suitable.

Meteorological effects on turbidity in the region are driven by cyclonic activity. The baseline dataset captures five to seven tropical cyclones that may have affected water quality during this period; thus, there are not expected to be any climatic shifts that would increase background suspended sediment load after collection of the background dataset.

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[9] The data collected for the Pluto LNG Foundation project focused on waters to the west of the Burrup Peninsula. It should be noted the turbidity regime to the east of the Burrup Peninsula is markedly different, with higher SSC levels. However, the data collected to the west of the Burrup Peninsula has been conservatively applied across the model domain when defining the zones of influence and impact.

5.5.4 ZoI thresholds and application

The ZoI is the area within which changes in environmental quality associated with dredge plumes are predicted and anticipated during the dredging, spoil disposal and backfill operations, but where these changes would not result in a detectable impact on benthic biota (EPA, 2021b).

To define the outer boundary of the ZoI, consideration has been given to the concentration of suspended sediments that may alter water quality but below which no change would be detectable. A threshold whereby dredge-induced turbidity may raise levels towards the upper limit of natural variation (greater than the 80th percentile of baseline data) are considered for the ZoI.

Table 5-7 presents the threshold SSC values used to define the extents of the ZoI, with the variation in natural turbidity considered for each ecological zone. The consideration of baseline water quality across the three ecological zones also reflects that it would be easier to visually detect change in environments with lower SSCs (Offshore zone) than those with higher SSCs (Zone A).

The ZoI threshold will be exceeded at any point within the model domain where trenching, spoil disposal, borrow ground dredging or backfill activities are forecasted to increase the depth-averaged concentration of SSC (specifically the contribution attributable to dredging activities) to a level greater than the seasonal 80th percentile of baseline SSC over a rolling 24-hour average period for that specific ecological zone.

To define the spatial extent of the ZoI, the 95th percentile model results have been used where SSC exceeds the defined threshold within each cell for 5% or more of the time (EPA, 2021b). This allows for a realistic representation of the ZoI by removing spurious spikes in the dataset.

Table 5-7: ZoI thresholds

Ecological Zone	Season	Background SSC (mg/l)	80th Percentile of background SSC (mg/l)	Threshold SSC for the ZoI (background + dredging excess SSC) (mg/l)
A	Summer	4.1	5.0	9.1
	Winter	1.8	2.3	4.1
B	Summer	2.5	2.7	5.2
	Winter	1.2	1.6	2.8
Offshore	Summer	1.8	1.8	3.6
	Winter	0.6	0.9	1.5

5.5.5 ZoMI and ZoHI thresholds and application

ZoMI and ZoHI thresholds have been derived for each ecological zone based on the most sensitive BCH known to form significant communities, as illustrated in Figure 4-2.

For Zone A and Zone B, SSC and DLI thresholds have been derived for the ZoMI and ZoHI based on outcomes from *WAMSI Dredging Science Node Theme 4 | Synthesis report: Defining thresholds and indicators of coral response to dredging-related pressures* (Jones et al. 2019) and supporting publications. The Jones et al. (2019) thresholds are applicable to Zone A and B where coral is considered the most sensitive BCH. This is because these thresholds have been developed for corals based on water quality and coral community monitoring around the Gorgon Project at Barrow Island. It is noted however that Barrow Island coral communities exist in relatively clear, almost oceanic conditions, and as such this has been considered in the application for Zone A and Zone B.

In summary, for Ecological Zone B where coral exist in relatively clear waters, the possible and probable effects thresholds from Jones et al. (2019) have been adopted for the ZoMI and ZoHI respectively. In contrast, corals in Zone A exist in a more turbid environment as reflected in the higher baseline SSCs recorded (Table 5-6). Corals in Zone A are expected to be more tolerant to elevated SSC and low light levels than those of Zone B due to adaptation and a different community composition of more tolerant species. Therefore, a conservative factor of 1.5[10] has been applied to the possible and probable effect thresholds adopted for the ZoMI and ZoHI within Zone A. Refer to Table 5-8, Table 5-9 and Appendix G for details.

Ephemeral seagrasses communities are also found in Zone A and B. In review of Statton et al. (2017) the seagrass threshold provided for *Halodule uninervis* is 14d DLI average not to be below 2.3 mol $m^{-2}d^{-1}$. Given this threshold is lower than that proposed for the coral communities, the coral threshold is applied across this ecological zone as a conservative threshold for all benthic communities.

Within the Offshore Zone, only sponges and filter feeders thresholds are used, as corals, seagrasses and macroalgae are not known to form significant communities in this zone. Filter-feeder sponge thresholds are adapted from Pineda et al. (2017a), based on Pineda et al. papers (2016a; 2016b; 2017b; 2017c). The thresholds chosen in Table 5-8 and Table 5-9 are those quoted in Pineda et al. (2017a) as relating to an LC10 (ZoMI) and LC50 (ZoHI) effect in a 28-day exposure (the only timeframe quoted).

Note, a sedimentation threshold is not proposed as studies about sedimentation effects on corals and sponges continue to be equivocal on the effects of sedimentation alone (Duckworth et al., 2017; Pineda et al., 2017a). In practice, sedimentation impacts will be driven by high SSC levels (which will also drive low light). Where thresholds have been evaluated for multiple stressors, SSC and DLI levels have been an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Duckworth et al., 2017; Pineda et al., 2017a). Thus, SSC and DLI thresholds proposed here would be breached well before SSC reached levels capable of sustaining required sedimentation rates that are predicted to impact benthic communities. Further, the coral threshold values implicitly account for sediment deposition effects because they were derived from analyses of in situ water quality and coral health data associated with a large-scale capital dredging project conducted in a relatively clear offshore location in the Pilbara (Barrow Island) (EPA, 2021b). As such they are considered to include the additive effects of sediment deposition, elevated SSC and reduced light availability (Jones et al 2019; EPA, 2021b).

To define the spatial extent of the ZoMI and ZoHI, the 95th percentile model results have been used (EPA, 2021b). Potential exceedances of the thresholds were evaluated over the duration of each dredge scenario by calculating rolling 3-day, 7-day, 10-day, 14-day and 28-day averages (as appropriate in each ecological zone) of SSC values in each model grid cell. Where any time-average SSC value exceeded the corresponding threshold value at any time, even if only on one occasion, the model grid cell is included in the appropriate ZoMI or ZoHI area.

Table 5-8: ZoMI thresholds

Ecological Zone	Receptor used for the basis of threshold value	Reference	Averaging period (days)	SSC threshold (mg/l)	DLI threshold (mol/d)
A	Corals[11]	Adapted from Jones et al. (2019)	3	29.1	0.7
			7	22.5	1.2
			10	19.6	1.5
			14	17.6	1.7
B	Corals	Jones et al. (2019)	3	19.4	1.1
			7	14.7	1.8

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[10] The adjustment factor of 1.5 was chosen as a multiplier, based on the background annual means and 80th percentile for Zone A being 1.6 to 1.7 times as high as those of Zone B.

[11] The thresholds for corals are the most conservative with the thresholds for mixed communities and seagrass being much higher.

Ecological Zone	Receptor used for the basis of threshold value	Reference	Averaging period (days)	SSC threshold (mg/l)	DLI threshold (mol/d)
			10	13.1	2.2
			14	11.7	2.5
Offshore	Sponges and filter feeders	Adapted from Pineda et al. (2017a)	28	22.5	0.9

Table 5-9: ZoHI thresholds

Ecological Zone	Receptor used for the basis of threshold value	Reference	Averaging period (days)	SSC threshold (mg/l)	DLI threshold (mol/d)
A	Corals	Adapted from Jones et al. (2019)	3	53.6	0.2
			7	36.8	0.4
			10	31.4	0.6
			14	27.0	0.7
B	Corals	Jones et al. (2019)	3	35.7	0.3
			7	24.5	0.6
			10	20.9	0.9
			14	18.0	1.1
Offshore	Sponges and filter feeders	Adapted from Pineda et al. (2017a)	28	47	0.3

5.6 Modelling results

5.6.1 Overview

Simulations indicated there may be significant spatial patchiness in the distribution of SSC at any time during trenching and spoil disposal, and borrow ground dredging and backfill activities. This is because of variability in the number of sediment suspension sources, variability in the flux from each of these sources, and the varying dynamics of the transport, settlement and resuspension processes affecting the sediments.

Mermaid Sound is dominated by tidal currents year-round and is relatively sheltered from variations in large-scale circulation, although reasonably distinct seasonal trends are evident in the modelling outcomes. Plume concentrations and distributions are forecast to vary markedly, with the results observed on any given day will not always represent the given season's prevailing transport patterns. Note, outcomes are presented over the entire scenario and do not represent an instantaneous plume footprint at any time.

Concentrations of suspended sediment in the key activity areas represent the combined influence of new discharges and resuspension of fine sediments from earlier discharges. Temporal variations in intensity of the dredging operations, including overlap of multiple operations in time or downtime periods, also influence turbidity peaks and troughs. At progressively more distant areas, the importance of resuspension as a contributor to the distribution of SSCs generally, and near-seabed concentrations particularly, becomes a greater factor.

The areas forecast to receive elevated concentrations are substantially larger than would be affected by plumes only from the primary sources. The plume extents tend to expand over periods of several weeks in the direction of net drift, indicating the progressive transport of fine sediments through continuous patterns of settlement and resuspension. In practice, resuspending sediment is rarely detectable or observable relative to background, apart from at the immediate dredging site.

With the duration of each seasonal scenario (ten months) spanning almost the entire range of seasonal conditions, the direction of net drift will shift from summertime trends (generally longshore in a north-easterly direction) to wintertime trends (generally longshore in a south-westerly direction), or vice versa, depending on commencement times.

Periodic high wave-energy events will be a major contributor to estimates of high SSC in the near-seabed layer, particularly in shallow exposed areas. While these processes are forecast to extend the influence of dredging, spoil disposal and backfill activities over a wider area, the longshore dispersal of finer sediments is indicated to be an important mechanism for limiting the trapping and build-up of fine sediments in the local region around the key activity areas. The build-up of re-suspendable fine sediments in areas remote from dredging, spoil disposal and backfill activities indicates the supply of fines to these areas will be greater than their removal, due to ongoing resuspension and longshore transport, for as long as sediment input from dredging, spoil disposal and backfill activities continues.

It should be noted the indicated management zone extents in each case represent a cumulative measure of exceedances of the relevant thresholds over a ten-month period, following the threshold criteria described in Section 5.5. They do not represent an instantaneous plume footprint at any time.

5.6.2 Pipeline trenching and spoil disposal

5.6.2.1 General trends

For pipeline trenching activities during winter conditions, sediment plumes at low concentrations are forecast to drift generally towards the south-west. The plumes tend to follow the bathymetric contours between East Intercourse Island and East Lewis Island, and also between West Lewis Island and Rosemary Island.

In contrast, the net drift direction forecast for sediment plumes from pipeline trenching activities during summer conditions is towards the north-east, with the plumes following the bathymetric contours as they turn around Legendre Island towards Delambre Island. This drift is imposed by the prevailing south-westerly winds over the summer season.

In general, the majority of the dispersing suspended material is forecast to migrate offshore rather than through Flying Foam Passage and Searipple Passage, which is attributable to the local bathymetric features. Much of the dredging occurs in water depths greater than that found within each passage, but strong tidal currents will drive significant sediment concentrations in and out of the passages on a regular basis.

5.6.2.2 Management zones

Figure 5-2 and Figure 5-3 show the ZoI and ZoMI for pipeline trenching and spoil disposal activities respectively. No ZoHI was predicted as a result of the activity, and therefore no figure included.

The north-south extent of the ZoI in ecological Zones A and B are broadly similar irrespective of scenario (i.e., seasonal start date). The ZoI extends from Angel Island to East Intercourse Island, with a larger overall spatial extent in Scenario 1 (where pipeline dredging operations will occur during winter) relative to Scenario 2 (where these operations will occur during summer).

In the Offshore ecological zone, a significantly larger ZoI is forecast along the pipeline in the vicinity of spoil grounds 2B and 5A for a winter versus summer start date. This is largely a consequence of the lower thresholds applicable during the winter period, and consequently the lower levels of dredge-excess SSC required to cause exceedances.

The ZoMI is predicted to occur in areas along the trunkline route where the highest intensity activities are likely to occur, with isolated pockets further afield near Conzinc Island, within Conzinc Bay, King Bay and around Intercourse Islands. These nearshore isolated pockets may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells and then “trapped” upon reversal of the tide. While there is a potential for dredged sediments to be found in the indicated areas, the persistently high concentrations at the water-land boundaries may be overstated, particularly in light of the long durations required to trigger the ZoMI thresholds.

5.6.3 Borrow ground dredging and pipeline stabilisation/backfill

5.6.3.1 General trends

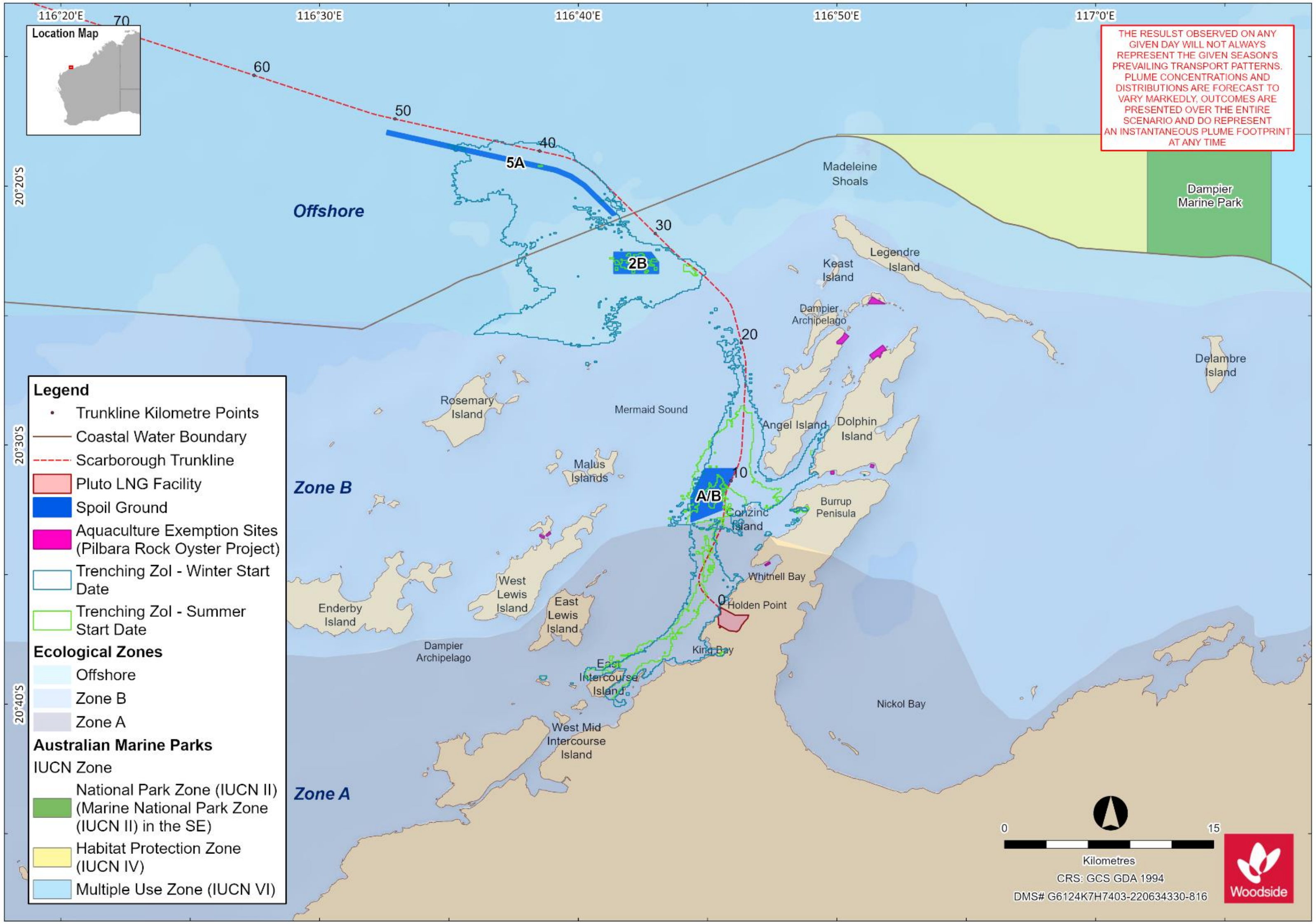
During borrow ground dredging, the majority of the sediment suspended by dredging is forecasted to be dispersed in the offshore areas north of Legendre Island. Strong tidal flows between Hauy Island and Delambre Island will aid movement of sediment towards the shallow waters of Nickol Bay, with this effect being greater during summer due to predominant net drift towards the east imposed by prevailing south-westerly winds.

Sediment plumes from the placement of backfill material along the pipeline route are near-negligible, which may primarily be due to the high sand content and low fines of the material, which will rapidly settle and have a low resuspension potential.

5.6.3.2 Management zones

Figure 5-4 show the ZoI for borrow ground dredging and pipeline stabilisation and backfill activities. No ZoMI or ZoHI were predicted as a result of the activity (i.e., thresholds were not exceeded for backfill and stabilisation activities), and therefore no figure included.

In the Offshore ecological zone, the ZoI predicted at the offshore borrow ground is only predicted when this activity is being undertaken during winter. This is largely a consequence of the lower thresholds applicable during the winter period, and consequently the lower levels of dredge-excess SSC required to cause exceedances.



THE RESULST OBSERVED ON ANY GIVEN DAY WILL NOT ALWAYS REPRESENT THE GIVEN SEASON'S PREVAILING TRANSPORT PATTERNS. PLUME CONCENTRATIONS AND DISTRIBUTIONS ARE FORECAST TO VARY MARKEDLY, OUTCOMES ARE PRESENTED OVER THE ENTIRE SCENARIO AND DO REPRESENT AN INSTANTANEOUS PLUME FOOTPRINT AT ANY TIME

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Figure 5-2: Zone of influence for pipeline trenching and spoil disposal activities

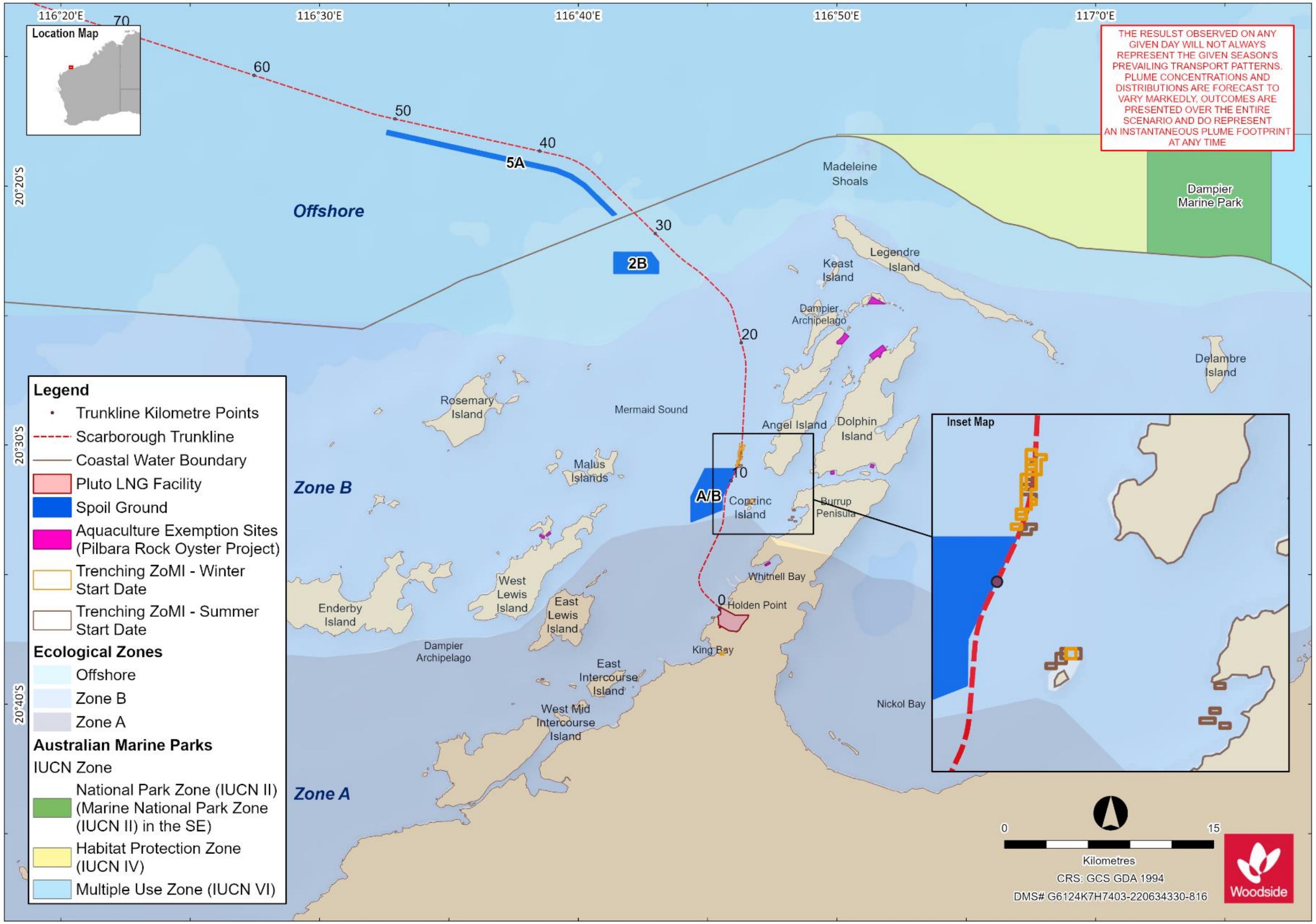

Figure 5-3: Zone of moderate impact for pipeline trenching and spoil disposal activities

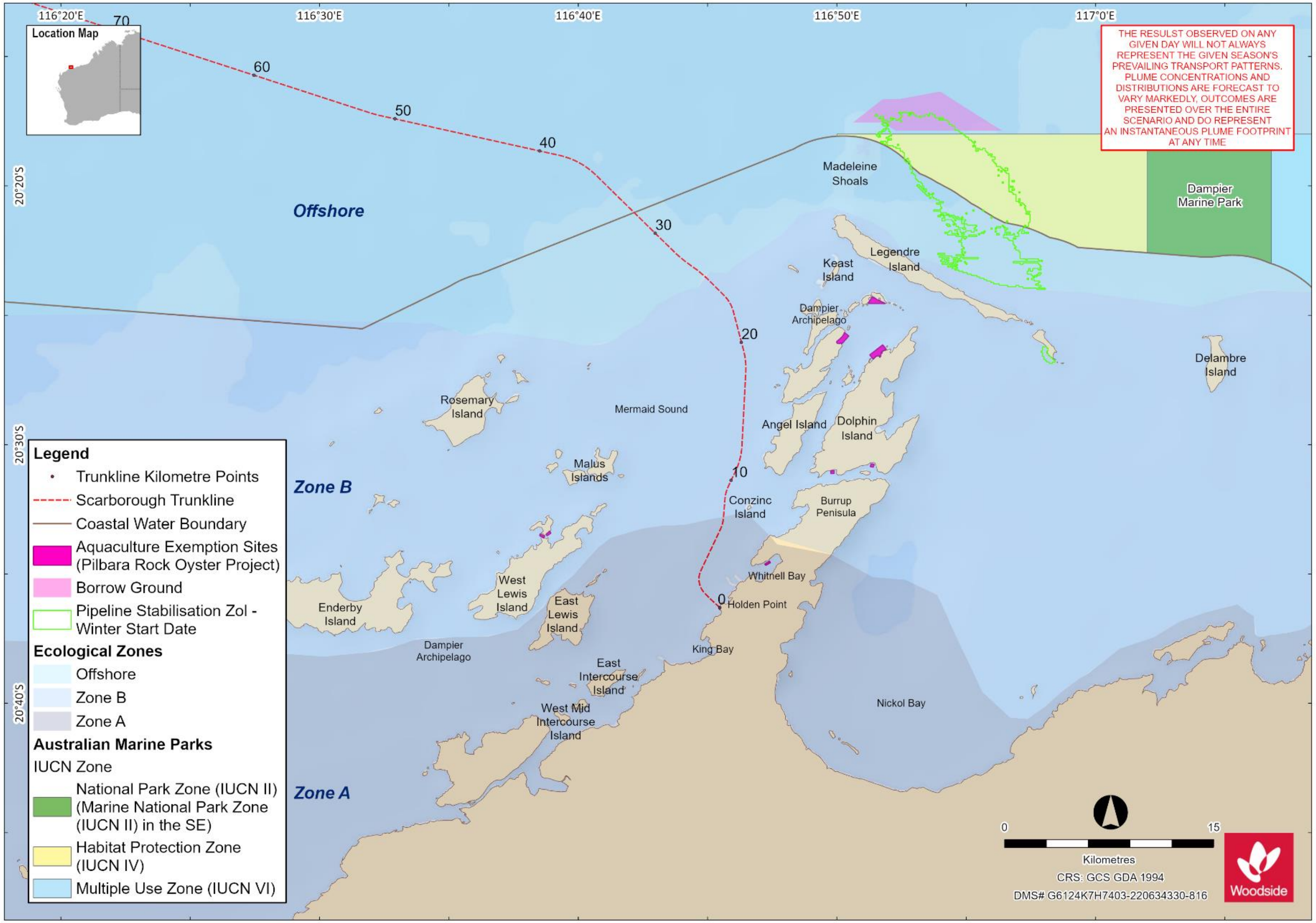

Figure 5-4: Zone of influence for pipeline stabilisation activities, with backfill material sourced from borrow ground

5.7 Local assessment units (unmitigated loss assessment)

Technical guidance for protecting benthic communities and habitats identifies implementing spatially-based evaluations of BCH and refers to adopting local assessment units (EPA, 2016b). The LAU is a spatially defined area, established to allow proponents to quantify historical and proposed loss of BCH. LAUs are location-specific and should be configured to account for aspects of the local marine environment, such as bathymetry and position of offshore reefs/islands, substrate type, water circulation patterns, exposure to waves and currents, and biological attributes such as habitat types. Wherever possible, other variables related to the functional ecology of the system should be considered when defining LAUs.

Between 2012 and 2014, Dampier Port Authority (DPA, now PPA) engaged MScience to assess the status of BPPH within Port limits, establish potential LAUs and perform an initial assessment of historical loss of each BPPH by LAU (Figure 5-5). DPA intended to align with EPA guidelines, provide a common framework for assessments within the Port by establishing agreed LAUs, and to become the custodian of BPPH data for these LAUs. Development proponents would then use this framework to avoid repeating the work of others and to operate within a set of guidelines agreed by DPA and EPA.

To ensure the relevancy of the habitat map produced for DPA, a towed video survey was completed over a selection of habitats within the ZoI for the project to provide confidence in the spatial distribution of habitats (Advisian, 2019b). Good correlation between the habitat map and the towed video transects was observed, thus the habitat map (Figure 4-2) previously used to calculate historic loss for the Port was selected for use in interpreting the modelling results and assessing impacts from the Scarborough Project.

In developing these LAUs, MScience and DPA considered the EPA guidelines, the previous use of management zones for development projects within the Port’s jurisdiction, current and planned usages (such as establishing safe anchorages and moorings), and the natural ecology and physical characteristics of the Dampier Archipelago. For consistency, these LAUs have been used for the project, with the addition of two LAUs to capture the corals on the western side of the Burrup Peninsula (Coral LAU) and a separate LAU to capture the offshore borrow ground area and habitat protection zone of the Dampier Marine Park (Offshore LAU). Historical loss for these LAUs considered the management zones defined for the Pluto LNG Foundation project, where no loss was predicted for Management Zone C (broadly aligned with the Coral LAU). Additionally, no historical impact has been approved or recorded for the offshore LAU.

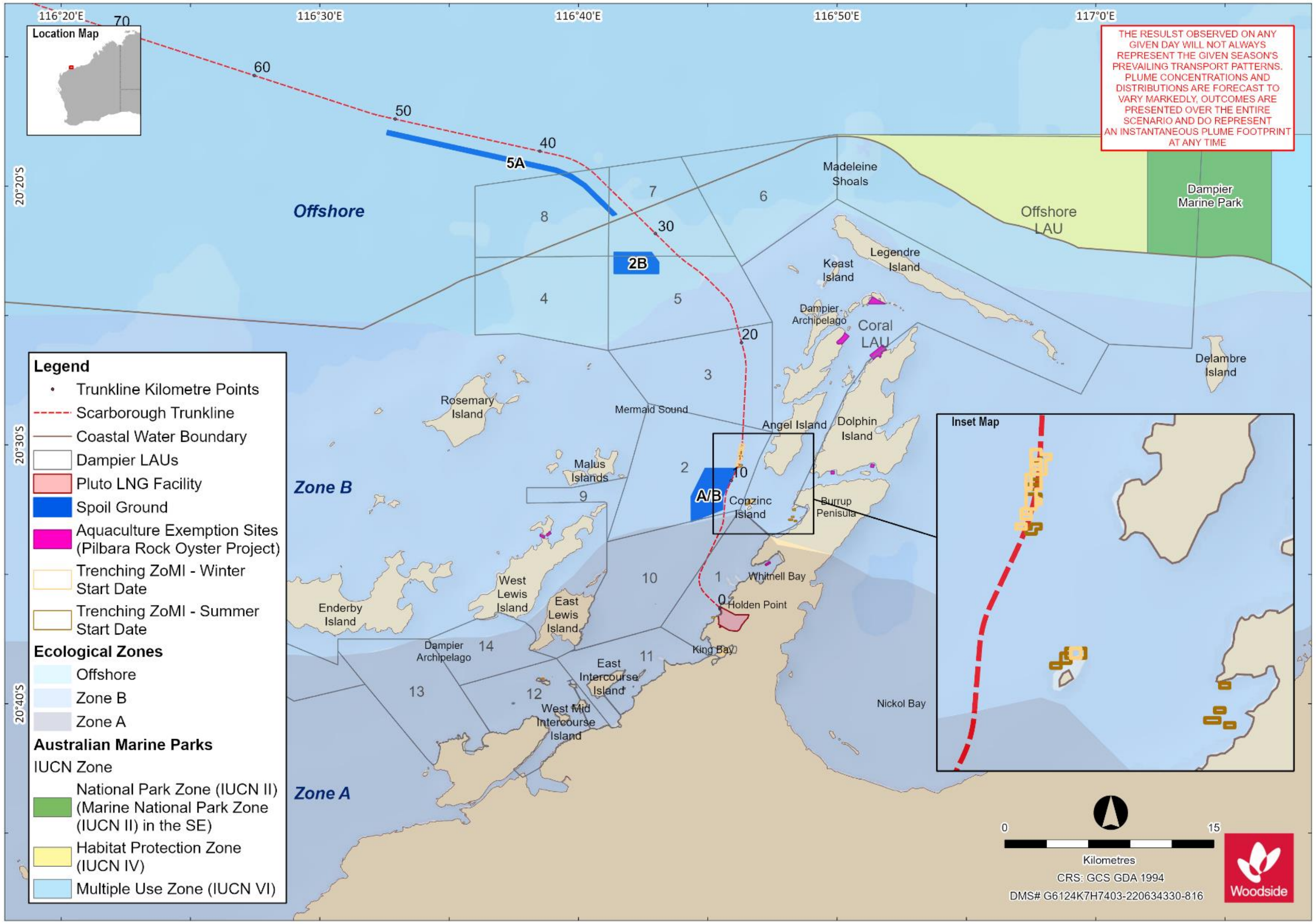

Figure 5-5: Local assessment units with zones of moderate impact overlaid for all operations

5.7.1 Percentage loss calculations

5.7.1.1 Historic loss

Historical loss for LAUs 1 to 15 was considered when defining the boundaries for the LAUs within the Port. A summary of the historical loss is presented in Table 5-10. Based on difficulties in mapping benthic microalgae and the ephemeral nature of seagrasses, estimates of current versus historical distributions of those habitats are not included here. Additionally, modelling shows these habitats are not expected to be impacted by the project.

Table 5-10: Historical loss

LAU	Current area (ha)	Historical area (ha)	% loss
1	59.9	73.7	18.7
2	0.1	0.1	0
3	0	0	0
4	0	0	0
5	8.4	8.4	0
6	0	0	0
7	0	0	0
8	0	0	0
9	1	1	0
10	66.1	66.1	0
11	59.8	76	21.3
12	58.4	58.5	0.2
13	0	0	0
14	10.7	10.7	0
15	0	0	0
Coral LAU	1248	1248	0
Offshore LAU	248	248	0

5.7.1.2 Modelled predictions of irreversible and reversible benthic communities and habitat loss

The ZoMI/ZoHI are generally limited to the footprint of the proposed infrastructure and the area immediately adjacent (Figure 5-6 to Figure 5-7). Some loss is predicted from the modelling at Conzinc Island and Conzinc Bay.

The ZoMI/ZoHI threshold exceedances in isolated pockets of King Bay and around the Intercourse Islands may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells and then ‘trapped’ upon reversal of the tide. While there is a potential for dredged sediments to be found in the indicated areas, the persistently high concentrations at the water-land boundaries may be overstated, particularly in light of the durations required to trigger the thresholds.

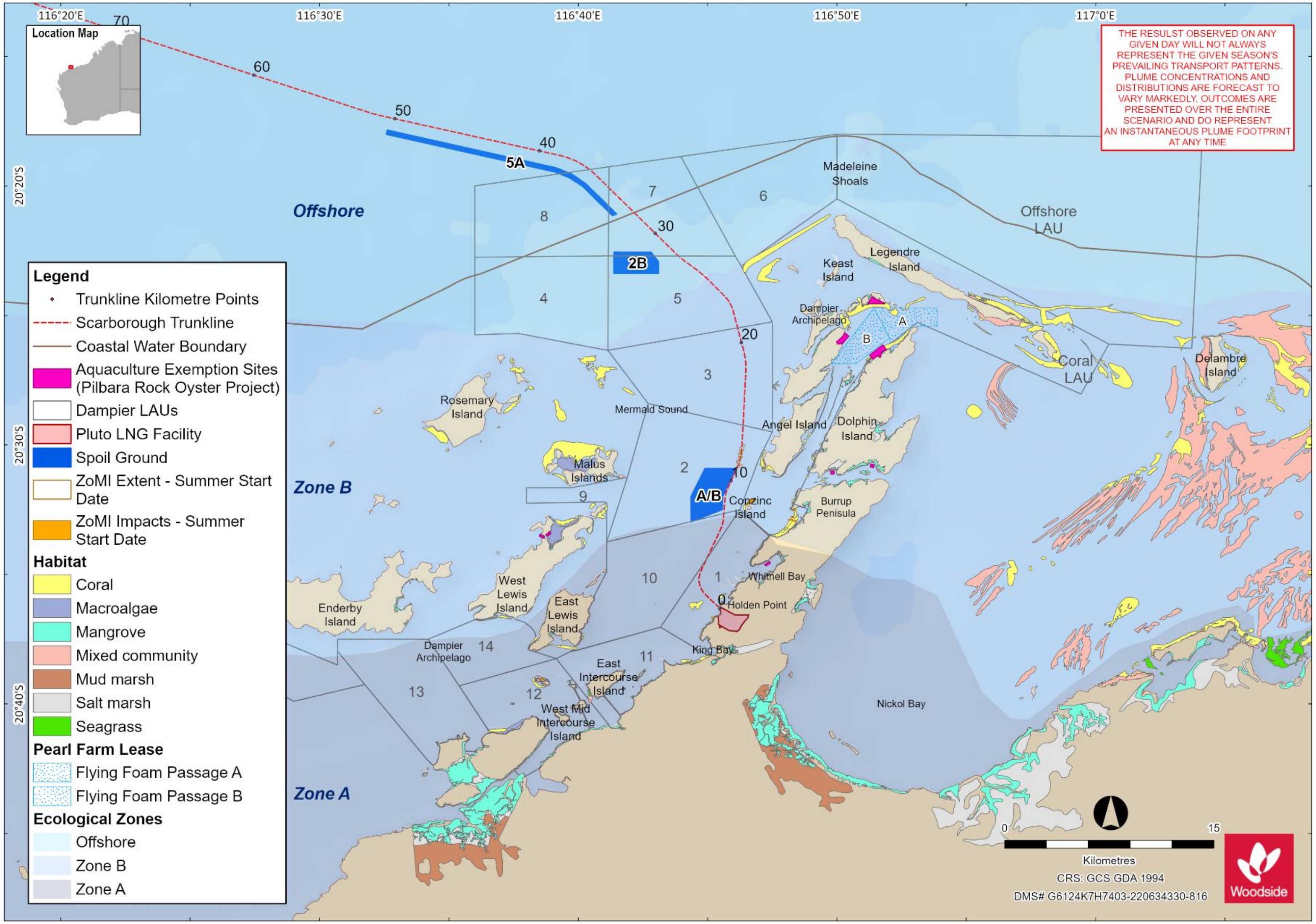

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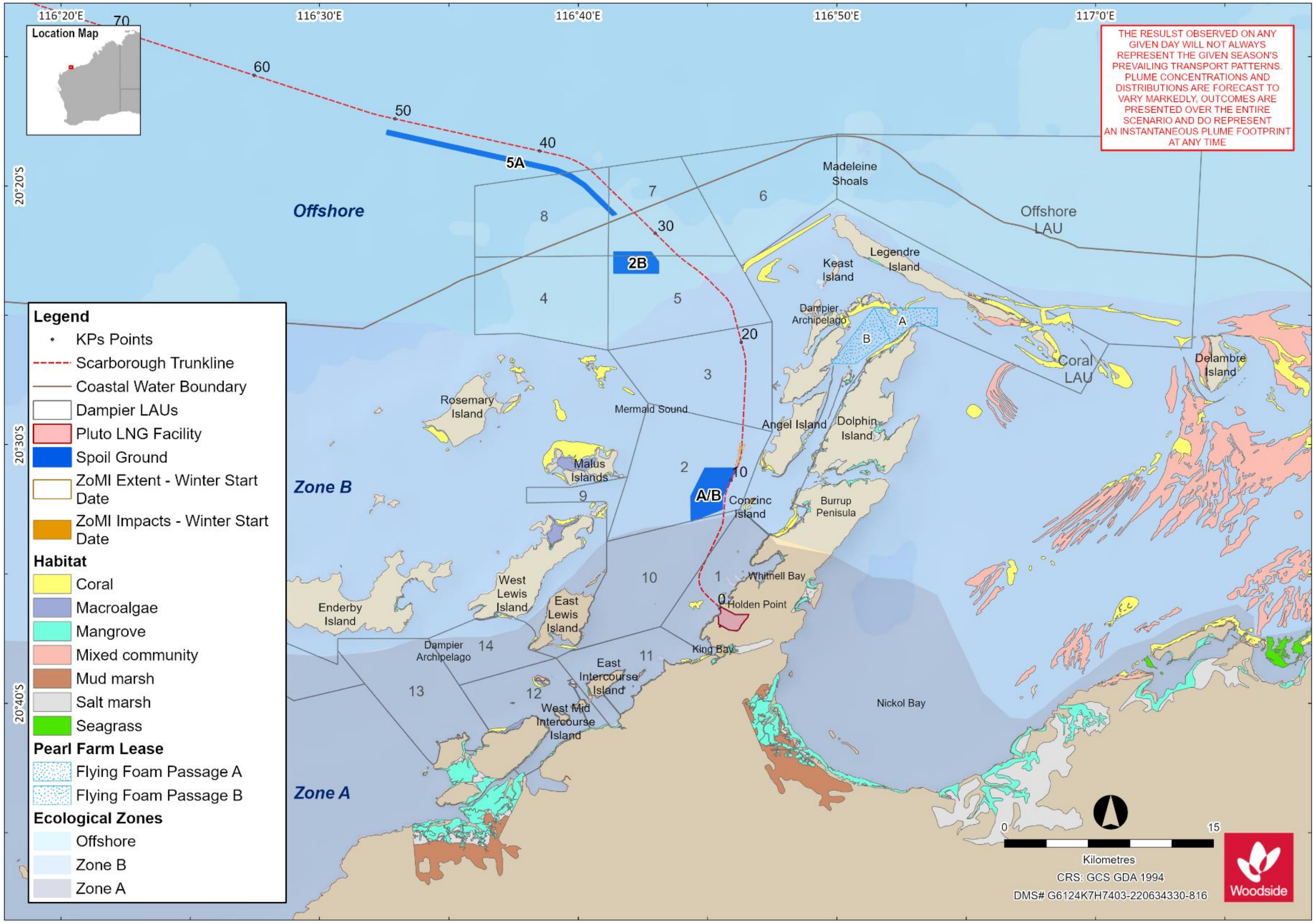
Figure 5-6: Predicted reversible loss from combined trenching and spoil disposal; and offshore borrow ground and backfill operations (summer start date)



THE RESULST OBSERVED ON ANY GIVEN DAY WILL NOT ALWAYS REPRESENT THE GIVEN SEASON'S PREVAILING TRANSPORT PATTERNS. PLUME CONCENTRATIONS AND DISTRIBUTIONS ARE FORECAST TO VARY MARKEDLY, OUTCOMES ARE PRESENTED OVER THE ENTIRE SCENARIO AND DO REPRESENT AN INSTANTANEOUS PLUME FOOTPRINT AT ANY TIME

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Figure 5-7: Predicted reversible loss from combined trenching an spoil disposal; and offshore borrow ground and backfill operations (winter start date)

Table 5-11: Predicted reversible and irreversible loss of BCH from operations commencing in winter

LAU	Historical area (ha)	Irreversible loss (ha)		% Irreversible loss (%)		Reversible loss (ha)		Reversible loss (%)		Historic loss (%)	Cumulative irreversible loss (%)[12]
		Predicted best case	Predicted worst case	Predicted best case[13]	Predicted worst case[14]	Predicted best case	Predicted worst case	Predicted best case	Predicted worst case		
1	73.7	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	18.70%	18.70%
2	0.1	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
3	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
4	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
5	8.4	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
6	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
7	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
8	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
9	1	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
10	66.1	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
11	76	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	21.30%	21.30%
12	58.5	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.20%	0.20%
13	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
14	10.7	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
15	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
Coral LAU	1248[15]	0.00	0.00	0.00%	0.00%	2.72	2.72	0.22%	0.22%	0.00%	0.00%
Offshore LAU	248[15]	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%

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[12] This represents the historic loss values only, as no irreversible loss (best or worse case) of significant BCH predicted for the Project.

[13] Best case assumes no impact to mixed communities in LAU 12.

[14] Worst case assumes impact to mixed communities in LAU 12.

[15] Area calculated from coral communities as defined in the habitat map presented as Figure 4-2.

Table 5-12: Predicted reversible and irreversible loss of coral communities associated with operations commencing in summer

LAU	Historical area (ha)	Irreversible loss (ha)		% Irreversible loss (%)		Reversible loss (ha)		Reversible loss (%)		Historic loss (%)	Cumulative irreversible loss (%)[16]
		Predicted best case	Predicted worst case	Predicted best case[17]	Predicted worst case[18]	Predicted best case	Predicted worst case	Predicted best case	Predicted worst case		
1	73.7	0.00	0.00	0.00%	0.00%	0.55	0.55	0.75%	0.75%	18.70%	18.70%
2	0.1	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
3	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
4	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
5	8.4	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
6	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
7	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
8	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
9	1	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
10	66.1	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
11	76	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	21.30%	21.30%
12	58.5	0.00	0.00	0.00%	0.00%	0.00	1.83	0.00%	3.13%	0.20%	0.20%
13	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
14	10.7	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
15	0	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%
Coral LAU	1248[19]	0.00	0.00	0.00%	0.00%	12.96	12.96	1.04%	1.04%	0.00%	0.00%
Offshore LAU	248[19]	0.00	0.00	0.00%	0.00%	0.00	0.00	0.00%	0.00%	0.00%	0.00%

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[16] This represents the historic loss values only, as no irreversible loss (best or worse case) of significant BCH predicted for the Project.

[17] Best case assumes no impact to mixed communities in LAU 12.

[18] Worst case assumes impact to mixed communities in LAU 12.

[19] Area calculated from coral communities as defined in the habitat map presented as Figure 4-2.

5.7.1.3 Analysis of predicted BCH loss

The percentage loss calculations (Table 5-11 and Table 5-12) consider the modelling results from dredging, spoil disposal and backfill operations at offshore borrow ground. To account for the uncertainty in the mixed community layer, a best case is presented using the coral habitat layer only and a worst case is presented including the coral and mixed community habitat layer when assessing percentage loss.

Areas of potential irreversible and reversible loss are calculated for a project winter start date (Table 5-11) and a project summer start date (Table 5-12). No significant areas of reversible or irreversible loss are predicted based on the modelling results and interpretation below.

No irreversible loss is predicted in LAU 1 and reversible losses remain small when compared with historical losses in this LAU.

No irreversible loss is predicted in LAU 12 and reversible losses remain small when compared with historical losses and only occur under a worst-case scenario in summer. The modelling only extends across the mixed community layer for which the applied coral thresholds are expected to be conservative.

No irreversible loss is predicted in the coral LAU and reversible losses remain small (less than 0.01%) with predicted losses slightly higher for the model runs with a summer start date. The areas of reversible loss are focused on the reefs fringing Conzinc Bay and Conzinc Island (Figure 5-6 and Figure 5-7). The assessment of empirical evidence from the Pluto LNG Foundation project campaign and water quality monitoring sites COBN and CONI showed water quality is unlikely to exceed the water quality thresholds during trenching operations.

The modelling is considered conservative in its assessment of predicted impact when compared with empirical evidence (Section 5.8), so the management measures described in Section 7.1 are designed to manage dredging, spoil disposal and backfill operations to prevent water quality levels exceeding the ZoMI threshold. As such, when these management measures are applied, no loss of coral is predicted.

5.8 Assessment against empirical evidence

The modelling results have been assessed against empirical evidence for the Pluto LNG Foundation project dredging campaign to confirm the results are conservative in their assessment of potential impacts. The water quality data from the Pluto LNG Foundation project dredging campaign has been assessed against the thresholds applied for this program. ZoI and ZoMI thresholds (as applied for the Scarborough Project modelling) were breached when applied to the Pluto LNG Foundation project data. However, coral monitoring during the Pluto LNG Foundation project showed no indirect impact relating to dredging activities at the receptor sites. As such, the thresholds used for this program can be considered conservative in their application.

6 Environmental management overview

The environmental factors, objectives and the key impacts and risks to be managed under this DSDMP are described in Table 6-1 and are in accordance with the Scarborough Project Nearshore Component Referral Supplementary Report (the referral).

A summary of the impact and risk assessment outcomes and further work proposed in the referral for each environmental factor relevant to this DSDMP are presented in Appendix H, while the full environmental risk assessment for the State waters component of Scarborough Project is detailed within the referral.

To support the impact and risk assessment process, a conceptual model illustrating the predicted relationships between environmental receptors (key environmental factors) and sources of environmental stress to which they may be exposed is presented in Appendix H. The model is informed by the activities described in Section 3 to determine the sources of potential environmental stress and the description of the existing environment in Section 4 to determine the key receptors and key environmental factors.

Table 6-1: Environmental factors, objectives and a summary of key impacts and risks

Key Environmental Factor	EPA objective	Summary of impacts and risks[20]	Project environmental protection outcome / objective	Relevant management framework
Marine Environmental Quality	Maintain the quality of water, sediment and biota so environmental values are protected.	Planned: • Reduced water quality/increased turbidity from dredging, spoil disposal and backfill activities • Changes to sediment quality and characteristics from dredging, spoil disposal and backfill activities • Reduced water quality from Project vessel discharges Unplanned: • Reduced water and sediment quality from accidental hydrocarbon release	Maintain ecosystem integrity as per the existing Mermaid Sound EQP. Cultural and spiritual values of the marine environment are protected through compliance with all marine environmental quality EPOs.	Management actions and targets specified in Section 7.
Benthic Communities and Habitat (BCH)	Protect benthic communities and habitats so biological diversity and ecological integrity are maintained.	Planned: • Physical removal of BCH • Indirect impacts (increased turbidity, reduced light, increased sediment deposition) on BCH from dredging and spoil disposal activities. • Project vessel discharges impacting BCH by reducing water quality	EPO 6-1(1) No detectable net reduction of live coral cover at any of the coral impact monitoring locations attributable to the Proposal.	Management actions and targets specified in Section 8.

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[20] Potential environmental impacts and risks are consistent with those identified in the project referral supporting document.

Key Environmental Factor	EPA objective	Summary of impacts and risks[20]	Project environmental protection outcome / objective	Relevant management framework
		Unplanned: • Accidental hydrocarbon release impacting BCH • Introduction of IMS impacting BCH		
Marine Fauna	Protect marine fauna so biological diversity and ecological integrity are maintained.	Planned: • Reduced water quality/increased turbidity • Removal/modification of important/critical habitats • Light emissions impacting marine turtle and seabirds and migratory shorebirds • Noise emissions impacting marine fauna Unplanned: • Accidental hydrocarbon release impacting marine fauna • Vessel strike impacting marine fauna • Entrainment of marine turtles • Introduction of IMS impact biodiversity	EPO 6-1(2) Avoid where possible and otherwise minimise direct and indirect impacts on marine fauna listed as specially protected fauna under the Biodiversity Conservation Act 2016	Management actions and targets specified in Section 9.
Social Surroundings	To protect social surroundings from significant harm.	Planned: • Physical presence of construction vessels displacing other users • Light emissions impacting marine turtle and seabirds and migratory shorebirds • Visual impacts from dredge plumes • Visual impacts from routine vessel discharges Unplanned: • Accidental hydrocarbon release preventing water-based activities • Accidental hydrocarbon release impacting fish and fisheries • Introduction of IMS impacting fisheries resources • Impacts to Aboriginal heritage sites/places	Maintain ecosystem integrity as per the existing Mermaid Sound EQP. Cultural and spiritual values of the marine environment are protected through compliance with all marine environmental quality EPOs.	To ensure all activities described in Section 4 that have the potential to impact cultural heritage are managed to an acceptable level, the CHMP will be implemented, which includes specific controls relating to Aboriginal and Cultural Heritage. In addition, MAC has identified marine environmental values that are of cultural importance pertinent to this DSDMP, and hence the associated management are described in Section 10. Other potential impacts to socials surroundings (e.g., aesthetics) are covered by management actions and targets specified in Section 7 to 9.

7 Management of marine environmental quality

7.1 Environmental quality management framework

This section presents the project activities (Section 3) in the context of the environmental quality management framework (EQMF) recommended through the National Water Quality Management Strategy, and as modified through EPA's *Technical Guidance for Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016a). Note the EPA's EQMF is designed for managing environmental quality over the long-term, with short-term exceedances associated with activities such as dredging accommodated within the EQMF as long as they do not compromise environmental quality over the medium/long-term.

The environmental values (EVs) form the basis of the EQMF and, in combination with associated environmental quality objectives (EQOs), represent the community's and other stakeholders' desired outcome for marine environmental quality. EVs are defined as particular values or uses of the environment that are important to a healthy ecosystem or for public benefit, welfare, safety or health (EPA, 2016a). Five EVs are considered potentially applicable to the WA marine environment~~,~~ specifically:

- Ecosystem Health
- Fishing and Aquaculture
- Recreation and Aesthetics
- Industrial water supply
- Cultural and Spiritual.

EQOs are high-level management objectives that describe what must be achieved to protect each EV. The EQOs for each EV are presented in Figure 7-1 and Table 7-1, with those applicable to the project also included in Table 7-3.

Environmental quality criteria (EQC) represent scientifically-based limits of acceptable change to a measurable environmental quality indicator that is important for protecting the associated EV. The EQC define the limits of acceptable change to the measured environmental quality indicators. The key to successful marine environmental performance under the EQMF is to maintain environmental quality within the bounds of the EQC. If the EQC are met, then it is assumed the EQOs are met and EVs are protected. The EQC for this EQMF are related to an increase in suspended sediment associated with the activities described in Section 3.

There are two levels of EQC:

1. Environment Quality Guidelines (EQGs): These are relatively simple and easy-to-measure triggers that, if met, indicate a high degree of certainty that the associated EQO was achieved. If the EQG is not met, there is uncertainty as to whether the associated EQO was achieved and a more detailed assessment against the EQS is required.
2. Environment Quality Standards (EQSs): These are numerical values or narrative statements that, if not met, indicate a significant risk that the associated EQO has not been achieved and a management response is required. The management response focuses on identifying the cause (or source) of the exceedance and then reducing the loads of the stressor. For Ecosystem Health EV, the EQS aligns with Environmental Protection Outcome (EPO) 6-1(1) specified in Ministerial Statement No.1172.

Figure 7-1 shows the EQMF in context of project activities, with supporting assessment in Table 7-1. Additional supporting information for the selection of the EQC are presented in Section 7.1.1.

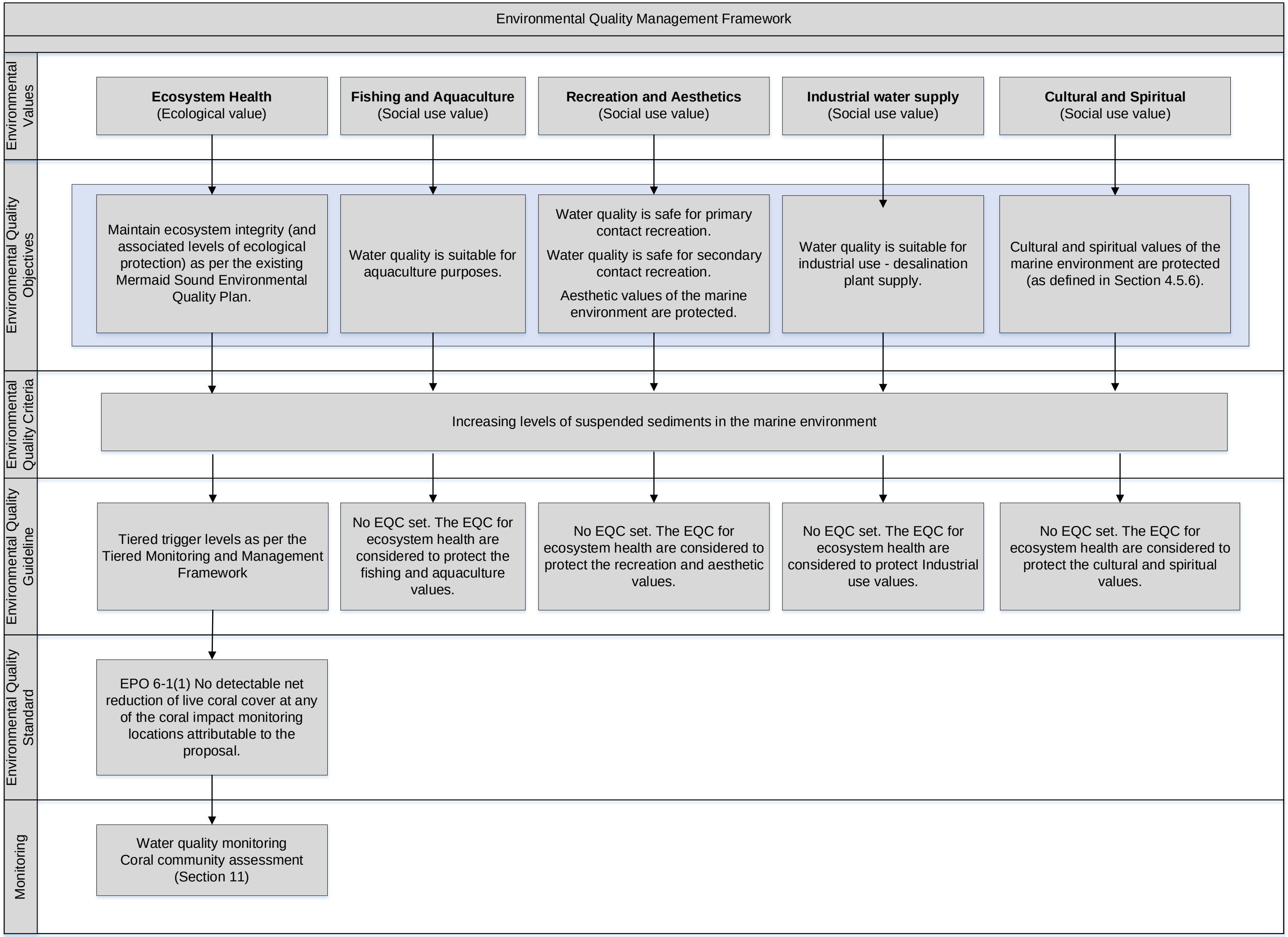

Figure 7-1: Environmental quality management framework

Table 7-1: Summary assessment of environmental values in the context of project activities

EVs (EPA, 2016a)	Activity-specific EV rationale	Activity-specific EQO	Monitoring	EQG	Management response/ reporting	EQS	Management response/ reporting
Ecosystem Health	Marine Environmental Quality and BCH are key environmental factors relating to the activities described in Section 3. See Section 7.1.2.	Maintain ecosystem integrity as per the existing Mermaid Sound Environmental Quality Plan (EQP).	Water quality monitoring as per Section 11.1. Coral community assessment as per Section 11.3. Monitoring action as per the tiered monitoring and management framework (TMMF) (Section 7.4).	Turbidity levels at impact monitoring sites will not exceed Tier 3 triggers attributable to the Project (Section 7.4).	Management response and reporting of Project attributable exceedance as per TMMF (Section 7.4).	EPO 6-1(1): No detectable net reduction of live coral cover at any of the coral impact monitoring locations attributable to the Proposal.	Within 24 hours of determining the EQS is not being achieved, report the non-achievement to the CEO. Reporting as set out in Section 12.5.2.
Fishing and Aquaculture	Aquaculture leases present in the region. However, no impacts to aquaculture have been predicted from the activities described in Section 3. See Section 7.1.3.	No EQOs, EQGs or EQSs are included as the activities described in Section 3 are not expected to impact fishing and aquaculture values. Further the EQC for ecosystem health are considered to protect the fishing and aquaculture values.					

EVs (EPA, 2016a)	Activity-specific EV rationale	Activity-specific EQO	Monitoring	EQG	Management EQS response/ reporting	Management response/ reporting
Recreation and Aesthetics	Suspended sediments may affect the aesthetic value of Mermaid Sound. Elevated SSC are expected to be confined within proximity of the dredging vessel, and temporarily in isolated pockets, as defined by the ZoMI. Boating, fishing and swimming are not expected to be affected through a localised increase in suspended sediments. See Section 7.1.4.	No EQOs, EQGs or EQSs are included as the activities described in Section 3 are not expected to impact recreational values, while the EQC for ecosystem health are considered to be protective of aesthetic values.				Reporting as set out in Section 12.5.
Industrial water supply	Desalination plant seawater intake located in King Bay. No affects from excess suspended sediment expected from the activities described in Section 3, as located outside but in proximity of Zone of Influence.	No EQOs, EQGs or EQSs are included as the activities described in Section 3 are not expected to impact industrial water supply values. Further the EQC for ecosystem health are considered to protect the industrial water supply values.				Where Project activities are likely to significantly increase turbidity in the vicinity of the intake location, Water Corporation will be notified

EVs (EPA, 2016a)	**Activity-specific EV rationale**	**Activity-specific EQO**	**Monitoring**	**EQG**	**Management EQS response/ reporting**	**Management response/ reporting**
Cultural and Spiritual	Cultural and Spiritual values are defined in Section 4.5.6.~~,~~ Based on the potential impact pathway of the proposal to the environmental values it is considered that if water quality requirements for the protection of Ecosystem Health are met the cultural and spiritual values defined in Section 4.5.6. will be met. See Section 7.1.6	No EQOs, EQGs or EQSs are included as the activities described in Section 3 are not expected to impact cultural and spiritual values, while the EQC for ecosystem health are considered to be protective of the defined cultural and spiritual values (Section 4.5.6).				Reporting as set out in Section 12.5.2.

7.1.1 Assessment of environmental values and development of environmental quality criteria

EQC represent scientifically-based limits of acceptable change to measurable environmental quality indicators that are important for the protection of the associated EV. EQC are developed where there is a clear impact pathway to the EV.

Sediment sampling along the proposed pipeline route has demonstrated sediments are suitable for unconfined ocean disposal, with results indicating all levels of potential contaminants of concern were below the NAGD (2009) screening levels. This conclusion is further supported by more recent studies as detailed in Section 4.2.2. Therefore, sediments to be dredged (and suspended during operations) are considered to be uncontaminated and suitable for unconfined ocean disposal.

The controls listed in Table 7-3 are designed to mitigate impacts from planned and unplanned events. When the management actions are implemented, the potential impacts to the selected EVs are limited to those resulting from an increase in suspended sediments. Therefore, EQC use turbidity as a proxy for suspended sediment levels as the environmental quality indicator. The relationship between the selected EQC and each EV is presented in Section 7.1.2 to Section 7.1.5.

7.1.2 Ecosystem health

Elevated levels of suspended sediments in the water column due to trenching and spoil disposal, and borrow ground dredging and backfill activities are expected to be spatially and temporally confined, due to the rapid progression of the activities along the trunkline route. This is supported by monitoring results from the Pluto LNG Foundation project, which indicated a rapid decrease in turbidity beyond the immediate trenching footprint[21] (MScience, 2018b).

Any changes to water quality are expected to be consistent with the limits of acceptable change for each level of ecological protection (LEP), as spatially defined in the existing Mermaid Sound EQP (Figure 7-2). No longer-term chronic effects on water quality are anticipated, based on the scope of the activities described in Section 3.

Sediment plume modelling (Section 5) shows isolated exceedances of the ZoMI within areas defined as a high LEP in the existing Mermaid Sound EQP. However, there are no exceedances of the ZoMI in areas defined as a maximum LEP (Figure 7-2). To meet EPO 6-1(1), the TMMF is designed to manage water quality to levels below which impacts are not predicted to BCH. The management actions and targets detailed in Section 7.3 have been designed to mitigate impacts to BCH and to protect ecosystem health. In addition, monitoring results from the Pluto LNG Foundation project dredging campaign suggests modelling is likely to be conservative in its prediction.

The limits of change in the key elements of ecosystem integrity are considered in Table 7-2 as defined in the *Technical Guidance – Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016d).

Table 7-2: Assessment of the levels of change in the key elements of ecosystem integrity

Key elements of ecosystem integrity	Limits of change within the High LEP (Figure 7-2)	Limits of change within the Maximum LEP (Figure 7-2)
Ecosystem Processes	Ecosystem processes are not expected to be affected by a temporary and spatially confined elevation in suspended sediment levels in proximity to the dredging operations. Significant BCH are not present close to the dredging operation.	Ecosystem processes are not expected to be affected by a temporary and spatially confined elevation in suspended sediment levels in proximity to the dredging operations. Significant BCH are not present close to the dredging operation.

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[21] the median and 80th percentile of turbidity measured in proximity to the dredge rapidly dropped below the median and 80th percentile of natural turbidity at two reference sites located in areas unaffected by dredging (MScience, 2018b)

Key elements of ecosystem integrity	**Limits of change within the High LEP (Figure 7-2)**	**Limits of change within the Maximum LEP (Figure 7-2)**
Biodiversity	No change to the variety and type of marine life is expected in the area defined as having a high LEP as changes to water quality are expected to be spatially and temporally confined.	No change to the variety and type of marine life is expected in the area defined as a maximum LEP as changes to water quality are expected to be spatially and temporally confined.
Abundance and biomass of marine life	No significant BCH are present within close proximity of the trenching and spoil disposal and backfill operations and thus no change to the abundance or biomass of marine life is expected. Additionally, the TMMF is designed to manage water quality to levels below which impacts are not predicted to BCH, and thus no changes to abundance or biomass are expected.	No significant BCH are present within close proximity of the trenching and spoil disposal and backfill operations and thus no change to the abundance or biomass of marine life is expected. Additionally, the TMMF is designed to manage water quality to levels below which impacts are not predicted to BCH, and thus no changes to abundance or biomass are expected.
The quality of water, biota and sediment	No contaminants of concern are present in the sediments to be dredged. Suspended sediments are expected to be temporarily elevated in proximity to the dredging operations, but there is not expected to be any resultant effects on biota. Additionally, the TMMF is designed to manage water quality to levels below which impacts are not predicted to BCH, and thus no changes to abundance or biomass are expected.	The trenching, spoil disposal and backfill activities may result in an elevation of total suspended solids in the maximum LEP, as reflected by the ZoI. However, these events are expected to be of short duration and at a relatively low level. The maximum LEPs experience high levels of TSS during cyclonic activity and the levels associated with the trenching, spoil disposal and backfill activities are not expected to exceed these levels. Additionally, the TMMF is designed to manage water quality to levels below which impacts are not predicted to BCH, and thus no changes to abundance or biomass are expected.

7.1.3 Fishing and aquaculture

7.1.3.1 Aquaculture

The modelled ZoI does not intersect with any Pilbara rock oyster project aquaculture leases (Figure 4-10) or aquaculture exemption application sites in Flying Foam Passage, Searipple Passage, Withnell Bay and off West Lewis Island (Figure 4-12). The Maxima Pearling aquaculture lease in Flying Foam Passage is around 5 km from the proposed pipeline route.

Peer reviewed modelling (Section 5) has shown the maximum contribution to SSC from the trenching and spoil disposal or borrow ground dredging and backfill operations (based on the 95th percentile results) are not expected to exceed 5 mg/l in the southern end of Flying Foam Passage, and less than 1 mg/l in the vicinity of the existing Maxima Pearling leases in the northern section of Flying Foam Passage. MODIS imagery collected during the Pluto LNG Foundation project during trenching activities (during the period the dredge was closest to the southern entrance of Flying Foam Passage) showed trenching did not affect turbidity levels within Flying Foam Passage. Strong tidal currents in Flying Foam Passage elevate turbidity levels naturally (MScience, 2018b).

Oysters have been shown to be tolerant of elevated SSC associated with dredging activities, as long as they do not become completely buried (Morton, 1977). They are comparatively tolerant when compared with other filter feeders against unwanted particles of various nature, and can thus continue to feed in turbid waters, even close to dredging projects (Schönberg, 2016). Intolerance thresholds for oyster eggs are cited at 188 mg/l, no effect concentrations are cited to about 200 mg/l, and sublethal effects to 4000 mg/l (Schönberg, 2016). Another recent study has shown the rock oysters studied thrived under highly turbid conditions (less than 700 mg/l) if other environmental variables were optimal (Chowdhury et al., 2019). The simulated SSC predicted are at least an order of magnitude below those cited to potentially cause impacts.

The water quality monitoring program (Section 11.1) includes several sites surrounding the entrance to Flying Foam Passage (ANG2, CONI and COBN), as well as a site at the southern end of Flying Foam Passage (FFP1). The tiered trigger levels (Section 7.4), based on water quality and set for the maintenance of ecosystem integrity, are an order of magnitude below the thresholds at which impacts to oyster communities are predicted. As such, they are considered to adequately protect the Maxima Pearling aquaculture lease. Note, management actions would be triggered to reduce turbidity levels in the event of a project-attributable Tier 2 exceedance and above, hence well before impacts are predicted to oysters, and thus no EQS are set for this EV.

Further, sediment sampling along the proposed pipeline route has demonstrated sediments are suitable for unconfined ocean disposal, with results indicating all levels of potential contaminants of concern were below the NAGD (2009) screening levels. This conclusion is further supported by more recent studies as detailed in Section 4.2.2. Therefore, sediments to be dredged (and suspended during operations) are considered to be uncontaminated; thus, no toxicological impacts from the resuspension of contaminants are predicted.

7.1.3.2 Fishing

Fish of the Dampier Archipelago and specific fisheries are set out in Section 4.4.6 and Section 4.5.5 respectively. Suspended sediments associated with trenching and spoil disposal or borrow ground dredging and backfill operations may affect fishes' ability to forage, hunt and avoid predators (Harvey et al., 2016). Elevated concentrations of suspended sediments may also cause physiological impacts, such as gill impairment. An analysis of available literature suggests that impacts range from minimal (10 mg/l SSC) to extreme (1000 mg/l SSC) (Harvey et al., 2016).

Modelling results (Section 5) suggest trenching and spoil disposal using Spoil Ground A/B may elevate suspended sediment concentration up to 10 mg/l in the direct vicinity of the activities (trunkline route between around KP10 to KP16 based on the 95th percentile results), with the simulated plume extending towards Flying Foam Passage, driven by the prevailing hydrodynamics. Modelling also simulated isolated pockets of elevated suspended sediments above 10 mg/l around King Bay and the Intercourse Islands. However, these pockets of elevated SSC may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells then 'trapped' upon reversal of the tide. The trenching and backfill operations are expected to rapidly progress along the pipeline route, ensuring increased SSC are spatially and temporally confined. This is supported by monitoring results from the Pluto LNG Foundation project, which indicated a rapid decrease in turbidity beyond the immediate dredging footprint[21] (MScience, 2018b).

SSC during high-energy metocean events, including cyclones, have been observed to naturally exceed the 10 mg/l threshold. The 95th percentiles for seven of the eight water quality sites monitored (August 2006 to May 2007) before the Pluto LNG Foundation project dredging campaign naturally exceeded 10 mg/l (MScience, 2007). Additionally, an analysis of the data collected outside of periods of dredging during the Pluto LNG Foundation project shows the maximum daily mean of 17 out of the 25 sites monitored exceeded 10 mg/l. Due to the factors outlined below, impacts to commercial or recreational fisheries are not expected as a result of increased SSC:

- SSC naturally exceed 10 mg/l during high energy metocean events, including spring tides.
- Trenching, spoil disposal and backfill activities are only predicted to raise SSC beyond 10 mg/l in spatially confined areas that will vary with the location of the dredge, which will rapidly progress along the pipeline route.
- SSC above 10 mg/l are expected to be temporally confined (based on the 95th percentile depth average results).

Impacts to habitat important to fishes are considered through the TMMF (Section 7.4), which is designed to prevent impacts to BCH.

Further, sediment sampling along the proposed pipeline route has demonstrated sediments are suitable for unconfined ocean disposal, with results indicating all levels of potential contaminants of concern were below the NAGD (2009) screening levels. This conclusion is further supported by more recent studies as detailed in Section 4.2.2. Therefore, sediments to be dredged (and suspended during operations) are considered to be uncontaminated; thus, no toxicological impacts from the resuspension of contaminants are predicted.

7.1.4 Recreation and aesthetics

Sediment sampling along the proposed pipeline route has demonstrated sediments are suitable for unconfined ocean disposal, with results indicating all levels of potential contaminants of concern were below the NAGD (2009) screening levels. his conclusion is further supported by more recent studies as detailed in Section 4.2.2. Therefore, sediments to be dredged (and suspended during operations) are considered to be uncontaminated; thus, no toxicological impacts from the resuspension of contaminants are predicted.

Potential impact to recreation and aesthetics is therefore limited to increased turbidity associated with the activity. The *Guidelines for Managing Risks in Recreational Water* (NHMRC, 2008) defines that the general aesthetic acceptability of recreational water can be expressed in terms of criteria for transparency, odour and colour. It has been suggested values for light penetration, colour and turbidity should not be significantly worse than natural background levels (NHMRC, 2008).

The ZoI defines the area in which a plume may be visible, noting that at any point in time the plume is likely to be restricted to a small portion of the ZoI in proximity to the activity. Areas within the ZoI are expected to be within the limit of natural variation; as such, potential impacts to aesthetics are considered to be limited to those areas within the ZoMI.

Modelling predicts elevated SSC at Conzinc Island and Conzinc Bay associated with trenching and spoil disposal activities, as reflected by the ZoMI. Elevation in SSC in these areas is expected to be temporary in nature due to the operations and the rapid progress of trenching along the trunkline route, as well as the limited use of Spoil Ground A/B. This is supported by monitoring results from the Pluto LNG Foundation project, which indicated a rapid decrease in turbidity beyond the immediate dredging footprint[21] (MScience, 2018b). The monitoring supported the predictions that turbidity may decrease by an order of magnitude over distances of several hundred metres from the trenching operations.

Primary (swimming) and secondary (boating) contact recreation are not expected to be affected by the localised increases in suspended sediments. These localised elevated levels of suspended sediments are expected to remain in proximity to the activity. The activities are not expected to change the recreational values of Conzinc Bay and no impacts to the proposed Conzinc Bay Tourism precinct or cultural tourism activities associated with the planned Murujuga Living Knowledge Centre are expected.

No specific EQGs or EQSs have been set, given potential impacts to aesthetics is limited to the ZoMI; as such, the EQC for ecosystem health are considered to be protective of aesthetic values, with notifications to the public required for tiered management trigger exceedance as a result of the activity.

7.1.5 Industrial water supply

No industrial water supply exists within the ZoI, however it is noted that there is a desalination plant water intake in King Bay operated by Water Corporation located close to the ZoI boundary. Based on information provided by the Water Corporation, the turbidity limit on the intake is 63 NTU. This is measured in-situ through instantaneous readings inline. The intake location in King Bay is approximately 2.5 km from the dredging activity, with the ZoI extending adjacent to the intake. Peer reviewed modelling has predicted dredging related excess SSCs in proximity to the intake to be less than 5 mg/l (~3.6 NTU), and further afield in the southern portion of King Bay to be up to 10 mg/L (~7.4 NTU) based on the 95th percentile depth averaged results.

Given there is a monitoring location adjacent to the Supply Base (i.e., SUP2) to the north of King Bay this can act as a sentinel site between the trunkline trenching activities and intake location. Where there is a Tier 1 Project attributable trigger at SUP2, the risk of elevated suspended sediment concentrations in proximity to the intake location will be assessed, and where Project activities are likely to significantly increase turbidity in the vicinity of the intake location, Water Corporation will be notified

7.1.6 Cultural and spiritual

Woodside has undergone extensive consultation with Traditional Custodians represented by MAC to understand the values of the marine environment that are of cultural importance (Section 2.3.2.1; MAC, 2021). For Traditional Custodians represented by MAC, Mermaid Sound and Dampier Archipelago (Murujuga) are considered one place where the entire environment and all ecosystems hold both cultural and environmental value, with these types of values intrinsically linked. MAC Elders were clear that all living things in Mermaid Sound are connected and important (MAC, 2021).

Key cultural and spiritual values of the marine environment for Traditional Custodians represented by MAC are set out in Section 4.5.6 and summarised as follows (MAC, 2021):

- Benthic communities and habitats (BCH) such as coral, seagrass, mangroves and macroalgae, soft bottom benthos and intertidal communities. These habitats support a diverse range of fauna through the provision of habitat and shelter, foraging habitat and food source, and important primary productivity.
- Protected marine fauna such as dolphins and whales that are of totemic importance, dugongs which are considered a food source, marine turtles and their habitat critical to survival including foraging and nesting habitat, and fish and sea snakes.

Dredging activities have the potential to indirectly impact BCH, such as coral and seagrass communities, through the release of additional sediments into the water column which can lead to a reduction in light received by benthic communities. These suspended sediments can be dispersed, resuspended and allowed to settle through oceanographic and sediment transport processes. The risk of sediment-related effects to BCH and hence protected marine fauna foraging habitat has been assessed using sediment plume modelling (Section 5) in context of the biological thresholds set out in Appendix G, which are aligned with the EPA (2021) *Technical Guidance – Environmental impact assessment of marine dredging proposals*.

Elevated levels of suspended sediments in the water column due to trenching and spoil disposal, and borrow ground dredging and backfill activities are expected to be spatially and temporally confined, due to the rapid progression of the activities along the trunkline route. The proposed pipeline trenching and spoil disposal (which generates the most turbidity compared with other project stages) is expected to have a total duration of around three months. Given the trunkline in State waters is around 32 km long, the predicted increases in suspended sediment in discrete areas such as Conzinc Bay will be intermittent, of relatively short duration and likely to occur within a period limited to weeks rather than months.

Peer reviewed modelling considered impacts to BCH, including coral habitats of the Dampier Archipelago and inshore of the proposed Borrow Ground (RPS 2022). Modelling has shown that trenching, spoil disposal and backfill activities undertaken in State waters are predicted to cause detectable changes in water quality from elevated SSCs. The ZoMI (defined as the potential for reversible impacts) from trenching and spoil disposal is predicted to occur in areas immediately adjacent to the trunkline route where the highest intensity activities are likely to occur. Discrete pockets are predicted further afield near Conzinc Island, within Conzinc Bay, King Bay and around Intercourse Islands where coral habitat may be present. These isolated pockets of moderate impact (i.e., reversible loss) are predicted by modelling where there are no controls in place. However, the management actions and targets, in particular the Tiered Monitoring and Management Framework (TMMF), detailed in Section 7.3 and Section 8 have been designed to impart the necessary controls to mitigate impacts to BCH and to protect ecosystem health (and the related cultural and spiritual values).

The TMMF is a proactive and adaptive framework informed by water quality to manage the dredging activities, such that impacts to BCH (based on coral communities as the most sensitive ecological receptor) are not realised through its implementation. This is achieved through timely implementation of responsive and contingency management actions. Specific locations of marine environmental values of are of cultural importance to MAC are described in Section 4.5.6 and shown in Figure 5-12. Monitoring sites as set out in Section 11.1.1 align with key areas of value to MAC, including habitat ay Gidley Island, Angel Island, Malus Islands, Conzinc Island, Conzinc Bay, Withnell Bay, Flying Foam Passage and Legendre Island.

The EQOs proposed in Table 7-1 are set to maintain ecosystem integrity as per the existing Mermaid Sound Environmental Quality Plan (EQP) (Figure 7-2), with the TMMF designed to ensure that the LEPs identified in Figure 7-2 are maintained. As described in EPA (2016), there is no difference in the accepted levels of change in the key elements of ecosystem integrity between a high and maximum LEP apart from changes to the quality of water, biota and sediment. A maximum LEP requires levels of contaminants and other measures of quality remain within limits of natural variation (no detectable changes), while a high LEP allows some reductions in water quality over the course of the Project but importantly these reductions must not be of sufficient intensity and/or duration to cause any effects on biota.

Based on the temporary and localised nature of elevated SSCs from seabed intervention activities, and the implementation of the TMMF, which is designed to reduce indirect impacts from turbidity further, there is not expected to be any resultant effects on biota in areas that have been identified as culturally important to MAC. This is further rationalised in Section 10, in context of a value mapping exercise.

With specific regard to the proposed Murujuga Living Knowledge Centre tourism precinct at Conzinc Bay, the TMMF will ensure a high LEP is maintained to protect the BCH that provide value to MAC's cultural tourism activities associated with the proposed Murujuga Living Knowledge Centre tourism precinct at Conzinc Bay. Water quality monitoring site COBN is located on the seaward edge of the coral community at the North of Conzinc Bay. Water quality monitoring sites CONI and CONI2 are located at Conzinc Island between the trunkline route (and Spoil Ground A/B) and Conzinc Bay. These monitoring sites will act as a sentinel site for Conzinc Bay and provide an early warning indication of changes in water quality (increases in turbidity) as a result of dredging activities.

Further, the dredging activity is not expected to result in the mobilisation of contaminants of concern based on the analysis of the Scarborough SAP Implementation Report (Advisian 2019) and other more contemporary data sets (Advisian 2019, O2 Marine 2021, MScience 2022). This will be further verified through the trenching and spoil disposal dredge plume assessment (see Section 11.4.1) which was included on MACs request. This study includes the collection of supplementary data to provide confidence that there are no contaminants of concern being mobilised by the activity, based on the highest risk area as an indicator.

No specific EQGs or EQSs have been set, given the EQC for ecosystem health, as well as the management actions and targets detailed in Sections 7.3, 8.1 and 9.1, are considered to be protective of MAC's cultural and spiritual values, as further rationalised in Section 10.

7.2 Environmental quality plan

The EQP is focused and designed around measuring and assessing any residual environmental concerns that remain after implementing any mitigation management strategies (EPA, 2016a). As per EPA (2016a), where an EQP exists that has established EQOs, a new EQP should only be proposed if amendments to the existing EQP are proposed.

The EQOs proposed (Table 7-1) are consistent with those in the existing Mermaid Sound EQP (Figure 7-2) and the LEPs are expected to be maintained throughout the activity described in Section 3. Any impacts to the Social Use EQO are expected to be spatially and temporally confined and within the bounds of natural variation; thus, no modifications are proposed to the existing Mermaid Sound EQP.

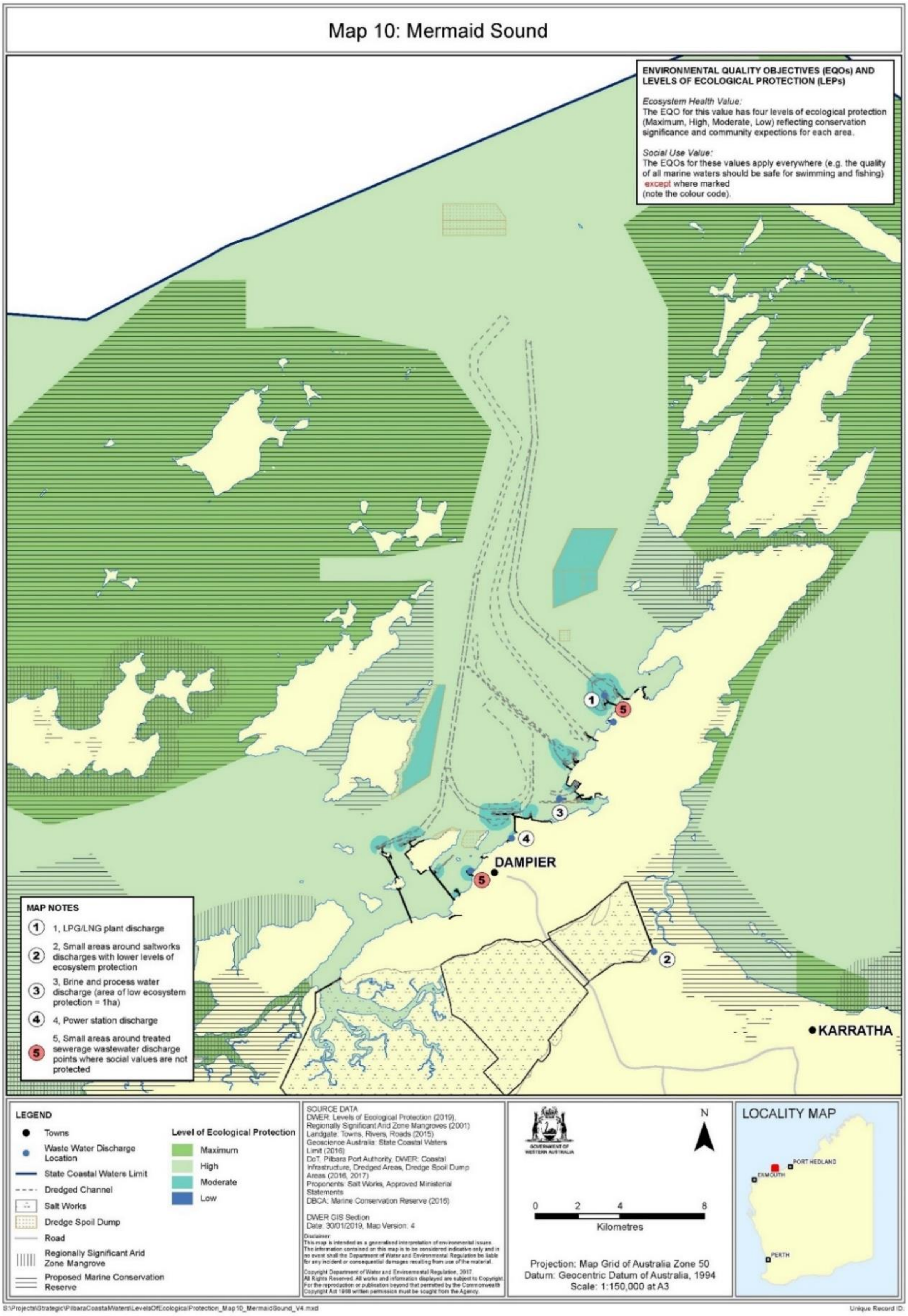

Figure 7-2: Environmental Quality Plan showing levels of ecological protection for ecosystem health and that all social use values (including cultural and spiritual) are protected throughout Mermaid Sound except in two small areas identified by red circles (EPA, 2019)

7.3 Marine environmental quality management framework

To ensure all activities described in Section 3 that have the potential to impact Marine Environmental Quality are managed to an acceptable level, the management framework in Table 7-3 will be implemented on the Project.

Table 7-3: Marine environmental quality management actions, management targets, monitoring and reporting

EPA Factor: Marine Environmental Quality

Environmental Objectives:

- Maintain ecosystem integrity as per the existing Mermaid Sound EQP.
- Cultural and spiritual values of the marine environment are protected (as defined in Section 4.5.6).

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA 1.1: Implement the water quality monitoring program and Tiered Monitoring and Management Framework (TMMF) to manage water quality associated with trenching, spoil disposal and backfill activities to a level where impacts are not predicted to occur to BCH.	**MT 1.1:** Trenching, spoil disposal and backfill activities are managed in accordance with TMMF to achieve EQS (EPO 6-1(1)).	Water quality monitoring as per Section 11.1 Coral community assessment as per Section 11.3 Implementation of the TMMF described in Section 7.4	Reporting will be as per the TMMF (Section 7.4) and Section 12.5	Responsibilities as detailed in the TMMF (Section 7.4)	Timings are detailed in the TMMF (Section 7.4)	Implementation of actions set out in Section 11.3.5.3.
MA 2.1: Overflow funnel/s on TSHD fitted with 'green valve/s' to minimise loss of fines.	**MT 2.1:** TSHD overflow sediment loss to the farfield minimised via use of green valve.	N/A	Inspection shows green valves installed on overflow funnel	Contractor	TSHD during dredging	N/A
MA 2.2: Use of spoil ground A/B is limited to BHD dredged spoil	**MT 2.2:** No spoil from the TSHD is disposed of in spoil ground A/B.	N/A	Records demonstrate that no spoil from the TSHD is disposed of in spoil ground A/B.	Contractor	TSHD spoil disposal	N/A
MA 2.3: THSD overflow pipes to be raised prior to spoil or backfill transport.	**MT 2.3:** THSD overflow pipes raised during transport to minimise losses through overflow enroute.	N/A	Inspections and/or records demonstrate controls implemented	Contractor	Transit to spoil ground or backfill location	N/A
MA 2.4: TSHD hopper door seals will be inspected prior to mobilisation.	**MT 2.4:** TSHD hopper door seals confirmed in good working order prior to mobilisation	N/A	Records of hopper door seal inspection	Contractor	Prior to mobilisation	N/A
MA 2.5: De-watering of the TSHD hopper will be confined to the pipeline corridor, spoil grounds and borrow ground area.	**MT 2.5:** No de-watering of the TSHD hopper occurs outside the pipeline corridor, spoil grounds and borrow ground area.	N/A	Dredge logs demonstrate de-watering of the TSHD hopper occurred within the designated areas.	Contractor	During TSHD activities	N/A
MA 3.1: Implement Marine Order 95 – pollution prevention – garbage (as appropriate to vessel class) which includes the following requirements: • maintenance of a Garbage Log Book • a garbage management plan where required	**MT 3.1:** Vessels compliant with Marine Order 95 – pollution prevention – garbage (as appropriate to vessel class).	N/A	Inspections and/or records demonstrate activity vessels are compliant with Marine Order 95 – Pollution prevention – Garbage (as appropriate to vessel class)	Contractor	During construction activities	N/A
MA 3.2: Implement Marine Order 96 – pollution prevention – sewage (as appropriate to vessel class) which include the following requirements: • a sewage treatment plant approved by an issuing body that complies with Regulation 9 of Annex IV (of MARPOL) and other guidelines as required; • a sewage comminuting and disinfecting system approved by an issuing body, that complies with Regulation 9 of Annex IV; or • a holding tank approved by an issuing body, that complies with Regulation 9 of Annex IV	**MT 3.2:** Vessels compliant with Marine Order 96 – Pollution prevention – Sewage (as appropriate to vessel class).	N/A	Records demonstrate activity vessels are compliant with Marine Order 96 – Pollution prevention – Sewage (as appropriate to vessel class)	Contractor	During construction activities	N/A
MA 3.3: Implement relevant vessel discharge requirements set out in the Port of Dampier Handbook.	**MT 3.3:** Vessels compliant with the relevant vessel discharge requirements set out in the Port of Dampier Handbook.	N/A	Inspection records demonstrate compliance with Port of Dampier Handbook vessel discharge requirements	Contractor	During construction activities	N/A

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA 4.1: Implement Marine Order 91 – oil (as relevant to vessel class), which includes the following requirements: • Oil Record Book • Valid International Oil Pollution Prevention (IOPP) Certificate. • Vessel specific SOPEP	**MT 4.1:** Compliance with Marine Order 91 – pollution prevention – oil (as appropriate to vessel class).	N/A	Inspections and/or records demonstrate vessels are compliant with Marine Order 91 (marine pollution prevention – oil) (as appropriate to vessel class)	Contractor	During construction activities	N/A
MA 4.2: Implement Marine Order 94 (as appropriate to vessel class) – packaged harmful substances, which provides information about preventing harmful substances carried by regulated Australian vessels, from entering the marine environment, including: • Vessels carrying harmful substances in packaged form must comply with 2 to 5 of MARPOL Annex III, with respect to stowage requirements • A Vessel Master may only wash a substance overboard if: – the physical, chemical and biological properties of the substance have been considered, and – washing overboard is considered the most appropriate manner of disposal, and – the Vessel Master has authorised the washing overboard.	**MT 4.2:** Compliance with Marine Order 94 (where relevant to vessel class) – packaged harmful substances.	N/A	Inspections and/or records demonstrate vessels are compliant with Marine Order 94 (marine pollution prevention – oil) (as appropriate to vessel class)	Contractor	During construction activities	N/A
MA 4.2: Implement waste management procedure/s which provide for safe handling and transportation, segregation and storage and appropriate classification of all waste generated.	**MT 4.2:** Hazardous and non-hazardous waste managed in accordance with the waste arrangements.	N/A	Inspections and/or records demonstrate compliance against waste arrangements	Contractor	During construction activities	N/A
MA 5.1: Implement Marine Order 91 (marine pollution prevention – oil) 2014, which requires Shipboard Oil Pollution Emergency Plan (SOPEP)/ Shipboard Marine Pollution Emergency Plan (as appropriate to vessel class), including appropriate initial responses prearranged and exercised for response to a hydrocarbon spill, as appropriate to vessel class.	**MT 5.1:** Compliance with Marine Order 91 (marine pollution prevention – oil) (as appropriate to vessel class).	N/A	All significant spills to be reported in accordance with the vessel SOPEP and regulatory requirements	Contractor	As per vessel SOPEP	N/A
MA 5.2: Bunkering equipment controls in place, including: • All hoses that have a potential environmental risk following damage or failure shall be linked to the vessel's preventative maintenance system. • All bulk transfer hoses shall have current certification and be in good condition and inspected as required. • Dry-break couplings and flotation on fuel hoses (on applicable vessels). • Visually monitor gauges, hoses, fittings and the sea surface during the operation. • There shall be an adequate number of appropriately stocked, located and maintained spill kits.	**MT 5.2** No significant spills of hydrocarbons to the marine environment from bunkering activities.	N/A	All significant spills to be reported in accordance with the vessel SOPEP and regulatory requirements	Contractor	As per vessel SOPEP	N/A
MA 6.1: Liquid chemical and fuel storage areas are bunded or secondarily contained when they are not being handled/moved temporarily	**MT6.1** Failure of primary containment in storage areas does not result in loss to the marine environment.	N/A	Inspection verify compliance	Contractor	During construction activities	N/A

7.4 Tiered monitoring and management framework

7.4.1 Purpose

The TMMF is a proactive and adaptive framework informed by water quality to manage the dredging activities, such that impacts to BCH (based on coral communities as the most sensitive ecological receptor) are not realised through its implementation.

The TMMF aims to manage trenching and spoil disposal, borrow ground dredging and backfill activities, and associated water quality to a level where impacts are not predicted to occur to BCH. It is designed to minimise the risk of water quality at receptor-based monitoring sites exceeding the biological thresholds at which reversible loss of coral (in Zone A and B) and sponges (in Offshore Zone) is predicted (i.e., ZoMI thresholds).

As such, the TMMF is designed to achieve no detectable reduction of net live coral cover at any of the coral monitoring locations attributable to the Proposal as defined by EPO 6-1(1) and provides confidence the established EQP for Mermaid Sound is adhered to.

7.4.2 Management trigger description and procedures

Management triggers are used in the TMMF to manage dredging activities within acceptable water quality boundaries, to avoid reversible impacts to coral communities as the most sensitive receptor in Zone A and B and sponges in the Offshore Zone.

The management triggers have been derived from the same dataset and literature (such as Jones et al., 2019) as the modelling thresholds described in Section 5.5 (and Appendix G), however have been applied conservatively, with the Tier 3 management trigger aligned with the ZoMI threshold (reversible impacts). Note, the SSC to NTU conversion ratio used to derive triggers, is consistent with that used for deriving background water quality for the modelling (Section 5.5.3).

The assessment of monitoring data against the tiered management triggers comprises two key aspects, being:

1. the comparison of measured data against the turbidity and DLI numeric values over a defined time period (following the procedure set out in Section 11.2.4). Note it is the combined effects (EPA 2021b) so both NTU and DLI values are required to be exceeded to move onto Step 2.
2. A Project attributability assessment to determine if trenching and spoil disposal or borrow ground dredging and backfill activities can reasonably be expected to have contributed to or caused the exceedance (as set out in Section 7.4.3).

Both parts of the assessment are required before it can be determined that an exceedance of a management trigger has occurred. For example, if both the NTU and DLI values are exceeded over the defined time period but the attributability assessment indicates that the exceedance is not attributable to Project activities then the determination is the trigger level has not been exceeded.

An overview of the TMMF is provided in Figure 7-3, with the detailed steps set out in Sections 7.4.2.1, 7.4.2.2 and 7.4.2.3.

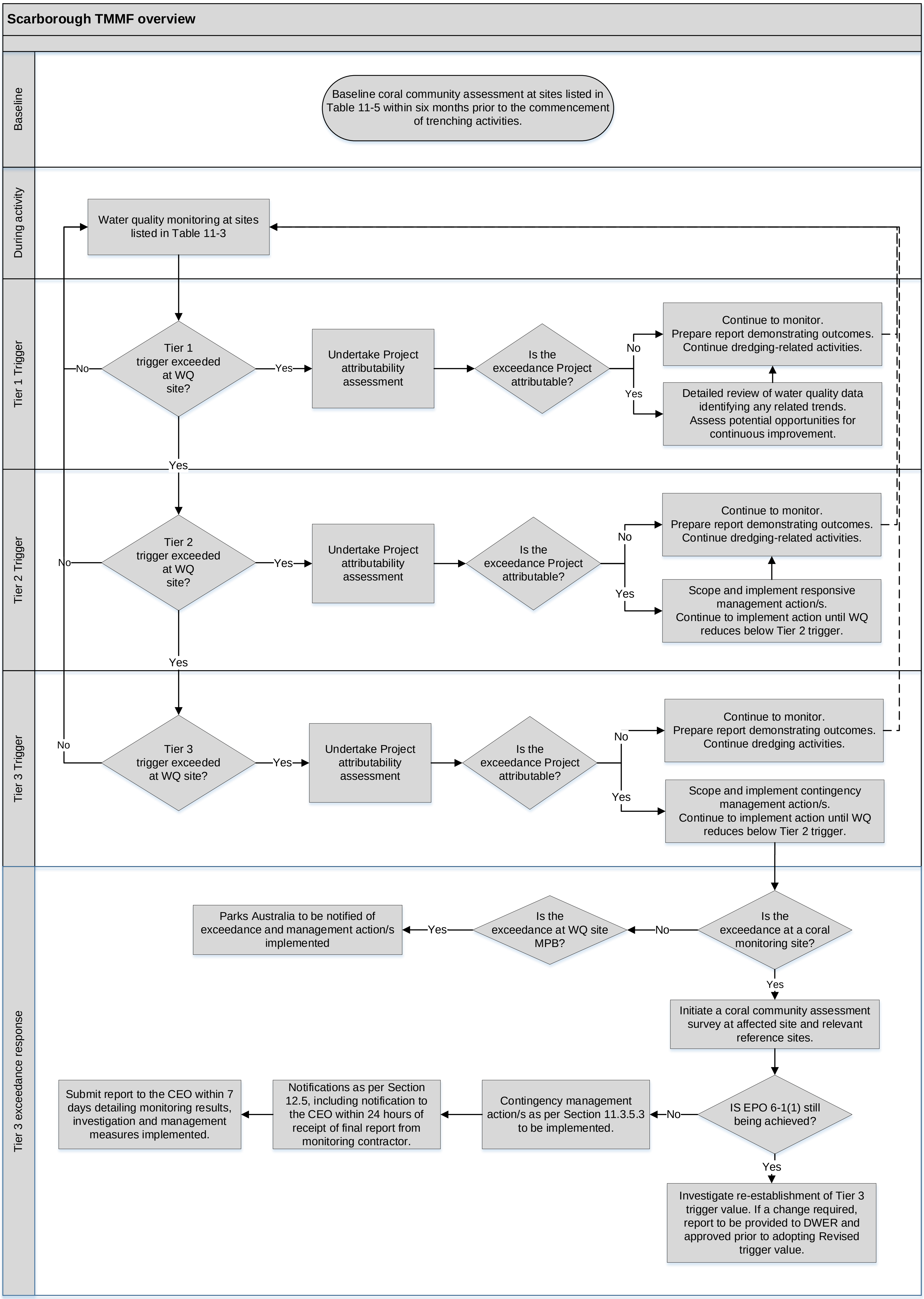

Figure 7-3: Tiered monitoring and management framework overview

7.4.2.1 Tier 1 management trigger

Table 7-4 describes the Tier 1 management triggers and how they are applied in the context of the TMMF, while Table 7-5 lists the associated trigger values. Data analysis methods for trigger assessment are described in Section 11.2.4.

Table 7-4: Tier 1 management triggers description

Aspect	Details
Term	Tier 1 management triggers are provided in Table 7-5, and are defined as: • being aligned with ZoI thresholds set for the modelling and impact assessment • designed to provide an early warning indicator on increasing turbidity trends, although at a level at which no impact to BCH (and coral as the most sensitive receptor) is predicted.
Sites	Impact and influence monitoring sites, as applicable to active activity (refer to Section 11.2.2).
Parameters	Trigger values are described in NTU which will be directly measured in field.
Action	In the event that a Tier 1 management trigger is exceeded: • Perform a project attributability assessment (refer to Section 7.4.3) within 72 hours of data confirmation to assess whether an exceedance has occurred. • Where project-attributable: – perform a detailed review of the water quality data identifying any related trends – assess potential opportunities for continuous improvement. • Continue to monitor water quality. • Continue trenching and spoil disposal, and/or borrow ground dredging and backfill operations.
Monitoring	Water quality monitoring as per Section 11.1.
Reporting	As per Section 12.5.

Table 7-5: Tier 1 management triggers values[22]

Trigger	Ecological Zone	Averaging Period	Turbidity (NTU)	DLI (mol/d)
Tier 1	Zone A	1	>16.07	<1.2
		4	>14	<1.5
		8	>12.57	<1.7
	Zone B	1	>10.5	<1.8
		4	>9.36	<2.2
		8	>8.36	<2.5
	Offshore	22 days	>11.25	<0.9

7.4.2.2 Tier 2 management trigger

Table 7-6 describes the Tier 2 management triggers and how they are applied in the context of the TMMF, while Table 7-7 lists the associated trigger values. Data analysis methods for trigger assessment are described in Section 11.2.4.

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[22] If additional baseline data is collected at these sites that demonstrates natural exceedances of these management triggers, these triggers may be revised, with proposed changes subject to approval by the CEO.

Table 7-6: Tier 2 management triggers description

Aspect	Details
Term	Tier 2 management triggers are provided in Table 7-7, and are defined as follows. • being aligned with the ZoMI threshold set for the modelling and impact assessment (Section 5.5.5); however, the duration term (averaging period) is reduced by two days to provide an opportunity (where project-attributable) to implement responsive management actions before a Tier 3 management trigger exceedance • designed to provide an early warning to the project that a duration term of the ZoMI, where impacts are predicted but are expected to be reversible within five years, is approaching its limit.
Sites	Impact and influence monitoring sites, as applicable to active activity (refer to Section 11.2.2)
Parameters	Trigger values are described in NTU and DLI, which will be measured in the field.
Action	In the event that a Tier 2 management trigger is exceeded: **Project attributability – straightforward** • Perform project attributability assessment (refer to Section 7.4.3) within 24 hours of data confirmation to assess whether an exceedance has occurred. • Where it is not considered attributable to the Project, continue operations as planned. No further action required. • Where exceedance is considered Project-attributable: – Scope and implement responsive management action/s (refer to Section 7.4.4.1) based on assessment of expected effect within 48 hours of determining exceedance. – Continue to implement management action until water quality reduces below Tier 2 trigger. – Prepare a report on the actions taken and effectiveness of implementation within 20 business days of ceasing response. **Project attributability – complex** • Where project attributability assessment (refer to Section 7.4.3) is complex and cannot be completed in 24 hours of data confirmation to assess whether an exceedance has occurred, then: – scope and implement responsive management action/s (refer to Section 7.4.4.1) based on assessment of expected effect within 48 hours of determining exceedance. – continue to implement management action until water quality reduces below Tier 2 trigger, OR – cease management action where exceedance is not considered attributable to the Project based on completed attributability assessment (Section 7.4.3) • Prepare a report on the actions taken and effectiveness of implementation within 20 business days of ceasing response.
Monitoring	Water quality monitoring as per Section 11.1.
Reporting	As per Section 12.5.

Table 7-7: Tier 2 management trigger values[23]

Trigger	Ecological Zone	Averaging Period	Trigger (NTU)	DLI (mol/d)
Tier 2	Zone A	1	>20.79	<0.7
		5	>16.07	<1.2
		8	>14	<1.5
		12	>12.57	<1.7
	Zone B	1	>13.86	<1.1

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[23] If additional baseline data is collected at these sites that demonstrates natural exceedances of these management triggers, these triggers may be revised, with proposed changes subject to approval by the CEO.

Trigger	Ecological Zone	Averaging Period	Trigger (NTU)	DLI (mol/d)
		5	>10.5	<1.8
		8	>9.36	<2.2
		12	>8.36	<2.5
	Offshore	26 days	>11.25	<0.9

7.4.2.3 Tier 3 management trigger

Table 7-8 describes the Tier 3 management triggers and how they are applied in the context of the TMMF, while Table 7-9 lists the associated trigger values. Data analysis methods for trigger assessment are described in Section 11.2.4.

Table 7-8: Tier 3 management triggers description

Aspect	Details
Term	Tier 3 management triggers are provided in Table 7-9, and are defined as: • being aligned with the ZoMI threshold set for the modelling and impact assessment (Section 5.5) and representing the NTU and light levels at which there is potential reversible loss of coral communities (as the most sensitive receptor) in Zone A and B, and sponges in the Offshore Zone. • This trigger is considered conservative in the prediction of impacts given that water quality exceeded these levels in the Pluto LNG Foundation project dredging campaign and no dredging related impacts were observed at BCH.
Sites	Impact and influence monitoring sites, as applicable to active activity (refer to Section 11.2.2).
Parameters	Trigger values are described in NTU and DLI, which will be measured in the field.
Action	In the event that a Tier 3 management trigger is exceeded: **Project attributability – straightforward** • Perform project attributability assessment (refer to Section 7.4.3) within 24 hours of data confirmation to assess whether an exceedance has occurred. • Where it is not considered attributable to the Project, continue operations as planned. No further action required. • Where exceedance is considered project-attributable: – Scope and implement contingency management action/s (refer to Section 7.4.4.2) based on assessment of expected effect within 48 hours of determining exceedance. – Continue to implement management action until water quality reduces below Tier 2 trigger. – Prepare a report on the actions taken and effectiveness of implementation within 20 business days of ceasing response. **Project attributability – complex** • Where project attributability assessment (refer to Section 7.4.3) is complex and cannot be completed in 24 hours of data confirmation to assess whether an exceedance has occurred, then: – Scope and implement contingency management action/s (refer to Section 7.4.4.2) based on assessment of expected effect within 48 hours of determining exceedance. – Continue to implement management action until water quality reduces below Tier 2 trigger. OR – Cease management action where breach is not considered attributable to the Project, based on completed attributability assessment (Section 7.4.3). • Prepare a report on the actions taken and effectiveness of implementation within 20 business days of ceasing response. **Reactive coral community assessment** • Where the exceedance is considered project-attributable (refer to Section 7.4.3), initiate coral community assessment survey at the affected site and associated reference sites to assess compliance against EPO 6-1(1).

Aspect	Details
	• Where no project-attributable impacts are detected, consider whether the Tier 3 trigger needs to be re-established. If a change to the Tier 3 trigger is required, a report must be provided to EPA and approved before implementing a new trigger. • In the event the EPO 6-1(1) is no longer being achieved, response as per Section 11.3.5.3
Monitoring	Water quality monitoring as per Section 11.1. Coral community assessment as per Section 11.3.
Reporting	As per Section 12.5.

Table 7-9: Tier 3 management trigger values[24]

Trigger	Ecological Zone	Averaging Period	Trigger (NTU)	DLI (mol/d)
Tier 3	Zone A	3	>20.79	<0.7
		7	>16.07	<1.2
		10	>14	<1.5
		14	>12.57	<1.7
	Zone B	3	>13.86	<1.1
		7	>10.5	<1.8
		10	>9.36	<2.2
		14	>8.36	<2.5
	Offshore	28 days	>11.25	<0.9

7.4.3 Project attributability assessment

When a tiered management trigger is exceeded, the initial response is to investigate the cause of the exceedance and whether or not the detected change can be reasonably attributed to dredging (trenching or borrow ground), spoil disposal or backfill activities, rather than a result of an anomalous reading, a natural event or an external anthropogenic event. This approach ensures adaptive management actions are targeted to improving water quality and the program can be completed effectively within the proposed timeframes. There are two key steps for assessing project attributability, as described below.

Step 1 – Assess data reliability

The first step is to assess whether the instrument is functioning correctly, and the data is reliable. If the trigger is a false trigger resulting from data quality issues, such as fouling on the sensor, no action is required. However, to reduce the potential for future false triggers, an investigation into possible improvements in data collection and quality assurance will be performed.

Step 2 – Evaluate multiple lines of evidence

Where the data is deemed to be reliable, the next step in the attributability assessment is to evaluate multiple lines of evidence to determine the cause of the exceedance. Information considered in the investigation may include:

- recent weather and oceanographic conditions, such as tidal phase, wind speed and direction, significant wave height and rainfall
- site specific water quality conditions at sentinel monitoring sites (where available) and monitoring sites further afield across the broader region

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[24] If additional baseline data is collected at these sites that demonstrates natural exceedances of these management triggers, these triggers may be revised, with proposed changes subject to approval by the CEO~~.~~

- review of baseline data and occurrences of elevated turbidity and reduced benthic light events including key drivers
- regional water quality from remote sensing data showing the visual plume trajectory
- location of dredging, spoil disposal or backfill activities relative to the monitoring site recording the exceedance
- nature of recent dredging activities in relation to the onset of the exceedance
- outcomes from the dredge plume assessment as described in Section 11.4.1 (where results are available)
- any incidental experimental evidence available, including reference to published scientific literature (where applicable).

The attributability assessment will be documented and appropriately conservative based on the evidence available. In the event an exceedance is found to be attributable to trenching and spoil disposal or borrow ground dredging and backfill activities, the appropriate actions will be identified and initiated as per the TMMF. For a Tier 2 and Tier 3 management trigger exceedance, this includes identifying and executing appropriate responsive or contingency management actions respectively, as described in Section 7.4.4.

7.4.4 Adaptive management actions

Two key adaptive management actions (responsive and contingency) are proposed to minimise the potential for dredging-related elevation in turbidity (and associated decrease in light) to impact sensitive receptors, particularly significant coral communities.

7.4.4.1 Responsive management actions

Responsive management actions will be implemented when a project-attributable Tier 2 exceedance has occurred. There are a range of options that are considered practical to reduce the mass of sediment released during trenching and spoil disposal or borrow ground dredging and backfill activities. These may include (Netzband et al., 2009):

- Adjust the suction flow velocity.
- Adjust the jet water flow velocity.
- Alter the overflow time or location of the TSHD.
- Adjust the overflow height.
- Adjust the TSHD trailing speed.
- Modify the rate of operations.
- Adjust sailing speed of barges (propeller wash).
- Optimise the timing and spacing of dredge activities.
- Optimise disposal location within spoil disposal ground.
- Relocate TSHD.

The selection of management action/s will consider the context of the dredging operation at the time (such as location, tides, water depth). Not all options will have similar effect in all circumstances and locations; therefore, any option implemented will require evaluation and subsequent modification where appropriate. The applicability and effectiveness of management actions will be assessed and rationalised by the Dredging Contractor in consultation with, and approved by Woodside, before implementation.

Water quality will continue to be monitored after Tier 2 trigger exceedance to assess whether the adopted management actions have been effective in improving water quality. Responsive management action/s can only cease (return to normal operations) once turbidity returns below the Tier 2 trigger or once superseded by implementing more effective management action/s.

7.4.4.2 Contingency management actions

Contingency management actions will be applied when a project-attributable Tier 3 exceedance has occurred. Contingency management actions are those known to markedly reduce the loss of fines sediment released during dredging activities. These may include (Netzband et al., 2009):

- Relocate TSHD.
- Optimise the spacing and timing of dredge activities.
- Temporarily cease overflow on the TSHD.
- Tidal operations for BHD and/or TSHD and/or all equipment.
- Production limit for BHD and/or TSHD and/or all equipment
- Temporarily suspend operations of BHD and/or TSHD.
- Temporarily suspend all dredging operations.

The applicability and effectiveness of management actions will be assessed and rationalised by the Dredging Contractor in consultation with, and approved by Woodside, before implementation. Water quality will continue to be monitored after Tier 3 trigger exceedance to assess whether the adopted management actions have been effective in improving water quality. Contingency management action/s can only cease (return to normal operations) once water quality returns to below the Tier 2 turbidity trigger.

8 Management of benthic communities and habitats

8.1 Benthic communities and habitat management framework

To ensure all activities described in Section 3 that have the potential to impact BCH are managed to an acceptable level and to achieve EPO 6-1(1), the management framework in Table 8-1 will be implemented on the Project.

The TMMF as described in Section 7.4 considers the activities to manage trenching, spoil disposal and backfill operations and associated water quality to a level where impacts are not predicted to occur to BCH.

Table 8-1: Benthic communities and habitats management actions, management targets, monitoring and reporting

EPA Factor: Benthic Communities and Habitats

Environmental Objective: EPO 6-1(1) *No detectable net reduction of live coral cover at any of the coral impact monitoring locations attributable to the Proposal.*

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA 1.1: Implement the water quality monitoring program and Tiered Monitoring and Management Framework (TMMF) to manage water quality associated with trenching, spoil disposal and backfill activities to a level where impacts are not predicted to occur to BCH.	**MT 1.1:** Trenching, spoil disposal and backfill activities are managed in accordance with TMMF to achieve EQS (EPO 6-1(1)).	Water quality monitoring as per Section 11.1 Coral community assessment as per Section 11.3 Implementation of the TMMF described in Section 7.4	Reporting will be as per the TMMF (Section 7.4) and Section 12.5	Responsibilities as detailed in the TMMF (Section 7.4)	Timings are detailed in the TMMF (Section 7.4)	Implementation of actions set out in Section 11.3.5.3.
MA 7.1: Dredges (including SHB) and RIV are positioned (using direct global positioning system) within approved footprints prior to and during trenching, backfill and rock placement activities.	**MT 7.1:** No trenching, backfill and rock placement activities to occur outside of the approved project footprints.	Pre and post trenching, backfill and rock placement bathymetric surveys	Vessel logs confirm vessel position during trenching, backfill and rock placement activities	Contractor	Trenching, backfill and rock placement activities	N/A
MA 7.2: Designated 'No dredge' out of zone alarms will be installed and used on the dredging vessel navigation system.	**MT 7.2:** No trenching, backfill and rock placement activities to occur outside of the approved project footprints.	Pre and post trenching, backfill and rock placement bathymetric surveys	Inspection verifies zone alarms in place	Contractor	Trenching activities	N/A
MA 7.3: Comply with in force Sea Dumping Permit (No. SD2019/3982 or amended), which includes the following: • Contractor must only dump within the disposal site. • Contractor must ensure the dredged material is dumped in a manner over the disposal site to minimise mounding from dumping activities. • Contractor must establish by GPS that, prior to dumping, the vessel is within the disposal site.	**MT 7.3:** Spoil disposal activities are compliant with in force Sea Dumping Permit (No. SD2019/3982 or amended).	Bathymetric survey of the disposal site is undertaken by a suitably qualified person: • before commencing dumping activities under this permit, and • within one month of completing all dumping activities authorised under this permit	Make and retain records comprising either weekly plotting sheets or a certified extract of the ship's log which detail: • the dates and times of when each dumping run commenced and finished • the position (as determined by GPS) of the dumping vessel at the beginning and end of each dumping run, including the path of each dumping run • the volume of dredged material (in-situ cubic metres) dumped and quantity in dry tonnes for the specified operational period and compared to the total amount permitted under the permit on a daily basis • a register maintaining a record of environmental incidents or environmental risks Bathymetric survey reporting to Australian Hydrographic Office as per Section 12.5	Contractor and Woodside	Trenching and spoil disposal activities	N/A
MA 7.4: Implement anchoring procedures to guide the setting of anchors for the SWLB and include: • Mooring design analysis • Accurate positioning of anchors • Prevention of excessive anchor wire drag on the seabed by ensuring sufficient tension is maintained during anchor running operations • Anchoring equipment certification (winches, anchor wires and associated hardware). • Anchoring within 750 m of the trunkline route centreline	**MT 7.4:** Anchoring procedures developed and implemented for SWLB to reduce the likelihood of anchor drag.	Pre- and post-SWLB activities bathymetric surveys	Progress reports confirm anchoring alignment.	Contractor	SWLB activities	N/A
MA 7.5: AHT to place anchors for the SWLB within the defined development envelope.	**MT 7.5:** No damage to significant coral communities from SWLB anchoring activities.	Pre- and post-SWLB activities bathymetric surveys	SWLB progress reports confirm anchoring placement	Contractor	SWLB activities	N/A
MA 7.6: During rock installation, if test placements are required, they will be conducted within the disturbance footprint.	**MT 7.6:** No RIV test placement occurred outside the disturbance footprint.	Pre and post rock placement bathymetric surveys	Records show RIV test placements were undertaken within the disturbance footprint.	Contractor	Rock installation	N/A

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA 8.1: During coral spawning critical window/s of environmental sensitivity (CWES) TSHD to either: • Avoid trenching and spoil disposal within Mermaid Sound (KP0 to KP32), OR • Reduce turbidity generating activities from trenching and spoil disposal in Mermaid Sound by: ○ TSHD to operate with no overflow; or where this is not possible suspend TSHD activities ○ No use of Spoil Ground A/B *Coral spawning CWES dates are defined below*[25]*:* • *12 to 22 March 2023; (full moon 7 March 2023)* • *11 to 21 April 2023; (full moon 6 April 2023)* • *28 November to 7 December 2023; (full moon 27 November)* • *30 March to 8 April 2024 (full moon 25 March 2024)*	**MT 8.1:** During coral spawning CWES controls in place to reduce turbidity generating activities in Mermaid Sound.	NA	Plan proposing selected dredge management action developed and approved by Woodside prior to confirmed coral spawning window. Dredge logs demonstrate selected dredge management action was implemented in Mermaid Sound (KP0 to KP32) during the coral spawning windows.	Contractor and Woodside	Plan proposing selected dredge management action required at least one week before confirmed coral spawning window.	If operating in Mermaid Sound (KP0 to KP32) and no controls are put in place, then cease dredging, spoil disposal and backfill activities in the area during the confirmed coral spawning windows
MA 9.1: Woodside IMS risk assessment process (Section 8.2) will be applied to project vessels and immersible equipment. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk will be implemented to minimise the likelihood of IMS being introduced	**MT 9.1:** Compliance with Woodside's IMS risk assessment process (Section 8.2)	NA	Records maintained of IMS risk assessments Records maintained of management measures which have been implemented where identified through the IMS risk assessment process	Contractor and Woodside	Prior to mobilisation	If the process is not applied to all applicable project vessels and immersible equipment, an incident report will be raised, and corrective actions put in place
MA 9.2: DPIRD Vessel Check will be completed for all applicable internationally sourced Project vessels entering WA coastal waters	**MT 9.2:** DPIRD Vessel Check completed for all applicable internationally sourced Project vessels	NA	Records maintained of completed Vessel Check assessment	Contractor and Woodside	Prior to arrival in WA coastal waters	If the process is not applied to all applicable internationally sourced project vessels, an incident report will be raised, and corrective actions put in place
MA 9.3: Project vessels will manage their ballast water using one of the approved ballast water management options, as specified in the Australian Ballast Water Management Requirements	**MT 9.3: C**ompliance with Australian Ballast Water Management Requirements	NA	Ballast water record system maintained by vessels which verifies compliance	Contractor	During mobilisation of all applicable vessels (as per vessel class)	NA

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[25] Gilmour et al (2016) states that the primary period of spawning for the region is in autumn. Autumn coral spawning CWES are defined as the 10 day period, five to 15 days after the predicted full moon in March and/or April, which is based on studies that have found that the majority of broadcast spawning species in Mermaid Sound spawn during neap tides approximately one week after the full moon (Gilmour et al. 2016). Spring coral spawning CWES are defined as the 10 day period, one to 11 days after the predicted full moon in November, which is based on studies that have demonstrated that Porites lutea spawns during spring tides predominantly 3 days after the full moon (Stoddart et al. 2012; Baird et al. 2011).

8.2 Invasive Marine Species Management Procedure

To minimise the risk of introducing Invasive Marine Species (IMS) as a result of the activities described in **Section 4**, the following sections define the risk assessment process proposed, which have been developed in consultation with Department of Primary Industries and Regional Development (DPIRD)[26].

8.2.1 Woodside IMS risk assessment process

8.2.1.1 Objective and scope

To minimise the risk of introducing IMS as a result of the proposal, all applicable vessels and immersible equipment will be subject to Woodside's IMS risk assessment process.

The objective of the risk assessment process is to identify the level of threat a contracted vessel, or immersible equipment poses if no additional risk reduction management measures are implemented. This allows Woodside (and its contractors) to apply management measures that are commensurate to the identified level of risk.

In context of the activities specified in **Section 4**, the IMS risk assessment process does not apply to the following:

- Vessels or immersible equipment that do not plan to enter the IMS Management Area (IMSMA)[27] or operational areas defined in environmental approvals
- 'New build' vessels launched less than 14 days prior to mobilisation
- Vessels or immersible equipment which have been inspected by a suitably qualified IMS inspector who has classified the vessels or immersible equipment as acceptably low risk no more than 14 days prior to mobilisation
- Locally sourced vessels or immersible equipment from within the Pilbara locally sourced zone[28]. Vessels, or immersible equipment are defined as Locally Sourced when the same supply facilities/port have been used since their last IMS inspection, full hull clean in dry dock or application of antifouling coating (AFC[29]).

8.2.1.2 Risk assessment process

Woodside's IMS risk assessment process was developed with regard to the national biofouling management guidelines for the petroleum production and exploration industry and guidelines for the control and management of a ships' biofouling to minimise the transfer of invasive aquatic species (IMO, 2012).

In order to effectively evaluate the potential for vessels and immersible equipment to introduce IMS, a risk assessment process has been developed to score and evaluate the risk posed by each Project vessel, or immersible equipment planning to undertake activities within the IMSMA. The risk assessment process considers a range of factors, as listed in Table 8-2.

The IMS risk assessments will be undertaken by a trained environment adviser who has completed relevant Woodside IMS training or by a qualified and experienced IMS inspector.

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[26] Consultation with DPIRD on the section content was finalised on 8 March 2022.

[27] IMSMA is based on current legal framework and includes all nearshore waters around Australia, extending from the lowest astronomical tide mark to 12 nm from land (including Australian territorial islands). The IMSMA also includes al waters within 12 nm from the 50 metre depth contour outside of the 12 nm boundary (i.e. Submerged reefs and atolls).

[28] The Pilbara Zone includes Port, nearshore and offshore movements between Exmouth and Port Headland (excluding high environmental value areas, World Heritage Areas, Commonwealth Marine Reserve Sanctuary Zones and State Marine Management Areas and Marine Parks).

[29] Vessels and immersible equipment can still be classified as locally sourced even if the AFC application occurred in a different port provided the amount of time between AFC application and departure to the locally sourced area (i.e. period of time in waters <12nm/50m water depth) did not exceed consecutive 7 days or the period of time the vessel or immersible equipment has spent within the locally sourced zone exceeds 1 year (i.e. the risk of introducing a species from a different location has already passed).

Table 8-2 Factors considered as a part of the risk assessment process

Vessels	Immersible equipment
vessel type	region of deployment since last thorough clean, particularly coastal locations
recent IMS inspection and cleaning history, including for internal niches	duration of deployments
out-of-water period before mobilisation	duration of time out of water since last deployment
age and suitability of AFC at mobilisation date	transport conditions during mobilisation
internal treatment systems and history origin and proposed are of operation	post-retrieval maintenance regime.
number of stationary/slow speed periods >7 days	
region of stationary or slow periods	
type of activity – contact with seafloor.	

Following implementation of the risk assessment process, vessels and/or immersible equipment are classified as one of three risk categories, as defined below.

- **Low risk** of introducing IMS of concern is defined as either no additional management measures required or, management measures have been applied to reduce the risk.
- **Uncertain risk** of introducing IMS is not apparent and as such the precautionary approach should be adopted, and additional management measures may be required.
- **High risk** of introducing IMS means additional management measures may be required.

Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of IMS being introduced and achieve a Low risk status.

Management measures may include inspection by a suitably qualified and experienced IMS inspector to verify risk status, cleaning of the hull and/or internal seawater systems or limiting the duration that the vessel spends within the IMSMA to a maximum of 48 hours (cumulative entries)[30].

Project vessels and immersible equipment are required to be a low risk of introducing IMS of concern prior to entering the IMSMA.

8.2.2 DPIRD Vessel Check

Vessel check is a biosecurity decision support tool developed by the DPIRD. The Vessel-Check portal provides an indicative risk assessment for a vessel, based primarily on the documented management practices used to mitigate the transfer of IMS. It aids in identifying any pre-border vessel management actions and processes which can mitigate the risk of vessels transferring IMS to as low as reasonably practicable (ALARP) (DPIRD 2021).

The Vessel-Check portal will be applied to all applicable internationally sourced Project vessels entering Coastal Waters (3 nm) of Western Australia. Applicable vessels are those required to undertake the activities described in **Section 4** and are mobilised from outside of Australian waters. Note this process will supplement the Woodside process described in **Section 8.2.1**, noting any actions issued by DPIRD will be complied with.

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[30] 48 hours is considered an appropriate and ALARP management control, as it significantly reduces the potential for any IMS associated with a vessel to successfully establish suitable habitat within the IMSMA. This reduction of risk is primarily achieved via a direct reduction of the propagule pressure associated with a particular vessel movement.

9 Management of marine fauna

9.1 Marine fauna management framework

To ensure all activities described in Section 3 that have the potential to impact marine fauna are managed to an acceptable level and to achieve EPO 6-1(2), the management framework in Table 9-1 will be implemented. The management measures have been developed with consideration to the environmental and cultural importance of marine fauna to Traditional Custodians, specifically dolphins and whales which have been highlighted for their totemic importance, dugongs which are considered a food source and marine turtles and their habitat critical to survival including foraging and nesting habitat.

For context, and on request by MAC, the indicative Project activities as they relate temporally to the key ecological windows are provided in Table 9-2. Noting that the timing of Project activities may vary based on operational and technical factors and that the periods indicated here are the likely early and late windows, although works have been risk assessed to cover all possible timings (refer to Section 3.1.3).

Table 9-1: Marine Fauna management actions, management targets, monitoring and reporting

EPA Factor: Marine Fauna.

Environmental Objectives: EPO 6-1(2) *Avoid where possible and otherwise minimise direct and indirect impacts on marine fauna listed as specially protected fauna under the Biodiversity Conservation Act 2016.*

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA10.1: Operate vessels when in transit in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, including the following measures[31]: • Project vessels will not travel greater than six knots within 300 m of a cetacean. • Project vessels will not approach closer than 50 m for a dolphin and/or 100 m for a whale (with the exception of animals bow riding). • If the cetacean shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots.	**MT 10.1:** Compliance with EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.05 and 8.06) Interacting with cetaceans to minimise potential for vessel strike.	N/A	Records demonstrate no breaches with EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans Records demonstrate reporting cetacean ship strike incidents to the National Ship Strike Database	Contractor	Project vessels during operations	All vessel strike incidents with cetaceans will be reported in the National Ship Strike Database (https://data.marinemammals.gov.au/report/shipstrike)
MA10.2: Project vessels will not travel greater than six knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark.	**MT 10.2:** Compliance with Department of Biodiversity, Conservation and Attractions (DBCA) whale shark interaction protocol to minimise potential for vessel strike.	N/A	Records demonstrate no breaches of protocols	Contractor	Project vessels during operations	All vessel strike incidents with whale sharks will be reported within 24 hours to the Conservation Operations Officer – Whale Sharks through email; whale.shark@dbca.wa.gov.au or phone (08)9947 8000.
MA 10.3: Comply with in-force Sea Dumping Permit (No. SD2019/3982 or amended), which includes the following: • Before commencing the dumping activities, Contractor must ensure a check is performed, using binoculars from a high observation platform, for marine species within the observation zone. • If any marine species[32] are sighted in the observation zone, must not commence dumping activities until either ten minutes after the last marine species is observed in the observation zone, or the vessel has moved to another area of the disposal site where it can maintain a minimum distance of 300 metres between the vessel and any marine species.	**MT 10.3:** Compliance of marine species observations set out in in force Sea Dumping Permit (No. SD2019/3982 or amended).	Marine fauna observer (MFO)[33] onboard TSHD and SHB (or supporting tug) to monitor, using binoculars from a high observation platform, for marine species within the observation zone	Make and retain records comprising either weekly plotting sheets or a certified extract of the ship's log which detail the person(s) undertaking the marine species observation required in Condition 6 of the in force sea dumping permit and any marine species observed within the observation zone for each run, including the date, time and approximate distance from the vessel, and the action taken to comply with Condition 7 of the in force sea dumping permit.	Contractor and Woodside	Prior to and during spoil disposal activities	Document any incidents involving the dumping activities that result in injury or death to any marine species. The date, time and nature of each incident and the species involved, if known, must be recorded, and the incident is to be reported to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) within 72 hours

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[31] For safety reasons, the distance requirements are not applied to vessel(s) holding station or with limited manoeuvrability e.g. anchor handling, loading, back-loading, bunkering, close standby cover for overside working and emergency situations.

[32] Marine Species means all whales, dolphins, dugongs and marine turtles listed under the *Environment Protection and Biodiversity Conservation Act 1999*.

[33] Marine fauna observer is a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for marine fauna. This role may be completed by vessel crew who are appropriately trained as per Section 12.2.2.

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA 10.4: When vessel operating: • at a speed in excess of 6 knots, and • in state (WA) waters north of minus 20.45 decimal degrees south, and • between 1 August and 31 October (inclusive) in any year. Vessels must not: • travel faster than six knots within 300 m of a whale • approach closer than 100 m from a whale. If a whale(s) shows any sign of being disturbed inside the distances specified, the vessel will immediately withdraw from the whale(s) at a constant speed of less than six knots.	**MT 10.4:** Project vessels to comply with EPBC 2018/8362 particular manners to mitigate potential impacts of the action on whales.	MFO[34] to monitor for whales from a high observation platform on the vessel using binoculars by day and thermal imaging equipment at night or in periods of low visibility	Records of MFO training for key vessel crew Records of sighting and locations of marine fauna in the vessels' daily logbook, including any corrective actions taken	Contractor	Project vessels between 1 August and 31 October (inclusive)	All vessel strike incidents with cetaceans will be reported in the National Ship Strike Database (https://data.marinemammals.gov.au/report/ shipstrike);
MA 10.5: For TSHD operations during daylight hours (excluding transit) adherence to defined observation and exclusion zone as set out in **Figure 9-1**: • whales: observation zone 300 m; exclusion zone 100 m • dugongs: observation zone 150 m (except for spoil disposal operations where the observation zone is 300 m); exclusion zone 50 m • dolphins: observation zone 150 m (except for spoil disposal operations where the observation zone is 300 m); exclusion zone 50 m[35] • turtles: observation zone 100 m (except for spoil disposal operations where the observation zone is 300 m); exclusion zone 50 m.	**MT 10.5:** Compliance with defined observation and exclusion zones for TSHD operations during daylight hours as set out in Figure 9-1.	MFO[34] onboard TSHD to monitor defined exclusion zones and observation zone	Records of MFO training for key vessel crew Records of sighting and locations of marine fauna in the vessels' daily logbook, including any corrective actions taken	Contractor	Daylight hours for TSHD activities (excluding transit)	Document and report to relevant regulators any incidents relating to marine fauna injury and mortality
MA 11.1: Installation of turtle deflection chains in front of the TSHD drag head.	**MT 11.1:** Turtle deflection chains installed and operational throughout the activity.	N/A	Records or inspection demonstrate turtle deflection chains are correctly installed	Contractor	TSHD activities	• In the event of discovery of a stranded, injured, or deceased turtle, the Dredge/Vessel Work Supervisor (or delegate) will immediately notify Woodside Site Representative (or delegate) and contact Wildcare on 9474 9055 and follow the advice provided. • On direction of Wildcare, and where safe and practicable to do so, Dredge/Vessel personnel to retrieve stranded, injured or
MA 11.2: At completion of dredge run (i.e., fill of hopper), stop dredge pumps as soon as practicable after the TSHD drag head is lifted from the seafloor.	**MT 11.2**: Dredge pumps not operated during transits.	N/A	Dredge logs	Contractor	TSHD activities	
MA11.3: At completion of dredge run (i.e., fill of hopper), visual inspection of the draghead to identify any turtle remains.	**MT 11.3:** TSHD draghead inspected at completion of dredge run to identify any turtle remains.	N/A	Inspection records	Contractor	TSHD activities	

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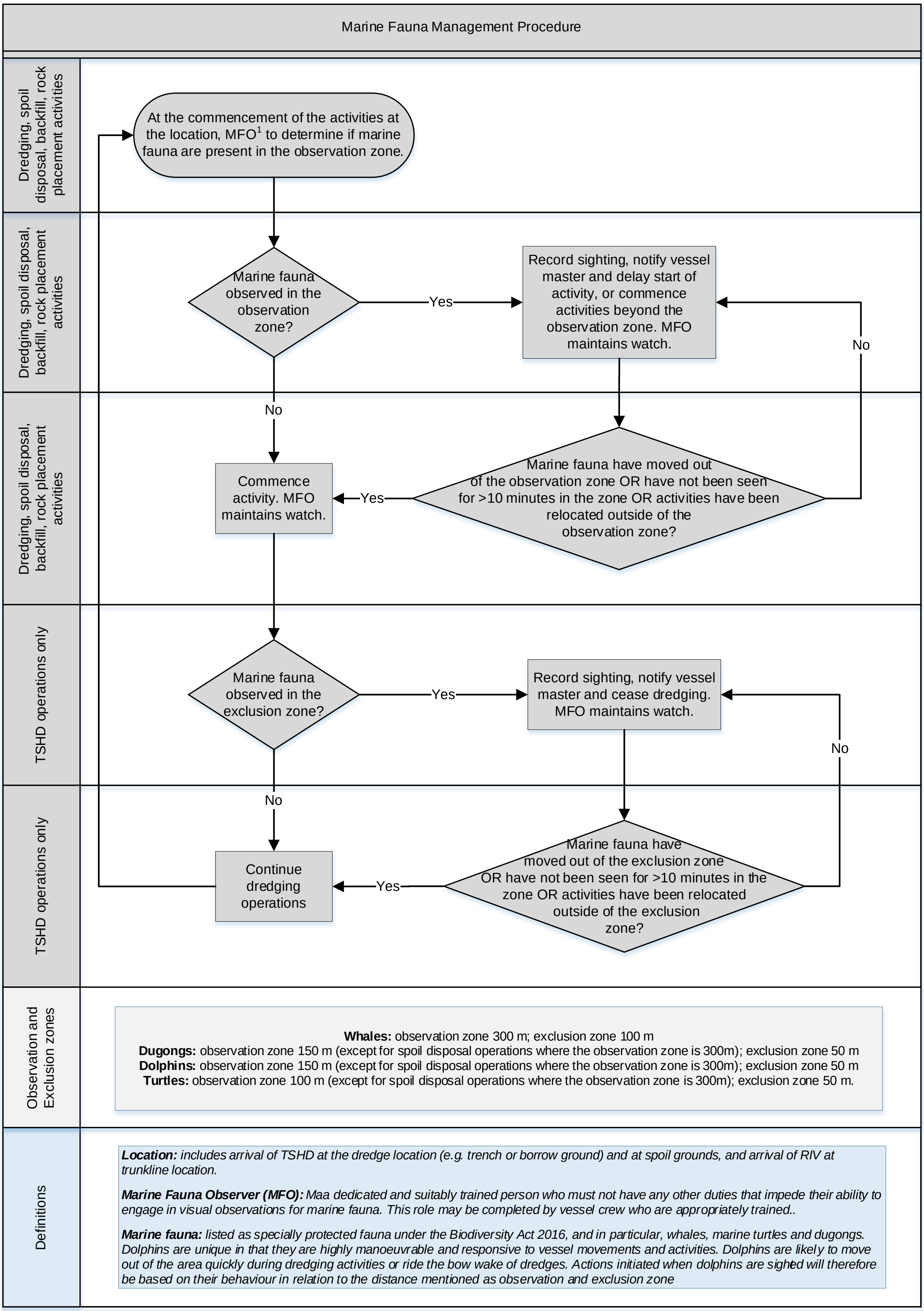
[34] Marine fauna observer is a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for marine fauna. This role may be completed by vessel crew who are appropriately trained as per Section 12.2.2.

[35] Dolphins are unique in that they are highly manoeuvrable and responsive to vessel movements and activities. Dolphins are likely to move out of the area quickly during dredging activities or ride the bow wake of dredges. Actions initiated when dolphins are sighted will therefore be based on their behaviour in relation to the distance mentioned as observation and exclusion zone.

Management Actions	Management Targets	Monitoring	Reporting	Responsibility	Timing	Contingency
MA 11.4: At the completion of TSHD loading, visual inspection of the hopper to identify any turtle strandings.	**MT 11.4:** Any stranded turtles identified prior to spoil disposal and Wildcare notified.	N/A	Inspection records	Contractor	TSHD activities	deceased turtle using a towel (or similar), and place the turtle in a warm dark place. Unless directed by the Wildcare officer do not place the turtle in water. • Dredge/Vessel Work Supervisor (or delegate) to complete: ○ Injured or Abandoned Fauna Notification and submit to wildlife.protection@dbca.wa.gov.au within 24 hours ○ WA Marine Turtle Stranding Form and submit to turtles@dbca.wa.gov.au within 24 hours.
MA 12.1: Primary Installation Vessels lighting will be limited to the minimum required for navigational and safety requirements, except for emergency events.	**MT 12.1:** No use of unnecessary lighting on the Primary Installation Vessel to minimise indirect impacts on turtle hatchlings from lighting.	N/A	Records or inspection demonstrate implementation of light minimisation measures	Contractor	TSHD, RIV, BHD and SWLB activities	N/A
MA 12.2: Lighting controls to be implemented on Primary Installation Vessels during peak turtle hatchling emergence periods (Dec to Mar) as follows: • Black out blinds/curtains will be installed and used at night. • Direct floodlights to target the intended work area and where practicable, angled downwards away from the ocean. • Turn off floodlights when not in use • Turn off lighting on vessel crane(s) at night-time when not in use (except red signalling light on crane mast) • Vessel crew will be trained in light reduction measures	**MT 12.2:** Vessel lighting managed to minimise indirect impacts on turtle hatchlings during peaks emergence periods (Dec to Mar)	N/A	Inspection reports and training records	Contractor	TSHD, RIV, BHD and SWLB activities peak turtle hatchling emergence period (Dec to Mar)	N/A
MA 13.1: Lighting controls to be implemented within the Onshore Project Area during turtle season (Sept to April) as follows: • Only lighting that is necessary for safe operations will be applied. • Shielding will be applied to relevant light sets to prevent direct light spill on Holden Beach • Temporary lighting will be switched off when not in use • Black out blinds/curtains will be installed and used at night on site offices. • Personnel will be trained in light management procedures	**MT 13.1:** Onshore Project Area lighting managed to minimise direct and indirect impacts to nesting turtles on Holden Beach and emerging hatchlings.	N/A	Inspection reports and training records	Contractor	During shore crossing works within turtle season (Sept to April)	N/A
MA 14.1: Noise generating equipment onboard dredges and RIV subject to periodic maintenance to ensure optimal performance.	**MT 14.1:** Noise generating equipment onboard dredges and RIV maintained as per maintenance systems requirements.	N/A	Maintenance systems records of noise generating equipment.	Contractor	As applicable to schedule	N/A



Whales: observation zone 300 m; exclusion zone 100 m
Dugongs: observation zone 150 m (except for spoil disposal operations where the observation zone is 300m); exclusion zone 50 m
Dolphins: observation zone 150 m (except for spoil disposal operations where the observation zone is 300m); exclusion zone 50 m
Turtles: observation zone 100 m (except for spoil disposal operations where the observation zone is 300m); exclusion zone 50 m.

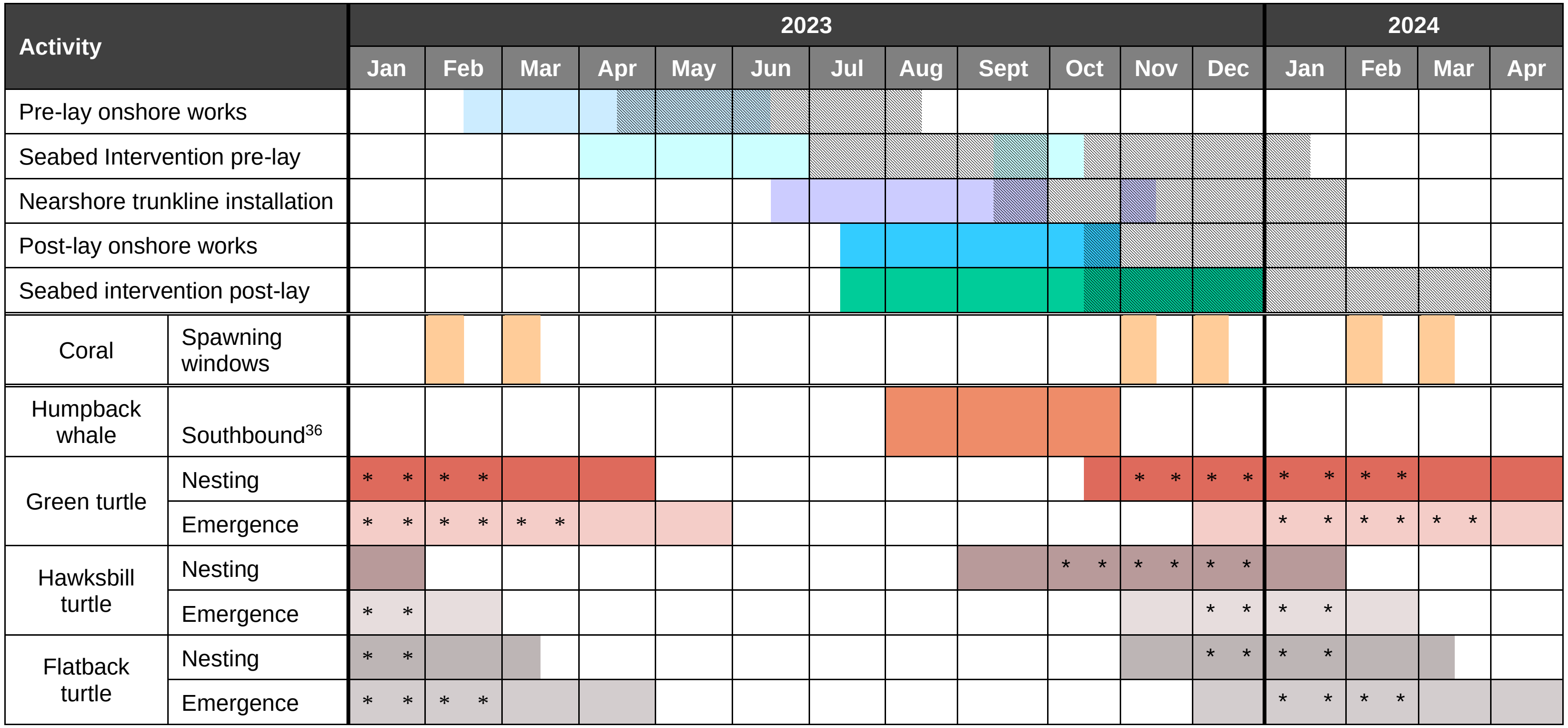
Location: *includes arrival of TSHD at the dredge location (e.g. trench or borrow ground) and at spoil grounds, and arrival of RIV at trunkline location.*

Marine Fauna Observer (MFO): *Maa dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for marine fauna. This role may be completed by vessel crew who are appropriately trained..*

Marine fauna: *listed as specially protected fauna under the Biodiversity Act 2016, and in particular, whales, marine turtles and dugongs. Dolphins are unique in that they are highly manoeuvrable and responsive to vessel movements and activities. Dolphins are likely to move out of the area quickly during dredging activities or ride the bow wake of dredges. Actions initiated when dolphins are sighted will therefore be based on their behaviour in relation to the distance mentioned as observation and exclusion zone*

Figure 9-1: Marine fauna management procedure during dredging, rock placement, backfill and pipelay operations

Table 9-2: Indicative nearshore Project activities timing in context of key ecological windows



Activity		2023												2024			
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Pre-lay onshore works			□■	■■	■▩	▩▩	▩▨	▨▨	▨□								
Seabed Intervention pre-lay					■■	■■	■■	▨▨	▨▨	▨▩	■▨	▨▨	▨▨	▨□			
Nearshore trunkline installation							□■	■■	■■	■▩	▨▨	▩▨	▨▨	▨▨			
Post-lay onshore works								□■	■■	■■	■▩	▨▨	▨▨	▨▨			
Seabed intervention post-lay								□■	■■	■■	■▩	▩▩	▩▩	▨▨	▨▨	▨▨	
Coral	Spawning windows		■□	■□								■□	■□		■□	■□	
Humpback whale	Southbound[36]								■■	■■	■■						
Green turtle	Nesting	* *	* *	■■	■■						□■	* *	* *	* *	* *	■■	■■
	Emergence	* *	* *	* *	■■	■■							■■	* *	* *	* *	■■
Hawksbill turtle	Nesting	■■								■■	* *	* *	* *	■■			
	Emergence	* *	■■									■■	* *	* *	■■		
Flatback turtle	Nesting	* *	■■	■□								■■	* *	* *	■■	■□	
	Emergence	* *	* *	■■	■■								■■	* *	* *	■■	■■

Note these indicative timeframes (early window solid; late window hatched) are subject to change where required due to technical and operational constraints.
*Peak turtle nesting and hatchling emergence periods (PENV 2022)

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[36] Northbound not applicable as main northbound migratory corridor is in the deeper waters of the continental shelf, passing to the west of Barrow and the Montebello Islands (Double et al. 2012)

10 Management of Social Surroundings

To ensure activities described in Section 3 that have the potential to impact Social Surroundings are managed to an acceptable level, the CHMP [SA0006GH1401311448] will be implemented on the Project. The CHMP has been developed to meet the objectives outlined in Condition 7-1 of Ministerial Statement No. 1172 and includes specific controls relating to Aboriginal and Cultural Heritage. Other potential impacts to socials surroundings (e.g., aesthetics) are covered by management actions and targets specified in Section 7 to 9.

In addition, MAC has identified marine environmental values that are of cultural importance to MAC, pertinent to this DSDMP, and hence the associated management are described below.

10.1 MAC identified values and associated management

Woodside has undertaken extensive consultation with MAC to understand the values of the marine environment that are of cultural importance to MAC (Section 2.3.2.1; Section 4.5.6).

A cultural heritage value mapping exercise was completed to determine if there were any plausible pressure:response pathways from the activities described in Section 3 to any of the identified marine environmental values of cultural importance to MAC set out in Section 4.5.6, and if so to determine the adequacy of the DSDMP in terms of protecting that value. The exercise followed the approach outlined in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) – Cultural and Spiritual Values and is presented in Table 10-1.

The assessment considered MAC cultural and spiritual values including, 'heritage' (e.g., sites); contemporary usage (e.g., harvesting seafood, ceremonies); a healthy environment (e.g., food web maintenance, seagrass as a foraging habitat); ecosystem integrity and seafood quality. The assessment found that apart from direct disturbance/interaction in the development footprint, increased suspended sediment concentrations (SSCs) and associated reduction of benthic light from dredging activities were the only indirect pathways of potential effect identified. The value mapping exercise and supporting rationale demonstrates how these values are being managed and protected.

Further to the value mapping, Section 11.1.1 provides a rationale for the selection of monitoring sites, which has been included to demonstrate how MAC's identified marine environmental values of cultural importance (Section 4.5.6) have been considered and how they are protected by the proposed program.

Table 10-1: Cultural and spiritual value mapping to monitoring / management

Identified Values (Section 4.5.6)	Identified areas (Section 4.5.6)	Pressure	Management / Monitoring Overview	DSDMP Reference
Values				
Mermaid Sound ecosystem health	Mermaid Sound	• Temporary / localised increase in SSCs • Contaminant release (not expected)	Management • Implement TMMF to manage water quality associated with trenching, spoil disposal and backfill activities to a level where impacts are not predicted to occur to BCH. • Use of a green valve and other dredge-based management actions. Monitoring • Water quality monitoring • Coral community assessment • Remote sensing • Dredge plume assessment	Table 7-3 Table 8-1 Section 11
Environmentally and culturally important benthic communities				
Coral communities	Withnell Bay; Conzinc Bay; south-west of Legendre Island	Increased SSCs and resulting light reduction	Management • Implement TMMF to manage water quality associated with trenching, spoil disposal and backfill activities to a level where impacts are not predicted to occur to BCH. • Use of a green valve and other dredge-based management actions. Monitoring • Water quality monitoring program.	Table 7-3 Table 8-1 Section 11
Coral spawning events	Mermaid Sound	Increased SSCs	Management • Reduction of turbidity generating activities in Mermaid Sound during coral spawning critical windows of environmental sensitivity (CWES)	Table 8-1
Seagrass communities	Conzinc Island; between Angel and Gidley Islands	Increased SSCs and resulting light reduction (during summer months)	Inherently protected through the TMMF, which is designed to protect corals in Ecological Zones A and B as the most sensitive benthic receptor.	Rationale in Section 10.2.1.2

Identified Values (Section 4.5.6)	Identified areas (Section 4.5.6)	Pressure	Management / Monitoring Overview	DSDMP Reference
Mangrove communities	Conzinc Bay north end; Flying Foam Passage; Searipple Passage; north-east bay of West Lewis Island, Malus Island	No significant impact pathway	Inherently protected through the TMMF, which is designed to protect corals in Ecological Zones A and B as the most sensitive benthic receptor.	Rationale in Section 10.2.1.3
Macroalgal communities	Not explicitly identified by Elders	No significant impact pathway	Inherently protected through the TMMF, which is designed to protect corals in Ecological Zones A and B as the most sensitive benthic receptor. :	Rationale in Section 10.2.1.1
Subtidal soft bottom communities	Not explicitly identified by Elders	Increased SSCs (phototrophic sponges in offshore area)	Management • Implement TMMF to manage water quality associated with trenching, spoil disposal and backfill activities to a level where impacts are not predicted to occur to BCH (with sponges as the most sensitive benthic receptor in Offshore Ecological Zone and corals in Ecological Zones A and B). • Use of a green valve and other dredge-based management actions. Monitoring • Water quality monitoring	Table 7-3 Table 8-1 Section 11
Intertidal sand and mudflat communities	Not explicitly identified by Elders	No significant impact pathway	N/A	-
Rocky shores	Not explicitly identified by Elders	No significant impact pathway	N/A	-
Environmentally and culturally important marine fauna				
Dolphins and whales	Mermaid Sound	• Vessel strike • Underwater noise	Management • Trained marine fauna observers (MFOs) and implementation of observation and exclusion zones, including defined distances and vessel speeds. • Periodic maintenance of noise generating equipment.	Table 10-1
Turtles	Withnell Bay, Gidley Island, Legendre Islands,	• Vessel strike • Entrainment	Management	Table 10-1

Identified Values (Section 4.5.6)	Identified areas (Section 4.5.6)	Pressure	Management / Monitoring Overview	DSDMP Reference
	Rosemary Island, Mermaid Sound	• Vessel light (turtle hatchling emergence)	• Trained MFOs and implementation of observation and exclusion zones, including defined distances and vessel speeds. • Engineering controls such as turtle deflection chains • Onshore and vessel lighting controls	
Dugongs	Gidley Island	• Vessel strike • Reduction of foraging habitat	Management • Trained MFOs and implementation of observation and exclusion zones, including defined distances and vessel speeds. • See *“seagrass communities*” for protection of foraging habitat	Table 10-1
Fish	Areas not specified but indicated throughout Mermaid Sound	No significant impact pathway	Inherently protected through the TMMF	Rationale in Section 10.2.2.2
Sea Snakes	Areas not specified but indicated throughout Mermaid Sound	No significant impact pathway	N/A	-
Other important values of Mermaid Sound				
Pilbara rock oyster project	Flying Foam Passage, Searipple Passage, Withnell Bay and off West Lewis Island	No significant impact pathway	Inherently protected through the TMMF	Rationale in Section 10.2.2.3
Fish traps	Conzinc Bay	No impact pathway	N/A	Refer to CHMP for management of fish traps and associated heritage values.
Squidding	Conzinc Island	Temporary / localised increase in SSCs may adversely affect this activity	• Inherently protected through the TMMF • Remote sensing	Section 11

10.2 Impact pathway supporting rationale

10.2.1 Benthic communities and habitats

10.2.1.1 General

Sediment-related impacts associated with dredging and spoil disposal activities can be separated into direct and indirect effects (Jones et al. 2016; Mills & Kemps 2016). Direct removal of significant benthic communities and habitats (BCH; Figure 5-2 of the DSDMP) within the trenching footprint is not required, although removal of some sparse individuals may be[37]. The proposed trunkline route has been selected to avoid sensitive habitats as far as practicable and utilise existing routes established as part of the Pluto LNG Foundation project. The proposed trunkline route is located parallel to the Pluto Trunkline with an offset of around 100 m through Mermaid Sound and within around 20 m at the shore crossing, which means much of the seabed within the corridor has been previously disturbed. Further, dredged material will be disposed at existing (i.e., pre-disturbed) spoil grounds within the region (Spoil Ground A/B and 2B in State waters and Spoil Ground 5A in Commonwealth waters).

Trenching, spoil disposal and backfill activities can also indirectly impact BCH through elevated suspended sediment concentrations, associated light reduction and increased sediment deposition (Jones et al. 2017). Appendix G of the DSDMP provides a description of the modelling thresholds as relevant to each ecological zone, including source literature and rationale. In summary, the impact thresholds for ecological zone A and B developed for the project are based on the latest contemporary scientific research from the Western Australian Marine Science Institution (WAMSI) Dredging Science Node (DSN) [38], published in Jones et al (2019) for coral as the most sensitive benthic receptor.

As described in Section 6.5.5 of the DSDMP and in Appendix G, it is acknowledged that ephemeral seagrasses communities are also found in Zone A and B and as such seagrass thresholds were considered when developing thresholds for the project. In review of Statton et al. (2017) the seagrass threshold provided for *Halodule uninervis* is lower than that proposed for the coral communities, and hence the coral threshold is applied as a conservative threshold for all benthic communities in Zone A and Zone B. Similarly, indirect impacts of dredging activities and associated elevated SSCs and reduced benthic light on other benthic primary producer communities (such as macroalgae) have been assessed using corals as the most sensitive receptor. However, given that seagrass and mangroves have been highlighted by MAC, further discussion is provided below.

Peer reviewed modelling has been completed that considers impacts to BCH, including coral habitats of the Dampier Archipelago and inshore of the proposed Borrow Ground (RPS 2022). Modelling has shown that trenching, spoil disposal and backfill activities undertaken in State waters are predicted to cause detectable changes in water quality from elevated SSC.

The ZoMI (defined as the potential for reversible impacts) from trenching and spoil disposal is predicted to occur in areas immediately adjacent to the trunkline route where the highest intensity activities are likely to occur. Discrete pockets are predicted further afield near Conzinc Island, within Conzinc Bay, King Bay and around Intercourse Islands where coral habitat may be present. No ZoMI or ZoI were predicted as a result of backfill activities, primarily due to the minimal fine sediment

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[37] In the long term, the trunkline will provide hard substrate to the marine environment, in areas where there is no cover rock berm, or rock backfill, which may support a range of benthic communities. These habitats not only have structural complexity but also create habitat for a large diversity of fish species.

[38] Dredging related effects on corals, seagrasses, sponges and other BCH has been studied in detail as part of the collaborative research program, known as the "Dredging Science Node", facilitated by the WAMSI. The results of the research have led to a better understanding of the system and have been translated directly into guidelines to help reduce the uncertainty associated with Environmental Impact Assessment and management of dredging impacts.

expected in the backfill material. Modelling has also shown that SSC levels are predicted to be an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Duckworth et al., 2017).

A tiered monitoring and management framework (TMMF) has been developed to manage dredging activities within acceptable water quality boundaries, to avoid reversible impacts to coral communities as the most sensitive receptor within Mermaid Sound, and sponges as the most sensitive receptor in the Offshore zone.

10.2.1.2 Seagrass

Seagrasses are primarily impacted by dredging operations by a reduction in daily light availability (through light attenuation by suspended sediment). As described in Section 4.3.2.3, seagrasses in the Dampier Archipelago are generally sparse, occurring in low abundance on shallow sandy sediments in sheltered areas and interspersed with other BCH. Environmentally and culturally important seagrass areas have been reported by MAC (2021) at Conzinc Island and between Angel and Gidley Island (Figure 5-12). Seagrass are considered culturally important to MAC as they provide protection and refuges for small marine animals and are foraging habitat for dugongs.

Surveys during the Pluto LNG Foundation Project found *Halophila ovalis* and *Halophila decipiens* to be the dominant seagrass species. The species were found to have a low percent cover (less than 10% to 15%) with increased biomass over the summer months. These are both ephemeral colonising species meaning they have short ramet turnover times (< months), sexual maturity is reached quickly (<months), rapid–colonising growth, rapidly fluctuating total standing biomass, a high level of reproductive effort producing seeds and an ability to build up a seed bank, even a short-lived one (Kilminster et al. 2015). In subtidal and intertidal habitats of the Pilbara intra-annual patterns in abundance were found to peak between November and February with minima in winter (Vanderklift 2017).

The TMMF described in Section 7.4 has been developed to manage dredging activities within acceptable water quality boundaries, to avoid reversible impacts to coral communities as the most sensitive receptor within Mermaid Sound. The water quality monitoring program described in Section 11 includes sites (such as CONI2) that have been identified by MAC for both coral and seagrass value, and hence by managing water quality to protect corals, it will inherently protect the seagrass in the area. Further, given seagrasses found in the area are ephemeral and that elevated suspended sediments because of dredging at any location will be of a short duration, recovery of any affects would be highly likely. Noting, some seagrass species have the capacity to die back when environmental conditions, such as temperature or light are outside of the species tolerance range but then re-establish from seed when favourable conditions return (McMahon et al. 2017).

10.2.1.3 Mangroves

As described in Section 4.3.2.5, the nearest mangrove communities/stands exist at the northeast pocket of the sandy beach at No Name and within King Bay, while regionally significant areas of mangroves occur at West Intercourse Island, Enderby Island Complex and Searipple Passage/Conzinc Bay (EPA, 2001). Environmentally and culturally important mangroves have also been identified by MAC (2021), including Conzinc Bay north end; Flying Foam Passage; Searipple Passage and north-east bay of West Lewis Island (Figure 5-12).

Excess deposition and accumulation of sediments within intertidal and subtidal areas may cause stress to mangroves (particularly in the seaward assemblage) due to smothering and burial of aerial root systems, with variable impacts depending on the species and sediment characteristics.

Peer reviewed modelling (Section 5) indicates that the regionally significant mangrove communities, in addition to those mangroves identified by MAC, are beyond the predicted ZoI. While King Bay is predicted to experience an additional 5 to 10 mg/L, with a discrete pocket in excess of 10 mg/L[39] (based on the 95th percentile depth averaged results). These elevations in SSC are expected to be spatially and temporally confined, due to the rapid progression of the activities along the trunkline route. Further the dispersion of suspended sediments from the activity towards mangrove areas is not at levels required to sustain excess deposition of sediments within these assemblages that may cause stress. SSCs would need to be very high and remain at those levels for substantial periods to result in any measurable level of sediment deposition, which is not probable during the trunkline trenching campaign. Therefore, there is no plausible risk that sedimentation rates will increase to the level that smother the mangrove roots and impact on mangrove health at these sites. Mangroves are also associated with areas where sediment deposition and accretion are a natural and regular event and as such, the risk posed to mangroves by any minor increased sedimentation from dredging activities (if it did occur) is considered to be low.

This is further supported by the outcomes of recent studies for significantly larger dredging programs (Cardno 2015; Jacobs 2016). For the Ichthys capital dredging program, approximately 16 Mm^3 of material was dredged within Darwin Harbour where significant mangrove communities were in close proximity to the activity. Mangrove monitoring sites within the ZoMI and ZoI showed sedimentation levels during and after dredging remained below the level considered to potentially impact mangrove health (>50 mm deposition). No dredging related impacts due to sediment deposition or increased SSCs were detected (Cardno 2015).

Similarly, the Pilbara Port Authority had very similar findings (Jacobs 2016) during capital dredging of approximately 8 Mm^3 for the South West Creek Dredging and Reclamation Project in Port Hedland. No data collected in pre-dredging, during-dredging and post-dredging surveys recorded any significant changes in sedimentation within the mangroves (using a more conservative criteria of >20 mm) or measurable effects on mangrove health in the study area (including at sites adjacent to the dredging and disposal activities within the ZoMI and ZoI).

10.2.2 Marine fauna

10.2.2.1 General

Dredging activities may also present a potential hazard to marine mammals and other protected marine fauna such as marine turtles and whale sharks. Vessel movements can result in interactions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial or serious injury or mortality. However, the management actions and targets detailed in Section 10 have been designed to mitigate unplanned interactions with marine fauna and meet EPO 6-1(2).

10.2.2.2 Fish

Fish of the Dampier Archipelago and specific fisheries are set out in Section 4.4.6 and Section 4.5.5 respectively. Fish are reported by MAC as culturally important species in Mermaid Sound and surrounds, with Thalu ceremonies associated with increasing fish stocks. Further, fish traps in Conzinc Bay, and others would have/do exist in coastal areas of islands (e.g., Angel and Gidley Islands) (Section 4.5.6).

Suspended sediments associated with trenching and spoil disposal or borrow ground dredging and backfill operations may affect fishes' ability to forage, hunt and avoid predators (Harvey et al. 2016). Elevated concentrations of suspended sediments may also cause physiological impacts, such as gill impairment. An analysis of available literature suggests that impacts range from minimal (10 mg/l SSC) to extreme (1000 mg/l SSC) (Harvey et al. 2016).

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[39] These pockets of elevated SSC may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells then 'trapped' upon reversal of the tide.

Modelling results (Section 5) suggest trenching and spoil disposal using Spoil Ground A/B may elevate suspended sediment concentration up to 10 mg/l in the direct vicinity of the activities (trunkline route between around KP10 to KP16 based on 95th percentile results), with the simulated plume extending towards Flying Foam Passage, driven by the prevailing hydrodynamics. Modelling also simulated isolated pockets of elevated suspended sediments above 10 mg/l around King Bay and the Intercourse Islands. However, these pockets of elevated SSC may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells then ‘trapped’ upon reversal of the tide. The trenching and backfill operations are expected to rapidly progress along the pipeline route, ensuring increased SSC are spatially and temporally confined. This is supported by monitoring results from the Pluto LNG Foundation project, which indicated a rapid decrease in turbidity beyond the immediate dredging footprint[21] (MScience, 2018b).

SSC during high-energy metocean events, including cyclones, have been observed to naturally exceed the 10 mg/l threshold. The 95th percentiles for seven of the eight water quality sites monitored (August 2006 to May 2007) before the Pluto LNG Foundation project dredging campaign naturally exceeded 10 mg/l (MScience, 2007). Additionally, an analysis of the data collected outside of periods of dredging during the Pluto LNG Foundation project shows the maximum daily mean of 17 out of the 25 sites monitored exceeded 10 mg/l. Due to the factors outlined below, impacts to fish are not expected as a result of increased SSC:

- SSC naturally exceed 10 mg/l during high energy metocean events, including spring tides.
- Trenching, spoil disposal and backfill activities are only predicted to raise SSC beyond 10 mg/l in spatially confined areas that will vary with the location of the dredge, which will rapidly progress along the pipeline route.
- SSC above 10 mg/l are expected to be temporally confined (based on the 95th percentile results).

Further, sediment sampling along the proposed pipeline route has demonstrated sediments are suitable for unconfined ocean disposal, with results indicating all levels of potential contaminants of concern were below the NAGD (2009) screening levels. This conclusion is further supported by more recent studies as detailed in Section 4.2.2. Therefore, sediments to be dredged (and suspended during operations) are considered to be uncontaminated; thus, no toxicological impacts to marine biota including fishes from the resuspension of contaminants are predicted.

10.2.2.3 Pilbara rock oyster project

The modelled ZoI does not intersect with any Pilbara rock oyster project aquaculture leases (Figure 4-10) or aquaculture exemption application sites in Flying Foam Passage, Searipple Passage, Withnell Bay and off West Lewis Island (Figure 4-12). The Maxima Pearling aquaculture lease in Flying Foam Passage is around 5 km from the proposed pipeline route.

Peer reviewed modelling (Section 5) has shown the maximum contribution to SSC from the trenching and spoil disposal or borrow ground dredging and backfill operations (based on the 95th percentile results) are not expected to exceed 5 mg/l in the southern end of Flying Foam Passage, and less than 1 mg/l in the vicinity of the existing Maxima Pearling leases in the northern section of Flying Foam Passage. MODIS imagery collected during the Pluto LNG Foundation project during trenching activities (during the period the dredge was closest to the southern entrance of Flying Foam Passage) showed trenching did not affect turbidity levels within Flying Foam Passage. Strong tidal currents in Flying Foam Passage elevate turbidity levels naturally (MScience, 2018b).

Oysters have been shown to be tolerant of elevated SSC associated with dredging activities, as long as they do not become completely buried (Morton, 1977). They are comparatively tolerant when compared with other filter feeders against unwanted particles of various nature, and can thus continue to feed in turbid waters, even close to dredging projects (Schönberg, 2016). Intolerance thresholds for oyster eggs are cited at 188 mg/l, no effect concentrations are cited to about 200 mg/l, and sublethal effects to 4000 mg/l (Schönberg, 2016). Another recent study has shown the rock oysters studied thrived under highly turbid conditions (less than 700 mg/l) if other environmental variables were optimal (Chowdhury et al., 2019). The simulated SSC predicted are at least an order of magnitude below those cited to potentially cause impacts.

The water quality monitoring program (Section 11.2) includes several sites surrounding the entrance to Flying Foam Passage (ANG2, CONI, CONI2 and COBN), as well as a site at the southern end of Flying Foam Passage (FFP1). The tiered trigger levels (Section 7.4), based on water quality and set for the maintenance of ecosystem integrity, are an order of magnitude below the thresholds at which impacts to oyster communities are predicted. As such, they are considered to adequately protect the aquaculture leases. Note, management actions would be triggered to reduce turbidity levels in the event of a project-attributable Tier 2 exceedance and above, hence well before impacts are predicted to oysters.

In addition, the dredging activity is not expected to result in the mobilisation of contaminants of concern based on the analysis of the Scarborough SAP Implementation Report (Advisian 2019) and other more contemporary data sets (Advisian 2019, O2 Marine 2021, MScience 2022). This will be further verified through the trenching and spoil disposal dredge plume assessment (see Section 11.4.1) which was included on MACs request. This study includes the collection of supplementary data to provide confidence that there are no contaminants of concern being mobilised by the activity, based on the highest risk area as an indicator.

11 Monitoring

11.1 Monitoring program overview

The proposed monitoring program to demonstrate that EPO 6-1(1) is being achieved and support the execution of the activities described in Section 3 is set out in Table 11-1. It has been developed in consideration of the pressure: response pathways and through extensive consultation with MAC.

Table 11-1: Overview of the key monitoring requirements

Section	Program	Key details
11.2	**Water quality monitoring**	• Telemetered turbidity and light monitoring at 19 monitoring sites across the Dampier Archipelago • Provide data to inform the management of trenching, spoil disposal and backfill activities and associated water quality to a level where impacts are not predicted to occur to BCH. • Web-based online data dashboard for telemetered near real time data including automated QAQC (as far as practicable), trigger assessment and notification.
11.3	**Coral community assessment**	• Baseline coral community assessment at 18 sites (within six months before activity) • Reactive coral community assessment at affected site/s and eight reference sites. • Post- dredging coral community assessment at 18 sites (unless rationalised) within three months of completion of backfill activities
11.4.1	**Dredge plume assessment**	• Nearshore trenching and spoil disposal dredge plume assessment, contaminant sampling and model validation • TSS and contaminant analysis by NATA accredited laboratory.
11.4.2	**Remote sensing**	• Sourcing of regular (daily where possible) remote sensing imagery using an appropriate platform (VIIRS as base case).

11.1.1 Monitoring site selection and rationale

The water quality monitoring program and coral community assessment surveys, set out in Section 11.2 and 11.3 respectively, provides a comprehensive suite of monitoring locations throughout the Dampier Archipelago. In accordance with *Technical Guidance – Environmental impact assessment of marine dredging proposals* (EPA 2021), monitoring sites have been selected based on dredge plume modelling outcomes in context of the ZoMI and ZoI. Where possible these sites have also been selected from the suite of pre-existing Pluto LNG Foundation project monitoring locations, which means in most instances, long term datasets are available to inform the monitoring programs for both water quality and coral community. It is noted that the nature and scale of the proposed trunkline dredging campaign is an order of magnitude lower in terms of volume (approximately 3 Mm^3 vs. 12 Mm^3) and duration (months vs. years) when compared to the Pluto LNG Foundation project. Note coral monitoring during the Pluto LNG Foundation project showed no indirect impact relating to dredging activities at the receptor sites.

In terms of the confidence in the modelling, the inputs, process and outcomes were peer reviewed (on request by MAC through consultation) with the relevant letters appended to the DSDMP and summarised in Section 6. In summary, the reviewer was satisfied with the modelling approach and the assumptions. Noting that while a level of uncertainty will always exist with modelling studies, the uncertainty has been managed through detailed review of relevant information in the literature, extensive past project experience, adoption of well-established models, adherence to suggested best practice as outlined in the WAMSI Dredging Science Node reports and adoption of conservative values for input parameters, where deemed necessary. Further that the interpretation and conclusions are considered appropriate, with due consideration to dredging science and guidance.

In review of the dredge plume modelling outcomes 12 sites were originally proposed (Revision 0 of the DSDMP). During the consultation process this was increased to 16 sites (Revision 3 of the DSDMP), with two sites (CRTS and HAM3) explicitly included on request by MAC. MAC has since provided a further list of 10 recommended sites (including an existing Scarborough Project site (CONI), three additional Pluto LNG Foundation sites (MIDR, HGPT and HSHL) and six new sites), and the majority of these are at a greater distance from the dredging activities than the existing monitoring sites, with many of these additional Reference sites at a significant distance from the outer boundary of the ZoI.

Table 11-2 has been included to provide a transparent assessment with regard to monitoring site selection. Note to provide context to the location of the recommended sites the ZoI is the maximum extent of predicted dredge plumes beyond which dredge-generated plumes should not be discernible from background conditions. No impacts to benthic communities are predicted to occur in the ZoI at any stage during the dredging campaign, however, visible plumes may occasionally be present.

Table 11-2: Monitoring site selection and rationale

Site	Ecological zone	Dredge plume modelling classification		MAC identified value (Section 4.5.6) and/or recommended site	Site selection		Rationale
		Trenching & Spoil Disposal	Borrow ground dredging & backfill		Water Quality	Coral community	
Sites within ZoMI (or directly adjacent to)							
CONI	B	Impact	Informative	Y Coral	Y	Y	Coral community identified within the ZoMI. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment) and identified culturally important benthic community.
CONI2 (Site 3)	B	Impact	Informative	Y Coral/Seagrass	Y	Y	Given the proximity of the recommended Conzinc Island site to the trunkline route, an additional impact monitoring site has been included. MAC identified both seagrass and coral as values, however a seagrass monitoring site is not considered appropriate given the colonising life history of the dominant seagrass species in context of the transient nature of the trenching activities and associated temporary increased in SSCs. A coral community site is considered appropriate given the coral thresholds are more conservative than the seagrass threshold and as such both habitat types will be protected through the implementation of the TMMF.
COBN	B	Impact	Informative	Y Coral	Y	Y	Coral community identified within the ZoMI. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment) and identified culturally important benthic community.
Sites within ZoI (or within 200 m)							
SUP2	A	Influence	Informative	-	Y	Y	Coral community identified within the ZoI. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment).
KGBY	A	Influence	Informative	-	Y	Y	Coral community identified within the ZoI. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment).

Site	Ecological zone	Dredge plume modelling classification		MAC identified value (Section 4.5.6) and/or recommended site	Site selection		Rationale
		Trenching & Spoil Disposal	Borrow ground dredging & backfill		Water Quality	Coral community	
SWIT	A	Influence	Informative	-	Y	Y	Coral community identified within the ZoI. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available.
ANG2	B	Influence	Informative	-	Y	Y	Coral community identified within the ZoI. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment).
HAUY	B	Informative	Influence	-	Y	Y	Coral community identified within the ZoI of the borrow ground dredging activities. HAUY is a new site that has not been monitored as a part of the Pluto LNG Foundation project. As such, during the pre-dredging baseline survey the site will be assessed and if appropriate established where significant coral communities (>10% cover) exist
Sites outside the ZoI							
MIDI	A	Reference	Reference	-	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment).
NWIT	A	Reference	Reference	-	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available.
Site 5 (Withnell Bay)	A	Reference	Reference	Y Coral / Oysters	N	N	The recommended site is greater than 1.0 km beyond the outer boundary of the ZoI and in this context, there is no plausible potential pressure: response pathway. The proposed monitoring program is designed to protect coral located closer to the dredging pressure, this includes sites surrounding the entrance to Whitnell Bay (SWIT and NWIT), as well as others closer to the dredging pressure (CONI and CONI2). Further, the tiered management triggers are an order of magnitude below the thresholds at which impacts to oyster communities are predicted. As

Site	Ecological zone	Dredge plume modelling classification		MAC identified value (Section 4.5.6) and/or recommended site	Site selection		Rationale
		Trenching & Spoil Disposal	Borrow ground dredging & backfill		Water Quality	Coral community	
							such, they are considered to adequately protect the aquaculture leases.
CRTS	B	Reference	Reference	Y Coral	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available and identified culturally important benthic community.
FFP1	B	Reference	Reference	-	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment).
GIDI	B	Reference	Reference	Y Seagrass	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets \ available (including the 2019 baseline coral habitat assessment).
HAM3	B	Reference	Reference	Y Coral	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available and identified culturally important benthic community.
HAM4/ HSHL	B	Reference	Reference	Y Coral	N	N	The recommended site is greater than 7.3 km beyond the outer boundary of the ZoI and in this context, there is no plausible potential pressure: response pathway. The proposed monitoring program includes reference sites CRTS, HAM3 and LEGD, which are located both east and west of the recommended site providing adequate monitoring in this area.
HGPT	B	Reference	Reference	Y Coral	Y	Y	The recommended site is greater than 4.2 km beyond the outer boundary of the ZoI and in this context, there is no plausible potential pressure: response pathway. However, to increase the coverage of Reference sites within the area it is proposed that HGPT is included. HGPT is proposed

Site	Ecological zone	Dredge plume modelling classification		MAC identified value (Section 4.5.6) and/or recommended site	Site selection		Rationale
		Trenching & Spoil Disposal	Borrow ground dredging & backfill		Water Quality	Coral community	
							as it is an existing Pluto LNG Foundation site for which water quality data already exists. Note only limited coral data exists for this site.
LANI	B	Reference	Reference	-	Y	Y	To increase the coverage of Reference sites within the area it is proposed that LANI is included, which is located between the ZoI boundary to the north and MACs two recommended additional sites (Site 1; MIDR) to the south. LANI is proposed as it is an existing Pluto LNG Foundation site for which water quality and coral data already exists.
LEGD	B	Reference	Reference	Y Coral	Y	Y	Coral community outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment) and identified culturally important benthic community.
MAL2	B	Reference	Reference	Y Mangroves	Y	Y	Site location (as well as other significant coral communities around Malus Island) lie outside the ZoI boundary, so hence identified Reference site. Location of pre-existing Pluto LNG Foundation project monitoring site with long term datasets available (including the 2019 baseline coral habitat assessment). Given the long-term data set, the high coral cover and stable and representative community composition[40], the proposed location is considered appropriate as a Reference site.

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[40] MAL2 was monitored as part of the 2019 baseline coral habitat assessment (Appendix D), which found that:

- MAL2 had the highest mean live coral cover of all sites (56.7%), with 0.2% bleaching. Cover was relatively consistent across all transects, ranging from 48.5 – 60.5% (Table 4-9 of Appendix D), with the 48.5% cover along transect 5 being a low ‘outlier’. Live coral cover at MAL2 remains very similar to that recorded in previous surveys (Figure 4-9 of Appendix D).
- Live coral cover at MAL2 was very stable between surveys reporting coverage estimates of approximately 56% cover in the 2019 survey. Community composition shows good agreement between surveys, with the community dominated by Porites, with almost no *Turbinaria* present (Figure 4-20 of Appendix D). *Turbinaria* were identified at <0.1% in the current survey.

Site	Ecological zone	Dredge plume modelling classification		MAC identified value (Section 4.5.6) and/or recommended site	Site selection		Rationale
		Trenching & Spoil Disposal	Borrow ground dredging & backfill		Water Quality	Coral community	
MIDR	B	Reference	Reference	Y Coral	N	N	The recommended site is greater than 3.7 km beyond the outer boundary of the ZoI and in this context, there is no plausible potential pressure: response pathway. However, in lieu of MIDR, LANI is proposed to increase Reference site coverage in the area,, which is located between the ZoI boundary to the north and MACs two recommended additional sites (Site 1; MIDR) to the south. LANI is proposed as it is an existing Pluto LNG Foundation site for which water quality and coral data already exists. Further, the proposed monitoring program also includes reference sites CRTS and MAL2, which are located east and southeast of the recommended site respectively.
Site 1 (Rosemary)	B	Reference	Reference	Y Coral	N	N	The recommended site is greater than 7.6 km beyond the outer boundary of the ZoI and in this context, there is no plausible potential pressure: response pathway. However, in lieu of Site 1, LANI is proposed to increase Reference site coverage in the area, which is located between the ZoI boundary to the north and MACs two recommended additional sites (Site 1; MIDR) to the south. LANI is proposed as it is an existing Pluto LNG Foundation site for which water quality and coral data already exists. Further, the proposed monitoring program also includes reference sites CRTS and MAL2, which are located east and southeast of the recommended site respectively.
Site 2 (Collier Rocks)	B	Reference	Reference	Y Coral / Oysters	N	N	The recommended site is greater than 6.5 km beyond the outer boundary of the ZoI and in this context, there is no plausible potential pressure: response pathway. The proposed monitoring program includes several sites surrounding the entrance to Flying Foam Passage (ANG2, CONI, CONI2 and COBN), as well as a site at the southern end of Flying Foam Passage (FFP1). The tiered management triggers are an order of magnitude below the thresholds at which impacts to oyster communities are predicted.

Site	Ecological zone	Dredge plume modelling classification		MAC identified value (Section 4.5.6) and/or recommended site	Site selection		Rationale
		Trenching & Spoil Disposal	Borrow ground dredging & backfill		Water Quality	Coral community	
Site 4 (Searipple Passage)	B	Reference	Reference	Y Mangroves	N	N	The recommended site is beyond the ZoI and there is no predicted impact to mangroves. The existing array of monitoring sites (including CONI, COBN and ANG2) is considered adequate to protect the BCH, including mangrove communities, identified as being at potential risk from turbidity generating activities and would provide early warning of any risk to sensitive areas outside of the predicted influence of these activities.
Site 6 (Malus Is)	B	Reference	Reference	Y Mangroves	N	N	The recommended site is greater than 4 km the ZoI and there is no predicted impact to mangroves. The existing array of monitoring sites is considered adequate to protect the BCH, including mangrove communities, identified as being at potential risk from turbidity generating activities and would provide early warning of any risk to sensitive areas outside of the predicted influence of these activities.
MPB	Offshore	Informative	Influence	-	Y	Y	This site is located on the northern edge of the Dampier Marine Park in Commonwealth waters. This site was chosen to inform the risk to the Habitat Protection Zone of Dampier Marine Park and its associated values - sponge communities. This site has been included in DSDMP to provide context of the broader monitoring program. Noting that activities within Commonwealth Waters (including the MPB monitoring site) will be covered under Environment Plans to be accepted by NOPSEMA.

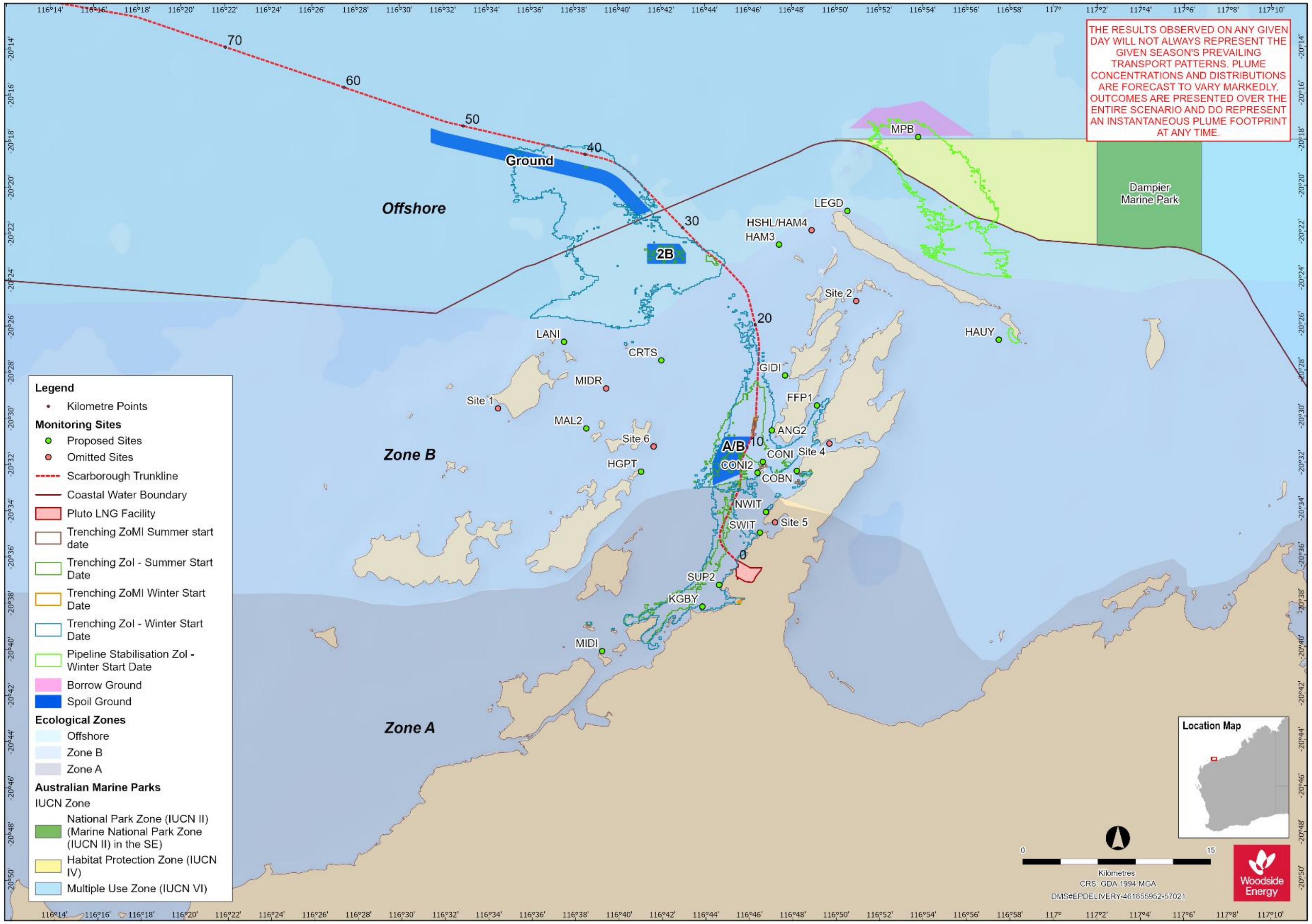

Figure 11-1: Monitoring site selection rationalisation (based on coral community site coordinates)

11.2 Water quality monitoring

11.2.1 Objective

The objective of the water quality monitoring program is to provide data to inform the management of trenching and spoil disposal, borrow ground dredging and backfill activities and associated water quality to a level where impacts are not predicted to occur to BCH.

The water quality monitoring program has been designed to support the application of the TMMF, described in Section 7.4. The selected approach involves telemetered water quality monitoring at a suite of fixed sites. Water quality monitoring sites will be paired as close as practicable with coral community monitoring sites, described further in Section 11.3.

11.2.2 Monitoring period

Water quality instruments will be deployed for a minimum of 14 days (one spring neap tidal cycle) before trenching and spoil disposal, to ensure reliable operability.

After ceasing the relevant activity, instruments will remain in-situ for four weeks (two spring-neap tidal cycles). Although not expected based on the results of the Pluto LNG Foundation project, if turbidity remains significantly elevated above background conditions, the period of time for which the instruments remain deployed will be assessed on a case-by-case basis.

11.2.3 Monitoring sites

Table 11-3 provides a list of the water quality monitoring sites and classification. Monitoring sites have been selected based on dredge plume modelling outcomes from a suite of pre-existing Pluto LNG Foundation project monitoring locations (where possible). This means in most instances, long-term baseline datasets are available to inform the monitoring programs for both water quality and coral community.

The monitoring sites have been classified as follows:

- <u>Impact sites</u>: are reactive monitoring sites where modelling shows there is an intersection of the ZoMI with significant coral habitat (or directly adjacent to). Impact sites include turbidity and light triggers that, if exceeded and are attributable to trenching and spoil disposal, or borrow ground dredging and backfill activities, initiate data review and responsive or contingency management action/s (as applicable to level).
- <u>Influence sites</u>: are reactive monitoring sites where modelling shows there is an intersection of the ZoI with significant coral habitat or sponge communities (for Dampier Marine Park boundary site). A conservative approach has been taken by categorising sites that fall just outside of the ZoI (within 200m of the boundary) as Influence sites.

  These sites may be classified as reference sites where it can be demonstrated they have not been influenced by the dredging plume. Conversely, they may be classed as impact sites if the Tier 2 management trigger is exceeded and attributed to the Project.
- <u>Reference sites</u>: are representative sites which are not predicted to be impacted or influenced by the sediment plume. These sites are primarily designed to provide contextual information to inform the assessment of water quality trends and more specifically provide information to support project attributability assessments. Data from these locations will be used, where appropriate, to assess project attributability of tiered trigger exceedances and coral community effects if required.
- <u>Informative sites</u> (water quality only): are sites that are predicted to be influenced or impacted by the sediment plume from one activity, however well removed from the other activity (i.e., influenced from trenching and spoil disposal or borrow ground dredging and backfill). Data from these locations will be used, where appropriate, to assess project

attributability of coral community effects if required. These sites will not be reactively managed.

The water quality monitoring sites shown in Figure 11-2 and Figure 11-3 will be in place for the duration of the relevant activity (trenching and spoil disposal or borrow ground dredging and backfill activities) providing spatial coverage of areas potentially affected at all times. Activity specific WQ site classification will apply on commencement of either trenching and spoil disposal, or borrow ground dredging and backfill. Note, elevations in turbidity associated with the activity are expected to be spatially confined, extending only to a small portion of the total ZoI at any point in time, given the rapid progress of the activity along the trunkline route.

Table 11-3: Water quality monitoring sites and classification per activity

Site	Ecological zone	Approximate Coordinates[41]		Water Quality Site classification	
		Easting	Northing	Trenching and Spoil Disposal	Borrow ground dredging and backfill
CONI	B	476808	7729505	Impact	Informative
CONI2[42]	B	476370	7728639	Impact	Informative
COBN	B	479515	7728801	Impact	Informative
SUP2	A	473311	7719704	Influence	Informative
KGBY	A	471969	7717955	Influence	Informative
SWIT	A	476560	7723855	Influence	Informative
ANG2	B	477519	7732026	Influence	Informative
HAUY[42]	B	495637	7739271	Informative	Influence
MIDI	A	463966	7714400	Reference	Reference
NWIT	A	477052	7725515	Reference	Reference
FFP1	B	481127	7734025	Reference	Reference
GIDI	B	478586	7736417	Reference	Reference
HAM3	B	478089	7746873	Reference	Reference
HGPT[43]	B	467093	7728731	Reference	Reference
CRTS	B	468703	7737627	Reference	Reference
LANI[43]	B	460932	7739109	Reference	Reference
LEGD	B	483562	7749562	Reference	Reference
MAL2	B	462706	7732185	Reference	Reference
MPB	Offshore	489206	7755467	Informative	Influence

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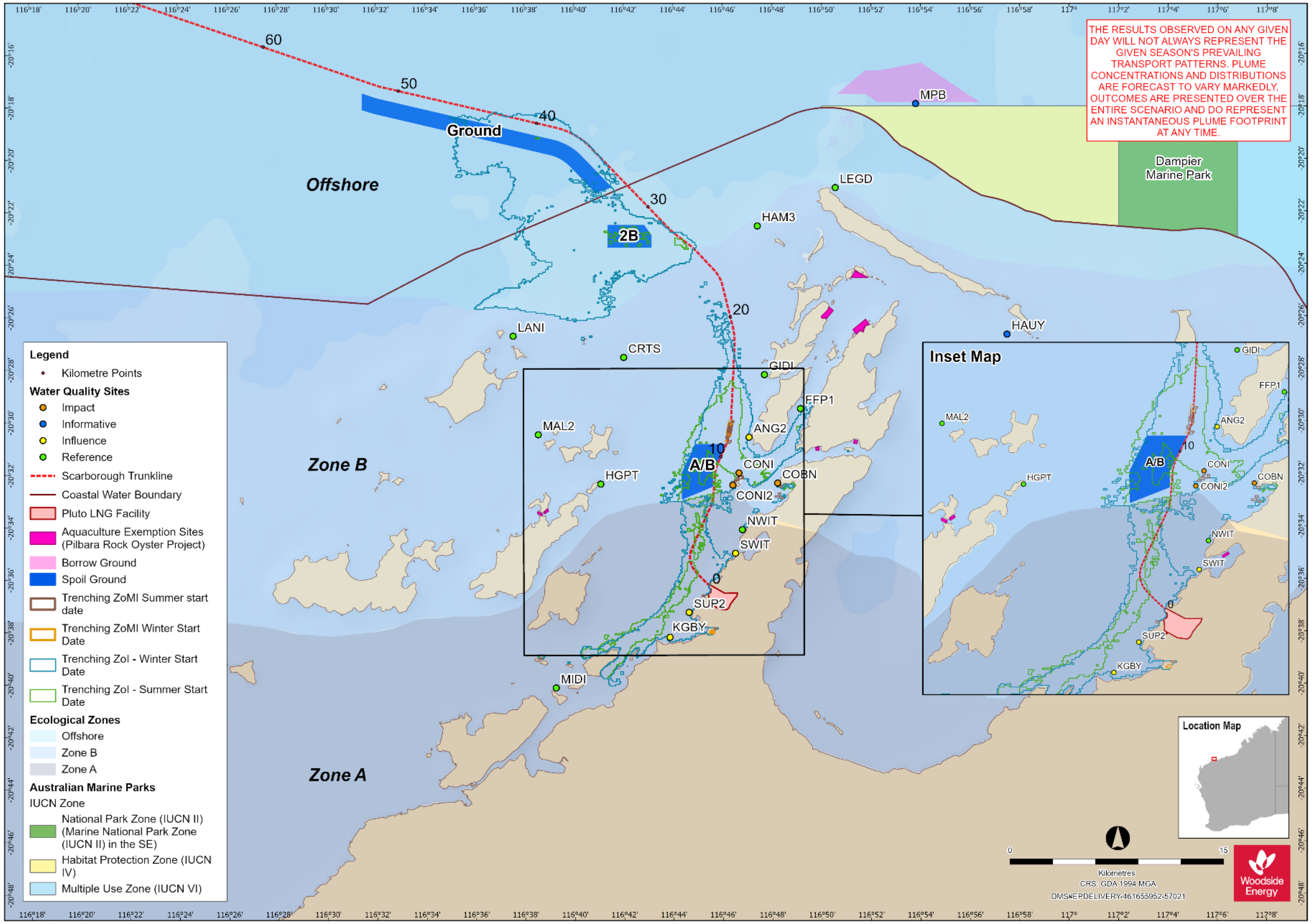
[41] Based on 2022 baseline monitoring program coordinates (where available). These are subject to change based on outcome of reconnaissance survey prior to the deployment of the monitoring systems for the construction phase~~.~~

[42] HAUY and CONI2 are new sites that have not been monitored as a part of the Pluto LNG Foundation project. As such, during the pre-dredging baseline survey the site will be assessed and where appropriate established where significant coral communities (>10% cover) exist.

[43] From Pluto LNG Foundation water quality monitoring program as not currently being monitored as a part of the 2022 baseline monitoring program. Site location subject to change as an outcome of reconnaissance survey.



THE RESULTS OBSERVED ON ANY GIVEN DAY WILL NOT ALWAYS REPRESENT THE GIVEN SEASON'S PREVAILING TRANSPORT PATTERNS. PLUME CONCENTRATIONS AND DISTRIBUTIONS ARE FORECAST TO VARY MARKEDLY. OUTCOMES ARE PRESENTED OVER THE ENTIRE SCENARIO AND DO REPRESENT AN INSTANTANEOUS PLUME FOOTPRINT AT ANY TIME.

Figure 11-2: Water quality monitoring sites for trenching and spoil disposal operations

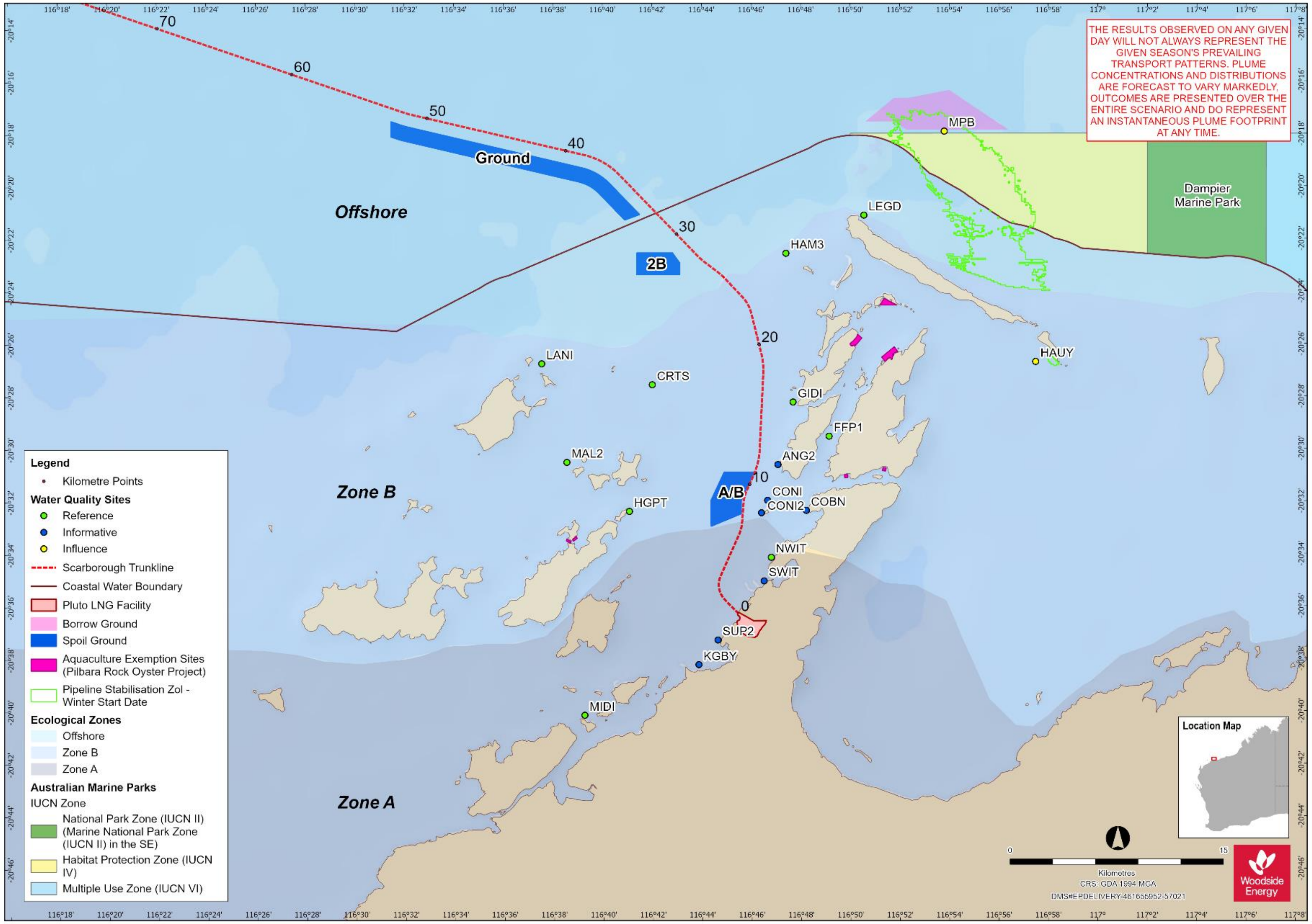


Figure 11-3: Water quality monitoring sites for borrow ground dredging and backfill operations

11.2.4 Methods

11.2.4.1 Monitoring system design

The act of deployment and retrieval of telemetered, cyclone-rated water quality instrument frames (and associated infrastructure), has the potential to cause localised damage to coral in complex reef environments, where large sand patches are not present. As such, at some locations, these systems cannot be installed in the immediate vicinity of the coral receptor, instead need to be installed at a location which offers the closest proximity to the coral communities.

The proposed water quality monitoring site locations set out in Table 11-3 broadly reflect the deployment locations (within the tolerances of vessel-based retrieval and redeployment) used during the 2022 baseline monitoring program[44]. These locations are considered appropriate to provide protection for the adjacent corals during the construction phase of the Project.

For the majority of sites, the monitoring systems will be installed within the same depth range as the adjacent reef, which may differ slightly from the measured depth at the nominated coral monitoring locations given the extent of the coral communities. The instruments will be deployed on the frames at around 0.5 to 1 m off the seabed to ensure accurate representation of the water quality (i.e., light and turbidity) conditions that are experienced by the neighbouring corals. An example of the proposed monitoring system design, which has been engineered to reduce the overall seabed footprint, is provided in Figure 11-4.

Based on learnings from the 2022 baseline monitoring program, three sites (LEGD, HAM3 and HAUY) experienced marked differences in depth between the water quality monitoring instruments and the adjacent coral communities, due to significant drop-offs (approximately >10 m) adjacent to the reef. For these sites a modified monitoring system design is proposed, which will allow robust in situ monitoring, in close proximity (i.e., within 100m) and at a depth that is more representative of the benthic receptor. An example of this alternative system is shown in Figure 12-5.

Note a reconnaissance survey is proposed prior to the deployment of the monitoring systems for the construction phase to identify any more suitable[45] locations closer to the proposed coral community sites, which is recently feasible due to an engineered change in mooring design. Where an individual site can be relocated closer to their respective coral community monitoring site, this change will not be subject to approval by the CEO. Conversely, any significant changes to site location further afield (outside of deployment tolerances) will be subject to approval by the CEO.

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[44] Note HGPT, LANI and CONI2 are new sites on recommendation of MAC and were therefore not a part of the supplementary baseline data collection.

[45] where the instruments can be safely deployed and retrieved without causing damage to the coral communities.

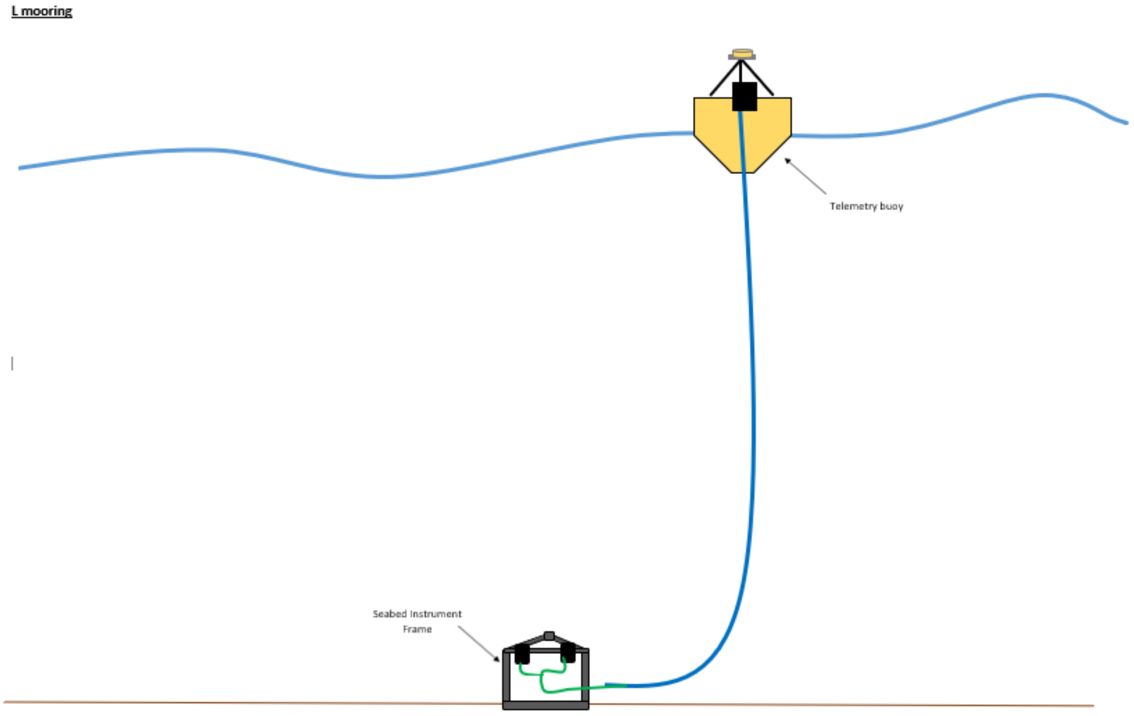

Figure 11-4: Example L mooring schematic

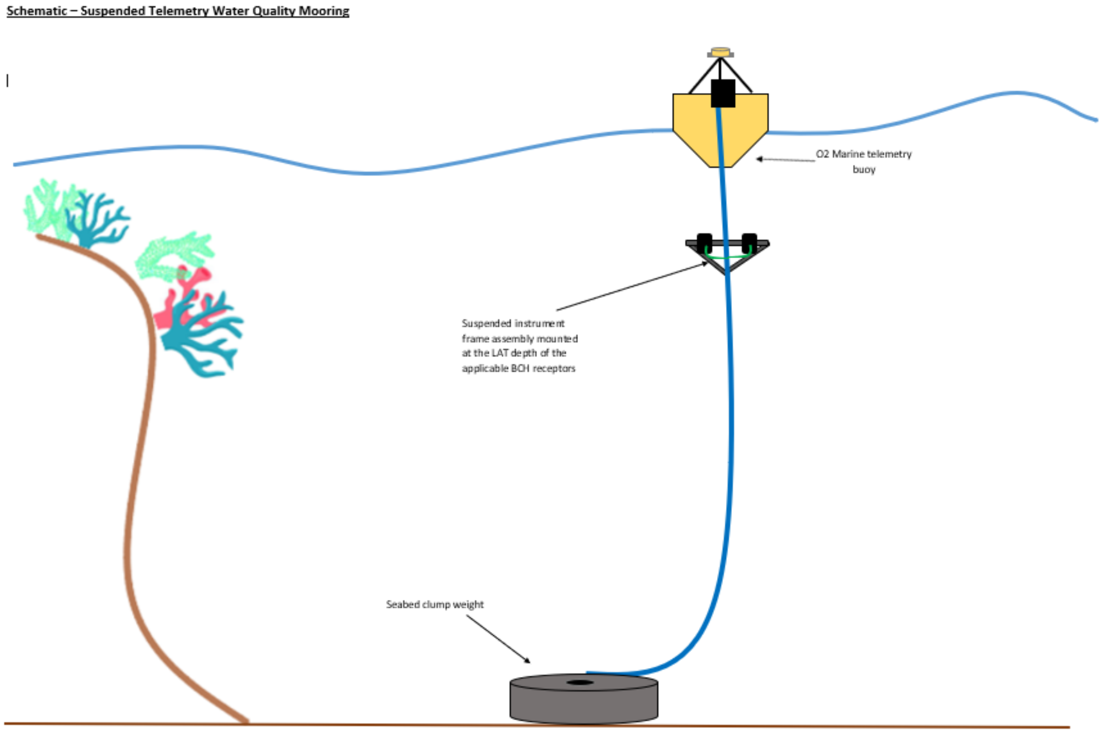

Figure 11-5: Example modified suspended mooring schematic for LEGD, HAUY and HAM3 locations (if required)

11.2.4.2 Data collection

The water quality monitoring program will be executed by a competent Monitoring Contractor. Data will be collected using single or multiparameter instruments mounted on a seabed frame.

The instruments will be programmed to record every 30 minutes at each monitoring site to provide early insight into the deterioration of water quality (natural or project-related). For the light sensors, they will likely be programmed to not record between 20:30 and 03:30 as no light is available between this period and battery and data usage could therefore be optimised. Turbidity and light data will be telemetered at appropriate frequencies to a host website, where water quality data from impact and influence sites can be compared against the tiered trigger levels as described in Section 11.2.4.5.

Servicing of the water quality monitoring instruments is expected to occur every six to eight weeks to ensure good data quality and minimise the risk of data loss, although this period may be reduced or extended based on the data recorded.

11.2.4.3 Parameters

The water quality monitoring program relies on near real-time measurements of turbidity and photosynthetic active radiation, the latter as a measure of Daily Light Integral (DLI). Turbidity can be elevated by dredging activities, which consequently reduces the light received by receptors at the seabed. Note, both the turbidity and DLI value are required to be exceeded to activate the management trigger assessment process outlined in Section 7.4.

Temperature and depth are informative parameters that will also be measured (but may not be telemetered) to provide context. These provide important environmental data that may be used in assessing a trigger exceedance and in identifying and assessing any naturally occurring impacts to benthic communities and habitats, such as thermal bleaching.

Table 11-4 lists the parameters to be measured and their associated function.

Table 11-4: Water quality parameters and units

Parameters	Units	Function
Turbidity	NTU	Reactive
Benthic light	Photosynthetic active radiation (mol photons m^{-2})	Reactive
Temperature	°C	Information
Depth	m (mean sea level)	Informative

11.2.4.4 Quality assurance and quality control

Water quality instruments will be calibrated and maintained in accordance with the manufacturer's recommendations. To manage potential loss of data due to equipment failure or fouling, there will be a maintenance schedule, with all instruments systematically retrieved, downloaded, cleaned and redeployed/replaced (as necessary) to maintain the data quality and ensure a high percentage of data collection.

Turbidity and light data are critical to managing dredging operations and will be used daily in management trigger assessments. As such, these instruments will be telemetered and uploaded to an online database at the end of each day. Therefore, any malfunctions or instrument losses and damage will be promptly identified and, if spurious turbidity or light data is observed in the recording equipment, these instruments will be repaired or replaced as soon as practicable.

The parameters of temperature and depth are used primarily to assist with the project attributability assessment; therefore, data loss is unlikely to present a significant problem provided it is minimised, where practicable, throughout the campaign.

Once collected, all data will be subject to rigorous quality assurance and quality control procedures. Before analysis and use of data in a management trigger assessment, its integrity will be checked and anomalous data will be removed from the dataset in accordance with the best practice methods (such as Jones et al., 2015b; Jones et al., 2016).

11.2.4.5 Data analysis

The analysis of water quality parameters will use best practice summary statistics and analysis techniques based on outcomes from the WAMSI DSN studies, where applicable (such as Jones et al., 2015b; Jones et al., 2016). After quality assurance and quality control, a trigger assessment will be completed. The following key steps will be followed to assess measured turbidity and light data against respective management triggers, at each impact and influence site, during the trenching and spoil disposal and borrow ground dredging and backfill activities. As stated in Section 7.4, the assessment of monitoring data against the tiered management triggers comprises two key aspects, being:

1. the comparison of measured data against the turbidity and DLI numeric values over a defined time period. Note it is the combined effects (EPA 2021b) so both NTU and DLI values are required to be exceeded to move onto Step 2.
2. A Project attributability assessment to determine if trenching and spoil disposal or borrow ground dredging and backfill activities can reasonably be expected to have contributed to or caused the exceedance (as set out in Section 7.4.3).

Both parts of the assessment are required before it can be determined that an exceedance of a management trigger has occurred.

Turbidity assessment

- A running means analysis of the quality controlled 30 min turbidity measurements will be conducted over multiple incrementing time periods.
- The running mean turbidity will be calculated based on an average of the previous N_T data points, where N_T is the number of recordings in the T day running mean. For example, for the three-day running mean (T = 3), N_T = 144 as there are 48 recordings per day based on a 30 min sampling interval. The T day running mean at a point in time t).

  Where $\overline{x}_T(t)$ is the mean calculated over the previous T days of the data from time *t*–T to time *t* days, and x_i (*t*) are the N_T data points up to and including time t (adapted from Jones et al., 2016).

  $$\overline{x}_T(t)= \frac{1}{N_T}\sum_{i=1}^{N_T} x_\text{i}(t)$$

- In the event of data loss, where less than 50% of the data points for any particular running time period were missing, the calculation will be completed on the available data, noting for a one day running mean that suggests at least one tidal period (ebb and flood) should have been captured.
- In the event of data loss, where greater than 50% of the data points for any particular running time period were missing, the running mean may be derived in a number of ways depending on the duration of data loss.

  Where more than 50% but less than 80% of data loss occurs, as relevant to the averaging period:

  - The running mean turbidity will be calculated on the available data, provided the expected maximum turbidity period based on review of previous water trends is captured.
  - Where the expected maximum turbidity period is not captured, then where possible a proximate monitoring site will be used as a surrogate.

Where greater than 80% of data loss occurs, as relevant to the averaging period:

  - Where possible a nearby monitoring site will be used as a surrogate until equipment repair/ replacement can occur. Note, even if the telemetered system is down, data in most instances will still be maintained on the logging instrument for download and analysis after repair.
  - Where not possible, a NTU breach will be assumed where the DLI trigger value has been exceeded.

- Once the site-specific running mean turbidity value for a time period has been calculated, it will be compared against the respective values in context of the defined averaging periods. Note, an exceedance only occurs where the respective DLI trigger has also been exceeded.

Daily Light Integral assessment

- Benthic light, expressed as a DLI (mol photons m^{-2} d^{-1}) will be calculated by summing the per second quantum flux measurements over a 24-hour period (Jones et al., 2019).
- Similar to the turbidity analysis, for assessment against the management triggers and to capture both acute and chronic scales, DLIs will be calculated over multiple time periods (from one-day to 14-day running mean intervals).
- In the event of data loss, where data between 10:00 and 14:00 is captured, the calculation will be completed on the available data, noting this period reflects the time when most light is received.
- In the event of greater than 50% data loss between 10:00 and 14:00, a DLI breach will be assumed where the NTU trigger value has been exceeded.

If an exceedance trigger event has occurred, Woodside in consultation with the Monitoring Consultant and Dredging Contractor (as appropriate) will complete a project attributability assessment (refer to Section 7.4.3).

11.3 Coral community assessment

11.3.1 Objective

The objective of the coral community assessment program is to provide data that will assist in determining whether the coral EPO specified in condition 6-1(1) is being or has been achieved.

11.3.2 Survey timing

The timing for coral community assessment is:

- baseline survey within six months before commencing trenching and spoil disposal activities
- reactive survey in the event of a Project-attributable Tier 3 management trigger exceedance (Section 7.4.2.3)
- post-dredging survey within three months after completing backfill activities.

11.3.3 Monitoring sites

Coral community assessment sites have been broadly paired with water quality monitoring sites (Section 11.2.2). Sites were selected, where possible, from the suite of Pluto LNG Foundation project sites with pre-existing coral community data, to allow an assessment of the variation in live coral cover over time among sites (the natural variation at sites). This allows for a reasonable estimate of the power of the monitoring program, before collecting additional baseline data.

The coral community monitoring sites have been classified as follows:

- Impact sites: are monitoring sites where modelling shows there is an intersection of the ZoMI with significant coral habitat. These sites are the key sites for the assessment against EPO 6-1(1) and will be used to determine whether there is project-attributable change to live coral cover.
- Influence sites: are monitoring sites where modelling shows there is an intersection of the ZoI with significant coral habitat. A conservative approach has been taken by categorising sites that fall just outside of the ZoI (within 200m of the boundary) as Influence sites.

  These sites may be classified as reference sites where it can be demonstrated they have not been influenced by the dredging plume. Conversely, they may be classed as impact sites if the Tier 2 management trigger is exceeded and is project-attributable.

  To ensure an appropriate statistical design for the monitoring program, it was assumed these sites were influenced. In the event monitoring data demonstrates a subset of these sites are reference, the power of the proposed monitoring program would be increased further.
- Reference sites: are representative sites which are not predicted to be impacted or influenced by the sediment plume.

Where there is evidence a plume was not present at a monitoring site or, if detected, was not at sufficient intensity, frequency or duration to have any possibility of adversely affecting corals as defined by the Tier 2 management trigger, these sites may not be monitored after ceasing backfill activities. Note, a minimum number of sites as defined by the design requirements will be monitored (refer to Section 11.3.4.1).

Table 11-5: Coral community assessment sites and function

Site	Ecological zone	Approximate coordinates[46]		Site classification (all modelling)	Monitoring history	
		Easting	Northing		Pluto	2019
CONI	B	476837	7729162	Impact	Y	Y
CONI2	B	476370	7728639	Impact	-	-
COBN	B	479487	7728716	Impact	Y	Y
SUP2	A	473437	7719662	Influence	Y	Y
KGBY	A	472497	7717671	Influence	Y	Y
SWIT	A	476529	7723696	Influence	Y	-
ANG2	B	477632	7731862	Influence	Y	Y
HAUY[47]	B	496929	7739185	Influence	-	-
MIDI	A	464008	7714219	Reference	Y	Y
NWIT	A	477059	7725275	Reference	Y	-
FFP1	B	480988	7734091	Reference	Y	Y
GIDI	B	478784	7736380	Reference	Y	Y
HAM3	B	478293	7746613	Reference	Y	-
HGPT	B	467093	7728731	Reference	Y	-
CRTS	B	469188	7736562	Reference	Y	-
LANI	B	460674	7739214	Reference	Y	-
LEGD	B	483389	7749405	Reference	Y	Y
MAL2	B	464559	7730303	Reference	Y	Y

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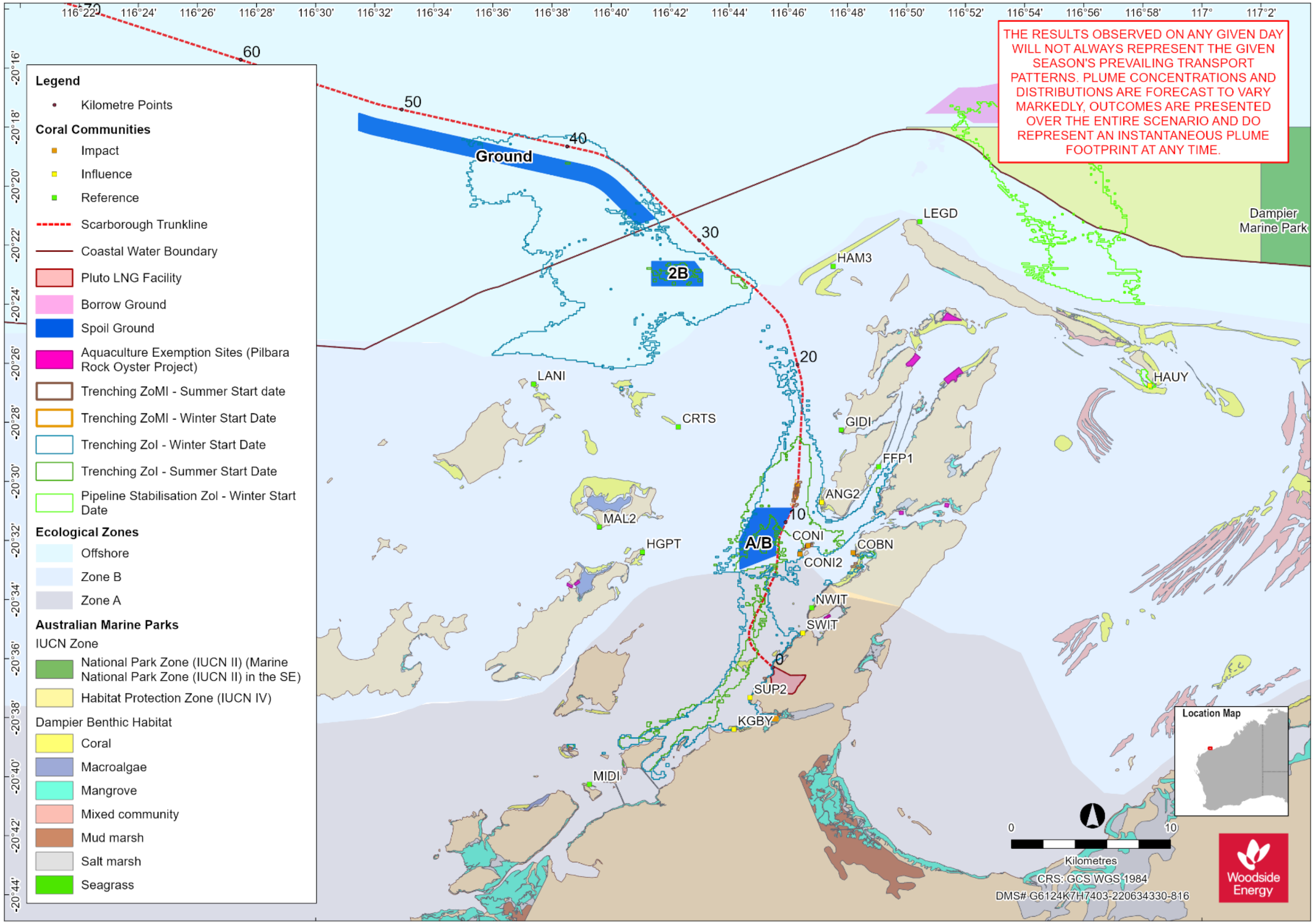
[46] Coordinates are subject to change based on site characteristics found during baseline survey.

[47] HAUY and CONI2 are new sites that have not been monitored as a part of the Pluto LNG Foundation project. As such, during the pre-dredging baseline survey, the site will be assessed and where appropriate established where significant coral communities (>10% cover) exist.



THE RESULTS OBSERVED ON ANY GIVEN DAY WILL NOT ALWAYS REPRESENT THE GIVEN SEASON'S PREVAILING TRANSPORT PATTERNS. PLUME CONCENTRATIONS AND DISTRIBUTIONS ARE FORECAST TO VARY MARKEDLY, OUTCOMES ARE PRESENTED OVER THE ENTIRE SCENARIO AND DO REPRESENT AN INSTANTANEOUS PLUME FOOTPRINT AT ANY TIME.

Figure 11-6: Coral community assessment sites

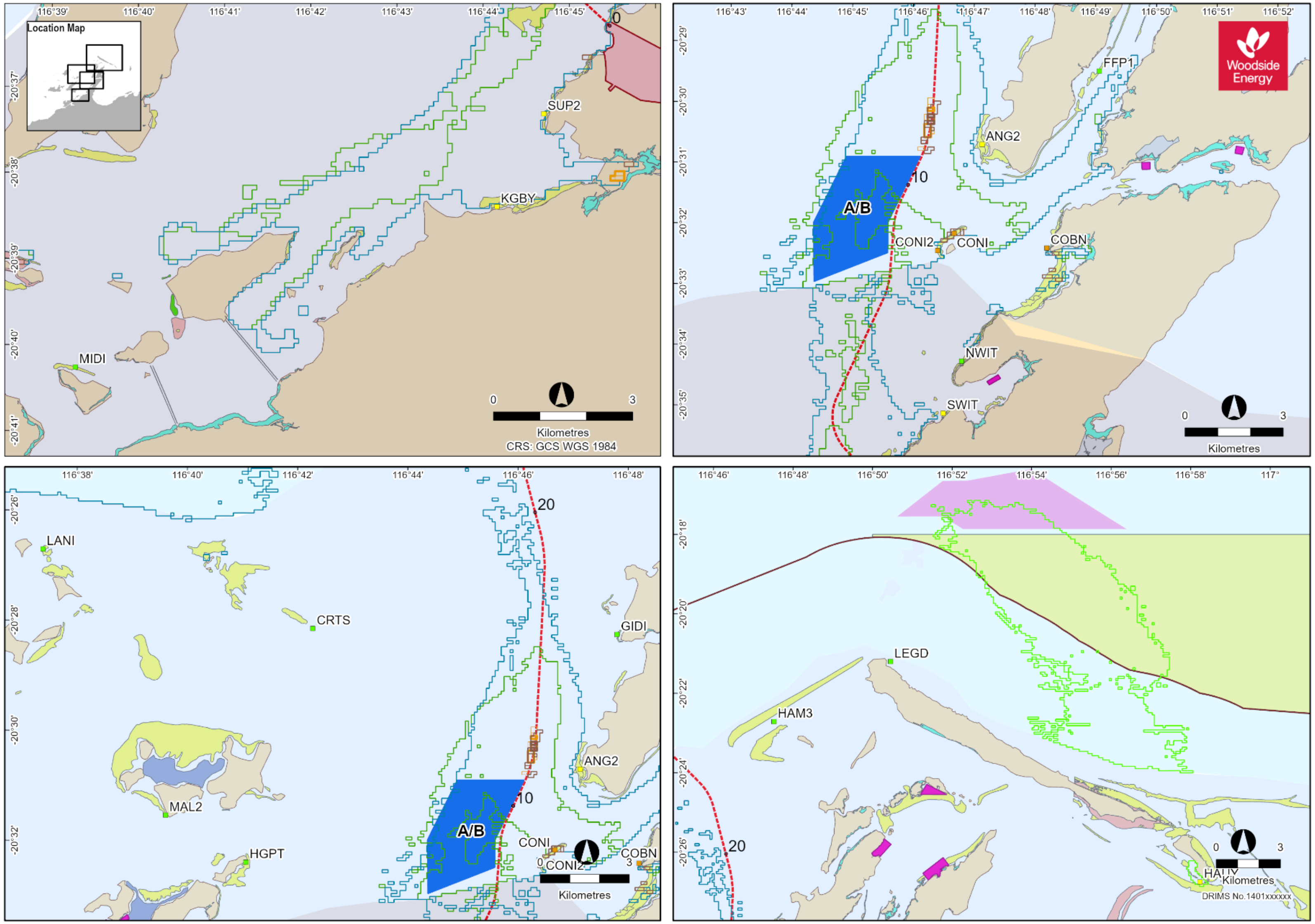


Figure 11-7: Coral community assessment sites (zoomed in)

11.3.4 Methods

11.3.4.1 Monitoring design

The monitoring program has been designed to detect net changes in live coral cover at impact monitoring sites, which are significantly different from natural changes occurring concurrently at reference sites. The statistical design has considered how much coral cover changes naturally from time to time and how that varies among different sites. As detailed in Section 11.3.3, sites were selected where possible from the suite of Pluto LNG Foundation project sites with pre-existing coral data, to allow an assessment of the variation in live coral cover over time among sites (the natural variation at sites). This allows for a reasonable estimate of the power of the monitoring program, before collecting additional baseline data.

A power analysis was completed for testing for a change in coral cover (Δ Coral Cover) along each transect between two periods (Before and After) then comparing the average of those transect changes at the impact site against the average across reference sites. Using fixed transects the program has been designed to detect lower absolute changes at an effect size of 13% at an appropriate level of power (0.8).

The proposed monitoring design is based on eight reference sites, and the collection of five fixed ten meter transects at each monitoring site, before and after dredging. The program is sufficiently robust to detect significant change in coral cover, for the following reasons:

- Five transects allows for contingency, as three transects provides similar return in terms of effect size, while any more than five transects has negligible returns in detecting smaller effects sizes.
- Eight reference sites allows contingency, given five reference sites still has power (0.8) to detect an effect size <15%. Further, at eight reference sites any further addition of reference sites provides only a diminishingly small increase in power/smaller effect size.

11.3.4.2 Data collection

The fixed transects will be collected using high resolution georeferenced cameras attached to a fit for purpose ROV (or similar technology) or hand-held by divers. Both methods allow robust data collection and repeatability of fixed transects.

In addition, as coral community assessments are only required pre- and post- dredging, in addition to a Tier 3 project attributable exceedance, the aim will be to plan surveys primarily on neap tides, in favourable conditions to ensure optimum visibility to facilitate quality data capture.

11.3.4.3 Parameters

The coral EPO described in condition 6-1(1) is described in terms of no detectable net reduction of live coral cover at any of the coral impact monitoring sites attributable to the Proposal. As such, the primary variable that will be examined will be change in percentage live coral cover.

During image processing, however, a wide range of abiotic categories (such as sediment cover, bare substrate) and biological stressors (such as bleaching, mucous) may also be scored to assist in inferring the potential drivers of any detected change in live coral cover. Each of these parameters will be available for quantitative, semi-quantitative or qualitative assessment. This data, along with the water quality data, will assist with interpreting the drivers in any observed change in coral cover.

11.3.4.4 Image analysis

Coral cover will be recorded from the transect, with a series of 30 overlapping digital still images taken at a fixed distance to provide an image of around 0.5 m by 0.7 m. A video of the transect will also be recorded. Coral will be scored using the CPCe software package or similar. Cover will be estimated for each transect by scoring a set of 30 points applied in a stratified random design to each of the 30 recorded images. An assessment of live coral cover, bleached coral and coral diversity at each site will be recorded.

11.3.5 Assessment against Environmental Protection Outcome 6-1(1)

11.3.5.1 Data analysis

After either a Tier 3 project-attributable exceedance (refer to Section 7.4.2.3) or at the completion of the backfill activities, a coral survey at the relevant sites will be completed. The survey will follow the coral monitoring design set out in Section 11.3.4.

To determine whether there has been a detectable reduction of net live coral cover at impact sites and whether or not project activities are reasonably considered to have caused or contributed to the impact the key steps outlined in Table 11-6 will be followed.

Table 11-6: Key steps for assessment against Environmental Protection Outcome 6-1(1)

Steps		Details
1	Water quality analysis and assessment of site function	Influence sites may be classified as reference sites where it can be demonstrated they have not been influenced by the dredging plume. Conversely, influence sites may be classed as impact sites if the Tier 2 management trigger is exceeded (project-attributable).
2	Record and assess the changes in coral cover at each site	Calculation of Δ Coral Cover during dredging for each transect within sites, then determine the average change (loss) in cover across the replicate transects at each site. For each transect in each site, Δ Coral Cover is calculated as the percentage cover in the After period is subtracted from that recorded in the transect in the Before period. Note, Δ Coral Cover is the simple arithmetic difference in percentage cover on a transect between the Before and After periods, regardless of the level coral cover at the site. It can be positive (less cover after dredging than before) or negative (more cover after dredging than before) loss. The average loss at a site (Average Δ Coral Cover) is then the average of the changes in cover across the replicate transects at that site. Average Δ Coral Cover during dredging is then similarly calculated within each of the reference sites. Those estimates of Average Δ Coral Cover are then further averaged across the reference sites as (mean) estimate of Average Δ Coral Cover at a site in the absence of dredging influence. Net loss in coral cover is then the Average Δ Coral Cover in the impact site minus the mean estimate of Average Δ Coral Cover across the reference sites.
3	One-sided F-test: Test if net loss at impact site is significantly greater than changes at reference sites	Formal test to determine whether there has been a detectable reduction of net live coral cover at impact sites. If not significant = unsupportive of impact hypothesis H_{Impact}: $\textit{Coral Cover Loss}_{\textit{Impact Site(s)}} > \textit{Coral Cover Loss}_{\textit{Reference Sites}}$ Sampling uncertainty is taken into account during statistical testing by contrasting the magnitude of the net loss in coral cover with the (natural) variation seen among reference sites in Average Δ Coral Cove, using a 'beyond BACI' (Underwood 1997) approach.
4	Attributability assessment	Uses multiple lines of evidence, based on causal criteria, to assess the impact hypothesis. Refer to Section 11.3.5.2 for details.

11.3.5.2 Project attributability assessment

Where a detectable reduction of net live coral cover at impact sites is recorded, an attributability assessment will be completed, in consideration of a range of criteria, including those provided in Table 11-7.

Table 11-7: Coral community assessment project-attributability criteria

Criteria	Natural-related cause	Potential dredging-related cause
Water quality – primary Elevated turbidity and associated decrease in benthic light associated with dredging is a potential source of mortality	Water quality thresholds have not been exceeded at the impact site where there is a significant loss of live coral cover. The coral impacts occurred before exposure to increased levels of change in water quality or sufficiently long after to reject any lag effects. Sites exposed to longer durations of higher exposure show lower losses, indicating another causal factor could be responsible for the impact.	Water quality thresholds have been exceeded at the site showing impacts but have not been exceeded at sites where no impact is observed. Sites which have been exposed to longer durations of high exposure have suffered higher losses.
Water quality – other Change in informative parameters likely to have contributed to coral mortality	The remote sensing imagery does not show plumes reaching the impacted sites during or preceding the impact. <u>Thermal stress</u> Coral shows a response linked to an increase in water temperature, indicating thermal stress. The impacts will be generally widespread but may be more prevalent in shallower water, where temperatures are likely to be higher or exposure more prolonged. <u>Increased energy</u> Physical damage or smothering of coral after high-intensity weather events.	Remote sensing imagery shows a clear evidence of a plume in the areas impacted. The abundance of bleached, dead or smothered coral at the monitoring sites increased after exposure to increased levels of turbidity from the dredging activity. Reference sites (if available) showed no similar effects.
Gradient of effect Relationship between dose and effect and distance from activity	<u>General</u> Stress or mortality occurred at random or widespread sites not linked to distance from the dredge, including at reference sites. <u>Increased energy</u> Generally widespread impact but could show increased localised effect in exposed and shallower areas. <u>Disease, predation, grazing and pollution</u> Highly localised impact within impact site or reference site. Signs of damage to surrounding habitats. Evidence of predators, including feeding scars. A ‘particularly large’ change in the response variable is observed with impact severity, and distribution could be linked to a periodic or unusual natural or anthropogenic event (‘pollution event’).	The proportion of stress or mortality observed at sites decreases with increasing distance from the dredge or disposal site. Impacts are not observed in the reference sites (if available). An appreciably large amount of dead and smothered coral within the ‘active plume’ area. The proportion of dead to live coral is higher than would be expected after natural change. No unusual natural events occurring in the preceding period (cyclones).
Experimental evidence	The observed effects are not known to occur as a result of dredging based on literature, including WAMSI DSN outcomes.	The observed effects were predicted at some level during the impact assessment phase. The impacts correspond with the results of modelling predictions.

11.3.5.3 Response

Where results of a reactive coral community survey demonstrate EPO 6-1(1) is no longer being achieved (i.e., there has been a detectable net reduction of live coral cover at a coral impact monitoring location attributable to the Proposal), then the relevant contingency management action will be implemented, as follows:

- Where a Tier 3 management trigger is still being exceeded as a result of the Project, then contingency management actions as set out in Section 7.4.4.2 will continue to be implemented until water quality returns to below the Tier 2 turbidity trigger.

- Where water quality monitoring results suggest turbidity is already below the Tier 2 trigger value (or once it does as a result of actions above) then risk to the coral community has been managed. However, to limit the potential for further reduction of live coral cover at the impact site, stricter measures will be adopted. Specifically, contingency management actions will be implemented in the event of a Project attributable Tier 2 trigger (rather than responsive actions) to avoid reaching Tier 3.

Conversely where there has been a Tier 3 Project-attributable exceedance with no impacts detected, the appropriateness of the trigger value will be investigated. If a change to the Tier 3 management trigger is deemed necessary, a report will be provided to DWER and approved prior to the adoption of the revised trigger value.

In the event EPO 6-1(1) is no longer being achieved, reporting shall be undertaken in accordance with Section 12.5. An investigation as to the likely cause will be completed and reported as per Section 12.5.2.

11.4 Other informative monitoring

11.4.1 Dredge plume assessment

A dredge plume assessment is proposed for the TSHD trenching and spoil disposal operations, which represent the greatest risk activity with regard to the dispersion of suspended sediment based on dredge plume modelling described in Section 6. This assessment has been included specifically on request by MAC.

11.4.1.1 Objective

The objectives of the dredge plume assessment are as follows:

1. To determine the distance from the TSHD at which turbidity associated with the trenching and spoil disposal operations returns to background levels.
2. To validate the dredge plume modelling related to TSHD sediment losses.
3. To collect supplementary data to provide confidence that there are no contaminants of concern being mobilised by the activity based on the highest risk area as an indicator.

11.4.1.2 Survey timing

A sampling event is planned to be conducted:

- During trenching activities undertaken approximately between KP0.8 and KP4.5, where the sediment typically includes a higher fines content (i.e., greatest potential plume extent), and in the nearshore area where greatest anthropogenic input of potential contaminants of concern would be expected.
- Assessment of disposal activities at Spoil Ground 2B.

Data collection for both activities is proposed to be undertaken on a representative day during a spring tidal cycle to capture the greatest plume extent.

11.4.1.3 Survey Method

Water quality profiles

To confirm the prevailing surface currents and thus the expected trajectory of the dredge plume, a drifter buoy (or similar) will be deployed prior to commencement of sampling. Once the prevailing current has been determined, sampling will be completed to determine the background turbidity levels upstream. This will consist of a minimum of three turbidity casts at representative locations upstream, and well removed from the trenching or disposal activity (example in Figure 11-8). Casts of the water column will be completed using a calibrated multiparameter instrument with turbidity and depth sensors (or similar such as acoustic doppler current profiler (ADCP)).

To determine the spatial extent of the dredge plume under representative conditions, water quality profiles will then be collected downstream along three transects radiating out from the TSHD (while trenching) with casts completed approximately every 100 m. Transect 1 aligns with the direction of the dominant current (as determined by the drifter buoy (or similar)) downstream of the TSHD. Transects 2 and 3 should be completed at around 45 degrees from the prevailing current. For transects 1 to 3, water quality profiler casts will continue along the pre-determined bearing from the TSHD until water quality is observed to return to background levels.

Water quality sampling

To establish a site-specific NTU-TSS (nephelometric turbidity unit – total suspended solids) relationship and allow TSS measurements to be directly related to turbidity profiles, TSS water samples will also be collected at multiple depths. If an ADCP is being used to infer turbidity instead of a through-water sensor cast, TSS data will be used to calibrate the backscatter signals.

Further based on MAC consultation outcomes, water samples will also be collected at each cast location for the analysis of potential contaminants of concern[48] (including the required additional samples to meet laboratory quality control and assurance requirements).

Aerial imagery

To support the in-situ sampling, aerial imagery will be captured during the survey, using a drone (or similar), to provide an understanding of aerial extent of the surface suspended sediment plume and inform sampling effort. The distance from the TSHD at which turbidity associated with the trenching and disposal operations returns to background levels will then be determined by assessing the turbidity profiles and aerial imagery in context of the operation.

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[48] It is noted that sediment sampling along the proposed pipeline route has demonstrated sediments are suitable for unconfined ocean disposal, with results indicating all levels of potential contaminants of concern were below the NAGD (2009) screening levels, which was further supported by more recent studies as detailed in Section 4.2.2. Therefore, sediments to be dredged (and suspended during operations) are considered to be uncontaminated.

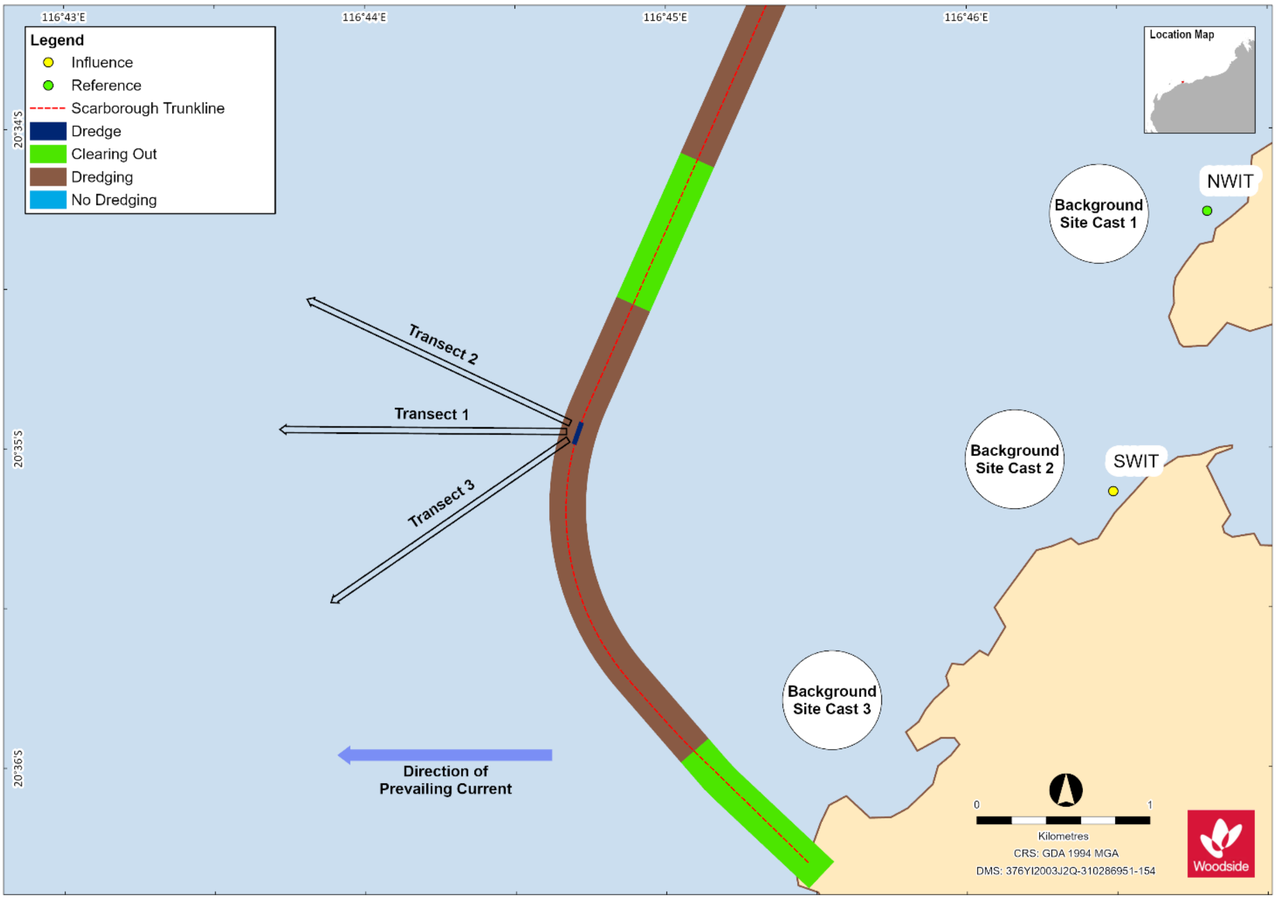

Figure 11-8: Example of dredge plume assessment sampling locations

11.4.1.4 Model validation method

To confirm the appropriateness of the model prediction, a hindcast model run will be completed based on the dredging activity at the time, as well as prevailing metocean conditions. The outputs of the hindcast model results will then be compared to the measured in field turbidity data (converted to SSC mg/L) (as described above) to verify the validity of the assumptions made in the simulations of TSHD sediment losses.

Outcomes of this assessment may be used when reviewing multiple lines of evidence to determine Project attributability of a site-specific water quality exceedance.

11.4.1.5 Assessment of potential contaminants of concern

Analyses will be completed by a National Association of Testing Authorities (NATA) accredited laboratory, capable of meeting the required practical quantitation limits (also referred to as limits of reporting). The suite of analytes to be tested includes:

- dissolved trace metals (Cu, Pb, Zn, Cr, Ni, Cd, Hg, As, Ag, Al, Fe and Sb).
- total recoverable hydrocarbons (TRH C6-C14; TRH C15-C36)
- tributyltin (TBT)

The results will be assessed against the following:

- The toxicant default guideline values for water quality in aquatic ecosystems (ANZECC & ARMCANZ 2019). This will be either the 95% or 99% species protection as relevant to the levels of ecological protection in Mermaid Sound, and how the guideline value was derived (Environmental Protection Authority, 2019).

- Where guideline values are not specified in ANZECC & ARMCANZ (2019) then results will be assessed against other relevant literature (e.g., CSIRO 2006).
- Where the guidelines values are being exceeded, results will then be compared against appropriate background data. This is particularly relevant where there is evidence of elevated natural concentrations (e.g., Arsenic and Nickel).

In terms of risk to the receiving environment, the assessment will consider weight of evidence to make an overall assessment with outcomes to be documented.

11.4.2 Remote sensing data

To provide a broader spatial resolution and to supplement the near real time monitoring of turbidity, remote sensing data will be obtained on a regular basis to capture the spatial extent of any visible surface suspended sediment plumes.

Visible Infrared Imaging Radiometer Suite (VIIRS) sensor will be the primary remote sensing platform for frequent image capture, which may be supplemented during periods of high activity by higher resolution (albeit reduced frequency) platforms such as Sentinel 2 imagery. VIIRS images will be collected daily where satellite platforms and environmental conditions allow, noting these images do not penetrate cloud cover.

The data will be downloaded as available, and the images interrogated to assess the dispersion of sediment plumes around the area of dredging and disposal. Total suspended solids (TSS) algorithms may be applied to allow interrogation of absolute TSS level (both natural and anthropogenic influences).

This data will be used to provide context to the project attributability of any elevated turbidity levels observed at the site-specific monitoring locations.

When there are visible plumes during trenching and spoil disposal, remote sensing images will be uploaded on the Project website when appropriate to allow recreational users and other stakeholders to identify where elevated turbidity may be occurring.

12 Implementation strategy

This section describes the implementation strategy, including roles and responsibility, inductions and training and internal and external reporting.

12.1 Roles and responsibility

Woodside and its Contractors will assign suitable resources to oversee the implementation of this DSDMP. Key roles and responsibilities are summarised in Table 12-1. Where responsibility is assigned to a role, the task may also be performed by a suitable delegate.

Table 12-1: Key roles and responsibilities in context of the DSDMP

Role	Key Responsibility
Woodside Project Manager	• Manage the activity so it is undertaken as per the relevant standards and commitments in this DSDMP. • Communicate with the Contractor • Notify the Woodside Environment Adviser of any scope changes in a timely manner. • Liaise with regulatory authorities as required. • Review this DSDMP as necessary and manage change requests. • Confirm all project and support vessel crew members complete an HSE induction. • Verify that contractors meet environmental related contractual obligations. • Approve proposed responsive or contingency management actions to be implemented in the event of a project-attributable Tier 2 or Tier 3 exceedance • Confirm environmental incident reporting meets regulatory and Woodside requirements. • Monitor and close out corrective actions identified during environmental monitoring or audits
Woodside Environment Advisor	• Verify relevant Environmental Approvals for the activities exist prior to commencing activity. • Review and approve the Contractor's Environmental Management Plan • Track compliance with the inforce DSDMP and applicable environmental approvals • Oversee execution of the proposed monitoring program • Assist with the review, investigation and reporting of environmental incidents. • Ensure environmental monitoring and inspections/audits are undertaken as per the requirements of this DSDMP. • Liaise with relevant regulatory authorities as required. • Perform external reporting of any environmental incidents/events • Monitor and close out corrective actions identified during environmental monitoring or audits. • Provide advice to relevant Woodside personnel and contractors to assist them to understand their environment responsibilities. • Liaise with contractors to ensure communication and understanding of environment requirements as outlined in this DSMDP
Woodside Corporate/ Indigenous Affairs Advisor	• Perform ongoing consultation with stakeholders throughout the Project • Perform ongoing consultation with traditional custodian groups throughout the Project
Woodside Client Representative	• Oversee implementation of the in force DSDMP in the field • Participate in health, safety and environment (HSE) inspections and audits • Participate in HSE incident investigations

Role	Key Responsibility
Construction Contractor	• Comply with the requirements set out in this DSDMP • Ensure all personnel are aware of their responsibilities under this DSDMP through a training and induction program • Investigate and propose effective responsive or contingency management actions for implementation, where required • Implement responsive or contingency management action on direction from Woodside • Participate in HSE inspections and audits • Report on HSE non-compliances and incidents • Participate in HSE incident investigations • Ensure personnel are competent to undertake the work they have been assigned. • Ensure vessels and equipment are appropriately maintained and operated to prevent risk of environmental incidents • Provide IMS risk assessment information and implement any required mitigation measures • Ensure oil spill preparedness and response activities relating to vessel risks and regular drills and exercises are performed • Ensure hydrographic surveys are performed before and after dredging activities • Establish and maintain clear communication with PPA
Marine Fauna Observer (Contractor)	• Complete designated marine fauna observation training • Monitor for marine fauna within the defined observation and exclusion zones before and during the relevant activities • Maintain records of marine fauna observations
Monitoring Contractor	• Implement the environmental monitoring programs as described in Section 11.

12.2 Inductions and training

12.2.1 Health, safety and environment induction

Inductions are provided to all relevant personnel (e.g., contractors and Company representatives) before mobilising to or on arrival at the activity location. The induction covers the HSE requirements and environmental information specific to the activity location. Attendance records will be maintained.

Contractor is required to prepare an HSE induction to be reviewed and approved by Woodside before commencing the activities. Each person working on the Project will be required to complete this induction before commencing works onsite and records will be maintained.

The environmental content of these inductions will cover information such as:

- description of the activity
- ecological and socio-economic values of the activity location, including the environmental and cultural values of the Dampier Archipelago
- DSDMP importance/structure/implementation/roles and responsibilities.
- Key environmental aspects/hazards and potential environmental impacts and related performance outcomes.
- general awareness of management measures for marine environmental quality, including waste, chemical and hydrocarbons and spills, benthic communities and habitat, and protected marine fauna
- reporting of environmental non-compliances and incidents.

12.2.2 Marine fauna observer training

Relevant crew onboard the applicable vessels will complete MFO training prior to undertaking the role and commencing activities. Woodside and Contractor personnel will be trained to deliver the MFO training ('train-the-trainer' model) by an external organisation specialising in marine environmental training, with expertise in marine fauna observations. Training materials will be developed by the external organisation in consultation with Woodside, to ensure Project specific information is incorporated. The bespoke training package will cover:

- An overview of Project activities and the marine megafauna that may be present during these activities
- An overview of the potential impacts and risks to marine megafauna
- An overview of controls and management procedures relevant to marine megafauna presence
- The role and responsibilities of MFOs
- The observation and reporting requirements.

When trained crew are undertaking observations, expectations are that:

- Observation equipment / tools are used as required (i.e., range-finding binoculars, marine megafauna ID prompts etc.)
- Escalation process carried out if marine megafauna are identified including alerting bridge crew so that appropriate response can be initiated
- Make and maintain records including the date, time and approximate distance from the vessel, and the action taken to comply with relevant controls set out in **Section 9**.

Records will be maintained as evidence of the personnel who have completed MFO training.

12.3 Inspections and reviews

Compliance with this DSDMP will be monitored through inspections and reviews as described in Table 12-2. Results will be communicated to the Woodside Project Manager, and any required closeout actions will be monitored to ensure timely rectification of any issues. Follow-up inspections will monitor any closeout actions from previous inspections.

Table 12-2: Inspections and reviews

Description	Timing	Purpose	Responsibility
Dredge vessel and pipelay vessel pre-mobilisation and readiness audit	Before mobilising to site and commencing activities	Confirm vessel readiness and compliance with requirements of this DSDMP	Woodside and Construction Contractor
Environmental Inspection	BHD trenching (one) TSHD trenching (one) TSHD backfill (one) Rock placement (one) SWLB pipelay (one) DPIV pipelay (one)	Confirm compliance with the DSDMP	Woodside and Construction Contractor
HSE reviews	Monthly	Complete compliance monitoring during dredging and backfill activities to ensure activities are being performed as per this DSDMP	Woodside and Construction Contractor
Water quality monitoring	Data review throughout turbidity-generating activities	To assess compliance against the tiered management triggers in Section 7.4	Woodside and Monitoring Contractor

12.4 Management of Non-conformance

Woodside classifies non-conformances with EPOs and management targets in this DSDMP as environmental incidents. Woodside employees and contractors are required to report all environmental incidents, and these are managed as per Woodside's internal event recording, investigation and learning requirements.

An internal computerised database called First Priority is used to record and report these incidents. Details of the event, immediate action taken to control the situation, investigation outcomes and corrective actions to prevent reoccurrence are all recorded. Corrective actions are monitored using First Priority and closed out in a timely manner.

12.5 Reporting

12.5.1 Internal reporting

12.5.1.1 Construction Contractor

Progress reports for activities will be prepared and issued to key support personnel and stakeholders, by relevant managers. The report provides performance information about seabed intervention and trunkline installation activities, heath, safety and environment, and current and planned work activities.

Meetings between key personnel are used to transfer information, discuss incidents, agree plans for future activities and develop plans and accountabilities for resolving issues.

Routine internal reporting between Woodside and the Construction Contractor will be completed. These reports will include the following where applicable to the scope:

- daily logs
- weekly plotting sheets or a certified extract of the ships log detailing disposal activities (as set out in Table 8-1)
- vessel track plots (dredging and support vessels)
- marine fauna observations and management measures implemented (as set out in Table 9-1)
- summary of any spills or other potential environmental incidents
- inspection outcomes and status of actions
- other matters relating to compliance with approval requirements.

Internal reports, where applicable, will address the relevant requirements set out in environmental management frameworks (Table 7-3, Table 8-1 and Table 9-1).

Regular dedicated HSE meetings will be held with the Site-based and Perth-based management and advisers to address targeted HSE incidents and initiatives. Minutes of these meetings will be produced and distributed as appropriate.

All incidents, non-compliances and near misses related to the activities described in Section 3 will be reported to Woodside by the Construction Contractor, with these documented and investigated as appropriate. Any associated preventive or corrective actions will be tracked to closeout by the Construction Contractor and verified by Woodside.

12.5.1.2 Monitoring contractor

Routine internal notification and reporting between Woodside and the Monitoring Contractor will also be completed. These reports will include:

- near real-time water quality data from sites daily to support tiered management trigger assessment (notification) (Section 7.4.2)
- trenching and spoil disposal water quality monitoring report
- borrow ground dredging and backfill water quality monitoring report
- baseline coral community assessment report
- reactive coral community survey reports (if required)
- post-dredging coral community assessment report.

Reactive and post-dredging coral community assessment reports to be provided by the Monitoring Contractor as soon as practicable but not exceeding 40 business days. These reports will include an assessment against EPO6-1(1) as described in Section 11.3.5 to determine whether the EPO is being achieved. As required by Condition 6-7, where the relevant EPO is determined to not be achieved the applicable reporting as set out in Table 12-3 will be completed.

12.5.2 External reporting

The external reporting requirements and responsibilities as they pertain to exceedances, incidents and non-compliances and other regulatory reporting are described in **Table 12-3** and

Table 12-4.

Table 12-3: External reporting: non-compliances, incidents, risks and exceedances

Description	Responsibility	Report	Timeframe	Permit
Any potential non-compliance with Ministerial Statement No. 1172.	Woodside	CEO	Seven days of non-compliance being known	Ministerial Statement No. 1172
Notification of non-compliance with Environmental Protection Outcomes (EPO) required by condition 6-1.	Woodside	CEO	24 hours of determining that any EPO is not being achieved	Ministerial Statement No. 1172
Report detailing: • the results of the monitoring which led to the determination that any EPO is not being achieved • the investigation being performed as required by condition 6-7(2) • any notification and contingency management actions implemented by the proponent.	Woodside	CEO	Seven days of determining any EPO is not being achieved	Ministerial Statement No. 1172
Report detailing the findings of the investigation required by condition 6-7(2).	Woodside	CEO	21 days of determining any EPO is not being achieved	Ministerial Statement No. 1172
Environmental incident occurs or an environmental risk identified during trenching and spoil disposal. Notification to include details of the incident or risk, the measures taken, the success of those measures in addressing the incident or risk, and any additional measures proposed to be taken.	Woodside	DAWE	72 hours of becoming aware	In-force Sea Dumping Permit (No. SD2019/3982 or amended)

Description	Responsibility	Report	Timeframe	Permit
Injury or death to any marine species[49] during trenching and spoil disposal. Notification to include the date, time and nature of each incident and the species involved, if known, must be recorded.	Woodside	DAWE	72 hours of becoming aware	In-force Sea Dumping Permit (No. SD2019/3982 or amended)
Injury or mortality to marine turtles during dredging, spoil disposal and backfill activities. Notification via Injured or Abandoned Fauna Notification Form and submit to wildlife.protection@dbca.wa.gov.au and WA Marine Turtle Stranding Form and submit to turtles@dbca.wa.gov.au.	Woodside/ Contractor	DBCA	24 hours of becoming aware	DSDMP
All vessel strike incidents with whale sharks during dredging, spoil disposal and backfill activities. Notification to the Conservation Operations Officer – Whale Sharks through email; whale.shark@dbca.wa.gov.au or phone (08) 9947 8000.	Woodside/ Contractor	DBCA	24 hours of becoming aware	DSDMP
Notification of incidents that result in pollution or material environmental harm.	Woodside/ Contractor	PPA	As soon as practicable	DSDMP

Table 12-4: External reporting – other

Description	Responsibility	Regulator	Timeframe	Permit
Contemporary baseline water quality report (Winter 2022), which includes: • details around the monitoring sites and monitoring approach, and • an assessment of the contemporary baseline water quality data against historic Pluto LNG Foundation data in order to determine whether current 1.5 multiplier is appropriate or if a new multiplier should be derived and applied between Ecological Zones A and B[50].	Woodside	DWER	Prior to the commencement of dredging (TSHD or BHD)	N/A
Bathymetry survey Provide a digital copy of the bathymetric surveys to the Australian Hydrographic Office (AHO), via email atdatacentre@hydro.gov.au.	Woodside	AHO	Within two months of the final bathymetric survey	In force Sea Dumping Permit (No. SD2019/3982 or amended)
Bathymetry report Provide a report on the bathymetry to DAWE. The report must include a chart showing the change in sea floor bathymetry as a result of dumping activities and include written commentary on the volumes of dumped material that appear to have been retained within the disposal site.	Woodside	DAWE	Within three months of the final bathymetric survey	In force Sea Dumping Permit (No. SD2019/3982 or amended)

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[49] Marine Species means all whales, dolphins, dugongs and marine turtles listed under the EPBC Act 1999.

[50] Any proposed changes to the multiplier applied between Ecological Zone A and B will be submitted to DWER for approval prior to implementation.

Description	Responsibility	Regulator	Timeframe	Permit
To facilitate annual reporting to IMO, Woodside must report to DAWE by 31 January each year, including on the day of the expiry of the permit or completion of all dumping activities under the permit, information at Appendix 2 to the permit, or in a format as approved by DAWE from time to time.	Woodside	DAWE	By 31 January each year	In force Sea Dumping Permit (No. SD2019/3982 or amended)
Reporting on Marine Fauna Management Measures Within one month of commencing the action, Woodside must report to DAWE on the progress in implementing the marine fauna control measures as described in the referral decision.	Woodside	DAWE	Within one month of the commencement of the action	EPBC 2018/8362
Annual Compliance Assessment Report, which includes: • all monitoring data and reportable incidents defined in this DSDMP • an analysis and interpretation of monitoring data to demonstrate compliance with the EPOs • an assessment of the effectiveness of monitoring, management and contingency measures implemented to ensure compliance with the EPOs.	Woodside	DWER (publicly available)	Annually	Ministerial Statement No. 1172

12.5.2.1 Exceedance reporting

In the event of an exceedance of management triggers as a result of the Project, MAC will be notified and public notifications made via a project website. These notifications are described in Table 12-5.

Table 12-5: Exceedance reporting

Description	Responsibility	Mechanism	Timeframe	Permit
Details of exceedances of management triggers as a result of the Proposal and contingency actions implemented	Woodside	Notification on project website Notification to MAC Notification to PPA	As soon as practicable	Ministerial Statement No. 1172
Public notification where marine recreational values are likely to be impacted as a result of the dredging, spoil disposal or backfill activities, as indicated by a Tier 3 Project attributable exceedance.	Woodside	Notification on project website Notification to MAC Notification to PPA	As soon as practicable	Ministerial Statement No. 1172

12.5.2.2 MAC notifications

In addition to other external reporting, MAC will also be provided:

- Regular update on Scarborough seabed intervention activities (e.g., area of operation etc.), with information provided on a project website. Note proposed weekly during active seabed intervention activities, with frequency subject to change as agreed with MAC.
- Invitation to a monthly briefing with the intent to provide a project update, overview of monitoring data and other requested information. Note frequency is subject to agreement with MAC.

12.5.2.3 Public availability of data

All validated environmental data, management plans and reports relevant to implementing this DSDMP will be made publicly available via a project website once finalised, including:

- this DSDMP
- baseline coral community assessment report
- annual compliance assessment report
- reactive coral community survey report (if required)
- post-dredging coral community assessment report
- post-dredging water quality report.

12.6 Review of Plan

In order to ensure the effectiveness and efficiency of the management measures outlined in this plan it is important to allow for periodic review of the overall management plan and for revisions, if approved by the CEO, to be implemented.

Such reviews may include but is not limited to the following considerations:

- modification of any of the proposed management measures following implementation and review of effectiveness.
- removal, update or modification to the DSDMP.

13 References

ABARES see Australian Bureau of Agricultural and Resource Economics and Sciences

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Appendix A

Stakeholder consultation

Appendix A.1 Phase 1 Consultation activities

Table 0-1: Phase 1 consultation activities to date – table excludes engagement with MAC detailed in Table 0-3

Date	Activity	Stakeholders involved	Summary of engagement
9 March 2018	Karratha Community Liaison Group	Attended by City of Karratha, DevelopmentWA and Pilbara Development Commission	Regular quarterly meeting. Provided an overview of the Burrup Hub, including the Scarborough Project acquisition.
26 April 2018	Quarterly Karratha heritage meeting	Ngarluma Aboriginal Corporation, Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation, Wong--Goo--Tt--Oo People	Regular quarterly meeting with traditional custodian groups. Provided an update about approvals pathways and schedule for Burrup Hub projects, including the Scarborough Project.
8 June 2018	Karratha Community Liaison Group	Attended by City of Karratha, Karratha Districts Chamber of Commerce and Industry, Pilbara Ports Authority, Department of Environment, Ngarluma Yindjibarndi Foundation Ltd, Department of Local Government, Arts, Culture and Sport and WA Police	Regular quarterly meeting. Provided an update about the Burrup Hub, including the Scarborough Project.
19 June 2018	Scarborough Update Meeting	Department of Energy and the Environment, Office of the Environmental Protection Authority and NOPSEMA	Provided an overview of the Scarborough Project.
27 July 2018	Scarborough Update Meeting	Department of Energy and the Environment	Provided an overview of the Scarborough Project.
6 September 2018	Quarterly Karratha heritage meeting	Ngarluma Aboriginal Corporation, Yindjibarndi Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation, Wong-Goo-Tt-Oo People	Regular quarterly meeting with traditional custodian groups. Provided an update about approvals pathways and schedule for Burrup Hub projects, including the Scarborough Project.
7 September 2018	Karratha Community Liaison Group	Attended by City of Karratha, WA Police, Karratha Community Association, Department of Education, Horizon Power, Pilbara Ports Authority, Pilbara Development Commission, Department of Sport and Recreation, Karratha Districts Chamber of Commerce and Industry	Provided an overview of the Burrup Hub activities and key environmental approvals required, including the Scarborough Project.
19 September 2018	Burrup Hub meeting, including Scarborough	Office of the WA Minister for Environment	Provided an update about the Burrup Hub, including the Scarborough Project, approvals pathways and schedule.

Date	Activity	Stakeholders involved	Summary of engagement
19 September 2018	Burrup Hub meeting, including Scarborough	Office of the WA Premier and Minister for State Development	Provided an update about the Burrup Hub, including the Scarborough Project.
28 September 2018	Burrup Hub Update Meeting	Department of Energy and the Environment	Provided an update about approvals for Burrup Hub projects, including the Scarborough Project.
10 October 2018	Burrup Hub Update Meeting	Office of the Environmental Protection Authority	Provided an update about the Burrup Hub, including Scarborough, approvals pathway and schedule.
18 October 2018	Scarborough Update Meeting	Department of Jobs, Tourism, Science and Innovation	Consultation about the key components of Scarborough and details of the Scarborough Project Agreement.
24 October 2018	Burrup Hub social impact assessment briefing	Department of Jobs, Tourism, Science and Innovation	Briefing on approach to Burrup Hub social impact assessment, including the Scarborough Project
1 November 2018	Scarborough Update Meeting	Department of Jobs, Tourism, Science and Innovation	Consultation about the key components of Scarborough and details of the Scarborough Project Agreement.
9 November 2018	Scarborough Update Meeting	Ngarluma Yindjibarndi Foundation	Provided an update about approvals for Burrup Hub projects including the Scarborough Project.
12 November 2018	Scarborough Update Meeting	Nyamba Buru Yawuru	Discussion regarding Burrup Hub developments and environmental approvals, including the Scarborough Project.
14 November 2018	Scarborough Update Meeting	Friends of Australian Rock Art	Burrup Hub environmental approvals briefing including the Scarborough Project.
19 November 2018	Scarborough Update Meeting	Pilbara Ports Authority	Provided an update about the Scarborough Project, including dredging and stabilisation scope.
29 November 2018	Scarborough Update Meeting	Dampier TACC (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, Department of Primary Industries and Regional Development, Toll, Water Corporation, DJTSI, Murujuga Land & Sea Unit)	Provided an update about the Scarborough Project, including dredging and stabilisation scope.
29 November 2018	Quarterly Karratha heritage meeting	Ngarluma Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation, Wong-Goo-Tt-Oo People	Regular quarterly meeting with traditional custodian groups. Provided an update about approvals pathways and schedule for Burrup Hub projects, including the Scarborough Project.
11 December 2018	Scarborough Update Meeting	WAMSI Dredging Science Node (includes Australian Institute of Marine Science, WAMSI, Department of Water and Environmental Regulation)	Provided an update about the Scarborough Project, including dredging and stabilisation scope.
19 December 2018	Burrup Hub Update Meeting	Conservation Council of WA	Burrup Hub environmental approvals briefing including the Scarborough Project.

Date	Activity	Stakeholders involved	Summary of engagement
24 December 2018	Email notification to stakeholders of State waters referral	Nyamba Buru Yawuru, Wilderness Society, Australian Government (Senator Dodson), Australian Fisheries Management Authority, Western Australian Fishing Industry Council, Ngarluma Yindjibarndi Foundation, Department of Primary Industries and Regional Development, Australian Conservation Foundation / Conservation Council of WA, Department of Biodiversity, Conservation and Attractions - Parks and Wildlife Service, World Wildlife Fund, Greenpeace, Friends of Australian Rock Art, Recfishwest, Australian Hydrographic Service, WA DoT, Member for Mining and Pastoral Regions, Member for Kimberley, Australian Marine Oil Spill Centre, Murujuga Aboriginal Corporation, Kimberley Land Council, Karratha and District Chamber of Commerce and Industry, Dampier Community Association, Karratha Community Association, Regional Development Australia, DevelopmentWA, PPA, Yara Pilbara Fertilisers, Pearl Producers Association, charter boat operators and recreational fishers	Provided an update about the Scarborough Project and advice of the referral of activities in State waters to EPA and DoEE, and proposed submission of an OPP to NOPSEMA.
11 January 2019	Email notification to stakeholders of State waters referral	Australian Maritime Safety Authority	Provided an update about the Scarborough Project and advice of the referral of activities in State waters to EPA and DoEE, and proposed submission of an OPP to NOPSEMA. AMSA reviewed the placement of the moorings and cross-referenced them with traffic data. Shows trunkline crosses charted shipping fairways where vessel traffic is heavy. Woodside to provide Marine Safety Information as per AMSA's request.
21 January 2019	Marine Parks Studies Meeting	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Provided an update about Scarborough. CSIRO discussed 2017 North West Shelf (NWS) survey and results from 11 sites in Australian Marine Parks (three in Dampier Marine Park and eight in Montebello Australian Marine Parks) that have been analysed for a report soon to be released to Parks.
22 January 2019	Scarborough Update Meeting	Department of Environment and Energy	Provide update about approvals for Burrup Hub projects and referral of activities in State waters. Discussion about Sea Dumping Permits and dredging (State and Commonwealth waters).
22 January 2019	Burrup Hub meeting, including Scarborough	Department of Industry, Innovation and Science	Provided an update about the Burrup Hub projects, including the Scarborough Project, schedule and environmental approvals.

Date	Activity	Stakeholders involved	Summary of engagement
30 January 2019	Scarborough Update Meeting	Department of Environment and Energy – Australian Marine Parks Division	A meeting was held with Parks Australia, where Woodside presented an overview of Scarborough, with particular focus on activities relevant to Australian Marine Parks. Figures used in the presentation clearly showed the route of the proposed Scarborough Project Trunkline through the Montebello Marine Park Multiple Use Zone, as well as proposed remotely operated vehicle (ROV) video transects and sampling locations along the trunkline route to support a benthic habitat study. An overview was also provided of proposed dredging and spoil disposal locations associated with preparing the trunkline, with a figure clearly showing proximity to Dampier Marine Park. An associated towed/drop camera survey was discussed in relation to the potential borrow ground north of Dampier Marine Park, accompanied by several figures supporting the methodology that had been used, in addition to transect locations and results from the survey.
5 February 2019	Burrup Hub meeting, including Scarborough	Department of Transport	Provided an overview of the Burrup Hub, including the proposed Scarborough development concept, environmental approvals and approaches to marine oil pollution and maritime transport emergencies.
8 February 2019	Burrup Hub social impact assessment update	Department of Jobs, Tourism, Science and Innovation	Provided an update on Burrup Hub social impact assessment, including the proposed Scarborough Project. An overview was provided of completed stakeholder consultation and the identified preliminary social impacts.
21 February 2019	Meeting to discuss cultural heritage	Department of the Environment and Energy	Discussed environmental approvals and cultural heritage matters, including the proposed Scarborough Project.
8 March 2019	Karratha Community Liaison Group	Attended by Ngarluma Yindjibarndi Foundation Ltd, City of Karratha, DevelopmentWA, WA Police, Dept. Local Government and Communities, Pilbara Ports Authority, Karratha Districts Chamber of Commerce and Industry, Regional Development Australia, Pilbara Development Commission and Dampier Community Association	Provided a briefing about the environmental approvals process, including proposed Scarborough Project OPP and highlighted opportunities for public comment.
12 March 2019	City of Karratha quarterly meeting	City of Karratha	Discussion on Burrup Hub activities, including the proposed Scarborough Project.
13 March 2019	Burrup Hub meeting, including Scarborough	Office of the Environmental Protection Authority	Provided monthly update of Burrup Hub developments, which included updates about the proposed Scarborough Project State and Commonwealth waters environmental approvals.
15 March 2019	Scarborough Update Meeting	Department of the Environment and Energy – Australian Marine Parks Division	Secondary meeting with Department of Parks, which presented preliminary findings of ROV video transects in Montebello Australian Marine Parks.

Date	Activity	Stakeholders involved	Summary of engagement
18 March 2019	Burrup Hub meeting, including Scarborough	Department of the Environment and Energy	Update about progress towards environmental approvals, which included updates about the proposed Scarborough Project State and Commonwealth waters environmental approvals.
28 March 2019	Quarterly Scarborough update	National Offshore Petroleum Titles Administrator	Quarterly update on the proposed Scarborough Project activities.
5 April 2019	Scarborough Update Meeting	Dampier Technical Advisory and Consultative Committee	Provided an update about the proposed Scarborough Project and progress of environmental approvals, including the OPP and State waters referral.
9 April 2019	Burrup Hub social impact assessment	Pilbara Ports Authority	Discussion on preliminary social impacts and opportunities assessment for the Burrup Hub, including the proposed Scarborough Project.
9 April 2019	Burrup Hub social impact assessment	City of Karratha	Discussion on preliminary social impacts and opportunities assessment for the Burrup Hub, including the proposed Scarborough Project.
11 April 2019	Scarborough Update Meeting	Department of the Environment and Energy – Australian Marine Parks Division	Provided update about the proposed Scarborough Project, environmental approvals and marine park studies. Particular focus was on presenting plume modelling results and figures from proposed use of the offshore borrow ground. The presentation outlined oil spill modelling results, the environments that may be affected and spill modelling outputs.
1 May 2019	Submerged heritage assessment and ethnographic consultation	Traditional Custodians and elders representing all five traditional owner groups with interests in the project area (Mardudhunera, Ngarluma, Yaburara, Yindjibarndi and Wong-Goo-Tt-Oo).	Preliminary desktop assessment and ethnographic inspection and consultation with Traditional Custodians about the potential for submerged Aboriginal heritage in the Scarborough offshore and landfall component of the proposed Scarborough pipeline. The consultation included both male and female informants and was conducted by a male and female heritage consultant.
13 May 2019	Burrup Hub full council briefing, including Scarborough	City of Karratha councillors	Provided an update about Woodside's Burrup Hub developments, including the proposed Scarborough Project.
15 to 16 May 2019	Burrup Hub public information sessions in Karratha and Roebourne	Various Karratha and Roebourne community members	Broad engagement with Karratha and Roebourne community members on issues and opportunities relevant to Burrup Hub developments, including the proposed Scarborough Project.
31 May 2019	DSDMP detailed discussion	Dampier TACC (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, Department of Primary Industries and Regional Development, Toll, Water Corporation, DJTSI, Murujuga Land & Sea Unit)	Woodside presented details of this DSDMP, including an update about environmental approvals, an overview of the dredging and disposal activities, the structure of the DSDMP, an update about key findings from the studies used to support the DSDMP (including modelling), and a summary of key controls and mitigation measures. Advice and feedback were sought during and after the presentation, before submitting the DSDMP.

Date	Activity	Stakeholders involved	Summary of engagement
6 June 2019	Quarterly Karratha heritage meeting	Attended by Ngarluma Aboriginal Corporation, Yaburara and Coastal Mardudhunera Aboriginal Corporation and Wong-Goo-Tt-Oo Aboriginal Corporation	Update about proposed Scarborough Project and environmental approvals, including expected public comment periods.
7 June 2019	Karratha Community Liaison Group meeting	Attended by City of Karratha; Pilbara Development Commission; DevelopmentWA; Regional Development Australia; and PPA	Update about the proposed Scarborough Project, including environmental approvals, including public comment periods for the OPP and DSDMP.

Appendix A.2 Phase 2 DSDMP Consultation activities

Table 0-2: Phase 2 stakeholder consultation activities performed to date

Date	Activity	Stakeholders Involved	Summary of Engagement
11 July 2019	Fact sheet emailed	Stakeholders identified in Table 2-1	An email was sent to stakeholders identified in Table 2-1, informing them of the submission of the DSDMP and the public comment period.
11 August 2019	Email	Western Australian Fishing Industry Council (WAFIC)	An email was sent, attaching fact sheets, fisheries maps and offering to provide any further information required.
16 August 2019	Email	Department of Primary Industries and Regional Development	An email was sent, attaching fact sheets, fisheries maps and offering to provide any further information required.
29 August 2019	Meeting	Department of Biodiversity, Conservation and Attractions	Woodside provided a briefing and presentation about the draft DSDMP and received initial verbal feedback about methodology as well as an update on marine fauna surveys.
6 September 2019	Meeting	Department of Environment and Energy	Update provided about submission of the DSDMP and period of response to comments.
20 September 2019	Letter offering further engagement	Department of Primary Industries and Regional Development	A letter, following up on the 16 August email, was sent to the Deputy Director General for Sustainability and Biosecurity. The letter offered more information or briefing about the DSDMP and related matters. Receipt of the letter was acknowledged.
28 November 2019	Quarterly Karratha heritage meeting	Ngarluma People, Yaburara and Mardudhunera People, Wong-Goo-Tt-Oo People	As part of a broader meeting, gave an overview of the proposed Scarborough Project and advised on expected timeframes for management plans and public comment period for this DSDMP.
12 March 2020	Quarterly Karratha heritage meeting	Ngarluma People, Yaburara and Mardudhunera People, Wong-Goo-Tt-Oo People	Update about proposed Scarborough Project and environmental approvals.

Date	Activity	Stakeholders Involved	Summary of Engagement
31 May 2020	Meeting	Dampier TACC (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, Department of Primary Industry and Resource Development (DPIRD), Toll, Water Corporation, DJTSI, MAC)	Update provided about the proposed Scarborough Project. Key points from this update are summarised below: • the proposed Scarborough Project and Pluto expansion final investment decision has been deferred until 2021. • EPA released its Report on Assessment (EPA Report Number 1664) for the Nearshore Component of the Scarborough Project on 6 January 2020. • As part of the report, EPA has recommended conditions including submission of a DSDMP and Cultural Heritage and Management Plan (CHMP) in consultation with MAC. Woodside will continue to engage MAC and finalise the plans in the second half of 2020. • Woodside's Commonwealth Sea Dumping Permit was issued on 3 December 2019.
11 June 2020	Quarterly Karratha heritage meeting	Ngarluma People, Yaburara and Mardudhunera People, Wong-Goo-Tt-Oo People	Update about proposed Scarborough Project and environmental approvals, including expected public comment periods.
25 August 2020	Meeting	Ngarluma Yindjibarndi Foundation Ltd	As part of a broader meeting with NYFL, Woodside CEO gave an overview of the Scarborough Project.
10 September 2020	Quarterly Karratha heritage meeting	Yaburara and Mardudhunera People, Wong-Goo-Tt-Oo People	Update about proposed Scarborough Project and environmental approvals.
27 November 2020	Meeting	Dampier Technical Advisory and Consultative Committee (TACC) (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, DPIRD, Toll, Water Corporation, DJTSI, MAC)	Update provided about the proposed Scarborough Project. Key points from this update are summarised below: • Environmental approvals and associated consultation will resume in second half of 2021. • Continue to consult with MAC on the DSDMP and CHMP. • Revised sediment dispersion modelling is currently being peer reviewed. • Geophysical and geotechnical surveys conducted during the Pluto LNG Foundation project and on the planned Scarborough Project pipeline route have confirmed no igneous rock, the type of rock on which art occurs, is present in the offshore pipeline area beyond the shore crossing. • Woodside has commissioned an ethnographic assessment and a separate archaeological assessment to assess if submerged heritage or archaeology persists in the Scarborough Project trunkline footprint.
27 November 2020	Meeting	Conservation Council of WA	Discussion on Woodside's climate strategy and environmental approvals.

Date	Activity	Stakeholders Involved	Summary of Engagement
9 December 2020	Quarterly Karratha heritage meeting	Ngarluma People, Wong-Goo-Tt-Oo People	Update about the proposed Scarborough Project and environmental approvals.
14 January 2021	Meeting	Ngarluma Yindjibarndi Foundation Ltd	Update about the proposed Scarborough Project and environmental approvals.
19 March 2021	Quarterly Karratha heritage meeting	Wong-Goo-Tt-Oo People	Update about the proposed Scarborough Project and environmental approvals.
30 April 2021	Meeting	Dampier Technical Advisory and Consultative Committee (TACC) (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, DPIRD, Toll, Water Corporation, DJTSI, Murujuga Land & Sea Unit)	Update provided about the proposed Scarborough Project. Key points from this update are summarised below: • Continue to consult with MAC on the DSDMP and CHMP. • Revised sediment dispersion modelling is being peer reviewed.
10 June 2021	Quarterly Karratha heritage meeting	Yaburara and Mardudhunera People, Wong-Goo-Tt-Oo People	Consultation with Traditional Custodians on measures included in the DSDMP and Cultural Heritage Management Plan.
19 September 2021	Quarterly Karratha heritage meeting	Yaburara and Mardudhunera People, Wong-Goo-Tt-Oo People	Update about the Scarborough Project and environmental approvals.
5 October 2021	Meeting	PPA	Update on the Scarborough Project, nearshore activities and environmental approvals.
18 October 2021	Meeting	WAFIC	Update on the Scarborough Project, nearshore activities and environmental approvals.
25 November 2021	Meeting	Dampier Technical Advisory and Consultative Committee (TACC) (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, DPIRD, Toll, Water Corporation, DJTSI, MAC)	Update provided about the Scarborough Project. Key points from this update are summarised below: • Ministerial Statement No. 1172 received 11 August 2021. • DSDMP is currently being revised to incorporate conditions. • Consultation with MAC on DSDMP ongoing. • DSDMP planned submission to EPA for assessment soon
13 December 2021	Quarterly Karratha heritage meeting	Wong-Goo-Tt-Oo People	Update about the Scarborough Project and environmental approvals.

Date	Activity	Stakeholders Involved	Summary of Engagement
27 May 2022	Meeting	Dampier Technical Advisory and Consultative Committee (TACC) (includes PPA, DBCA, DoT, Rio Tinto, DoEE, Department of Planning Lands and Heritage, DPIRD, Toll, Water Corporation, DJTSI, MAC)	Update provided about the Scarborough Project. Key points from this update are summarised below: • Environmental approval update • Overview of State Waters Trunkline Installation EP • DSDMP is currently being finalised in consultation with MAC with submission to EPA expected in June 2022. • Overview of additional baseline water quality monitoring being conducted prior to commencement of activities in 2023.

Appendix A.3 MAC consultation summary

Table 0-3: Murujuga Aboriginal Corporation consultation phases 1 and 2 (Key meetings in bold)

Date	Activity	Summary of Engagement
Phase 1		
12 June 2018	Meeting	A briefing provided on the proposed Scarborough Project, as part of the of the Burrup Hub
11 September 2018	Meeting	A briefing provided on the proposed Scarborough Project, as part of the of the Burrup Hub
12 December 2018	Meeting	Provided an update about the proposed Scarborough Project., proposed shore crossing activities and discussion on future engagement and opportunities to work together.
9 January 2019	Meeting	Ongoing engagement and progress update about the proposed Scarborough Project, as part of the of the Burrup Hub
24 January 2019	Meeting	Ongoing engagement and progress update about the proposed Scarborough Project, as part of the of the Burrup Hub
10 April 2019	Meeting	Discussion on preliminary social impacts and opportunities assessment for the Burrup Hub, including Scarborough.
Phase 2		
11 July 2019	Email	An email was sent to MAC informing them of the submission of the DSDMP and the public comment period.
5 September 2019	Meeting	Woodside provided an overview of ethnographic fieldwork and desktop research conducted to inform heritage commitments, and the key elements of the DSDMP that related to heritage. Woodside committed to ongoing engagement with MAC about any issues related to the DSDMP.
10 September 2019	Letter	MAC issued a letter to Woodside with formal comment on DSDMP (Revision 0) and request for meeting.
11 October 2019	Email	Woodside provided written response to MAC's comments on the DSDMP raised in the above letter, along with a copy of the revised DSDMP (Revision 1) incorporating changes made in response to these comments.
15 October 2019	**Meeting**	**Woodside met with MAC and discussed comments raised on DSDMP.**
16 October 2019	Email	MAC emailed Woodside a briefing note summarising key talking points on DSDMP from meeting on 15 October 2019.
6 November 2019	Letter	Woodside provided a written response to MAC's comments on the DSDMP raised in the above briefing note, along with a copy of the revised DSDMP (Revision 2) incorporating changes made in response to these comments.
2 December 2019	Letter	MAC provided additional comments in response to 6 November letter.
6 December 2019	Email	Woodside provided tabulated responses to MAC's comments raised after 15 October meeting.
17 January 2020	Email	MAC requested additional information from Woodside in the form of an 'information package'. Woodside delivered the component of this information package related to the DSDMP.
27 March 2020	Letter/report	MAC issued report with feedback to Woodside across three issues: 1. review of Draft Cultural Heritage Management Plan for the Scarborough Project (Ref no: SA0006GH1401311448) 2. review and MAC response to updated DSDMP (Rev 2 -submitted to EPA)

Date	Activity	Summary of Engagement
		3. Implementation Plan for the Employment of Marine Fauna Observers and Cultural Heritage Monitors for the Scarborough and Pluto Expansion Projects.
10 July 2020	**Meeting**	**Woodside presentation including a proposed DSDMP engagement roadmap, update on the project and discussed impact assessment approach for sediment related impacts including modelling and tiered monitoring and management framework.**
14 August 2020	Letter	Woodside issued MAC detailed written responses to comments on Rev 2 of the DSDMP received 27 March 2020.
11 December 2020	**Meeting**	**Woodside presentation and discussion on seabed intervention and shore crossing works addressed in the DSDMP.**
2 February 2021	**Meeting**	**Woodside presentation and discussion on:** • **seabed intervention and shore crossing scope** • **revised sediment dispersion modelling** • **December 2019 Section 43a application including pipelay and associated anchoring**
15 February 2021	Meeting	Woodside and MAC CEO visited the shore crossing location to understand the exact location and landscape referred to in the DSDMP.
16 February 2021	**Meeting**	**Woodside presentation and discussion about:** • **nearshore activities** • **benthic communities and habitat (BCH) mapping** • **sediment dispersion modelling** • **ecological zones and coral compositions** • **modelling thresholds and outcomes** • **environment quality guidelines.**
25 February 2021	**Meeting**	**Woodside provided a fly-through of the trunkline corridor using GIS data and modelling layers.** **Presentation and discussion about:** • **baseline water quality data** • **tiered monitoring and management framework** • **marine fauna observers.**
10 March 2021	Meeting	Project overview provided by Woodside to MAC CEO
19-20 May 2021	Meeting	Presentation of Project Overview to MAC Circle of Elders
21 July 2021	Meeting	Woodside provided an overview of seabed intervention techniques to MAC's approvals officer
23 July 2021	**Meeting**	**Woodside provided further information and discussion about seabed intervention scope and use of spoil grounds to be included in updated Revision 3 of DSDMP.**
30 July 2021	**Meeting**	**Woodside provided further information and discussion about:** • **water quality monitoring sites – MAC and Woodside discussed the location and number of water quality sites for the monitoring program** • **protection to marine fauna** • **how other matters raised by MAC will be addressed in DSDMP Revision 3.**
24 September 2021	Email	MAC requested further Woodside feedback about specific topics discussed at meeting on 30 July 2021, specifically: • the outstanding rationale for historical baseline data associated with Pluto TSS and determining thresholds

Date	Activity	Summary of Engagement
		- rationale associated with determining distinctions between Ecological Zones A and B - provision of the data source for the current BCH configuration, rather than having to look at Rio Tinto metadata - answers to MAC questions posed regarding nutrient and contaminants (in sediments) that could be disturbed - navigational chart showing pipeline route to assist with validation of values with Elders - formal arrangements and/or letters of undertaking (or a Memorandum of Understanding confirming procurement or use of MAC reps to perform monitoring/observational works associated with the dredge and marine works for the Scarborough Project.
5 October 2021	Meeting	Woodside provided an overview of seabed intervention techniques and heritage management to MAC's underwater heritage consultant
12 October 2021	Email	Woodside provided a written response to five of the six items raised in email received on 24 September.
20 October 2021	Email	Woodside provided a written response to the remaining item raised on 24 September.
11 November 2021	Report	MAC provided Woodside a summary of the cultural and spiritual values of the marine environment to be considered in the DSDMP, along with a presentation/position about intangible heritage values.
15 December 2022	Meeting	Woodside presents an overview of the Scarborough Project to the MAC Board
10 February 2022	**Meeting**	**Woodside met with MAC to discuss Scarborough trunkline construction activities and the links to associated approvals including State and Commonwealth Environment Plans and the DSDMP and CHMP.** **A presentation pack prepared for the MAC Circle of Elders (CoE) detailing Scarborough Project trunkline construction activities and associated environmental and cultural heritage management measures was reviewed. A number of actions were agreed to assist in finalising the EP's, DSDMP and associated CoE presentation pack.**
18 February 2022	Email/report	MAC provided an analysis of the SAP and its implementation, detailing key issues on the SAP and associated contamination risks.
14 March 2022	Email/report	Woodside provided MAC a revised MScience water quality thresholds report.
21 March 2022	Email/report	Woodside provided MAC a memo responding to queries raised on 18/2/22 regarding the Scarborough SAP and its implementation.
25 March 2022	**Meeting**	**Woodside met with MAC to discuss MAC involvement in Scarborough seabed intervention and environmental management activities. MAC also outlined remaining concerns with the DSDMP. MAC agreed to document these concerns and provide in writing to Woodside.**
6 April 2022	Email	MAC provided list of actions/items resulting from meeting on 25 March 2022.
8 April 2022	Letter	Woodside proposed a schedule for conclusion of engagements on DSDMP (and CHMP) prior to submission.
20 April 2022	Email/report	Woodside provided MAC an update on status of all actions from 10 February and 25 March 2022.
22 April 2022	Report	Ahead of proposed MAC Circle of Elders (CoE) meeting and subsequent re-submission of the DSDMP, Woodside provided a copy of the revised DSDMP (Revision 3) to MAC.

Date	Activity	Summary of Engagement
27 April 2022	**Meeting**	**Meeting on request of MAC to discuss key remaining concern (assessment of contaminants) with the MAC Board.**
9 May 2022	Letter	Letter from MAC after 27 April 2022 meeting requesting contaminant monitoring and sharing of data.
18 May 2022	Letter	Woodside response to 9 May 2022 letter including a commitment to conduct additional sampling of the sediment plume for contaminant analysis.
2 June 2022	Presentation material	Presentation pack provided to MAC ahead of 3 June 2022 Circle of Elders (CoE) meeting.
3 June 2022	**CoE Meeting**	**Presentation to MAC Board and Circle of Elders (CoE) detailing Scarborough trunkline construction activities and associated environmental management and monitoring measures developed in consultation with MAC and included in the revised Dredging and Spoil Disposal Management Plan (REV 3).**
9 June 2022	Email	Email from MAC confirming they intend to submit a final letter to DWER regarding consultation on the DSDMP and no further consultation/meetings were necessary prior to this letter.
17 June 2022	Report	DSDMP (REV 3, June 2022) developed in consultation with MAC submitted to DWER and a copy provided to MAC.

Appendix B

Sediment Sampling and Analysis Plan Implementation Report

Scarborough

Sediment Sampling and Analysis Plan Implementation Report

4 July 2019

Level 4, 600 Murray St
West Perth WA 6005
Australia

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Executive Summary

Scarborough gas resource, located in Commonwealth waters approximately 380 km off the Burrup Peninsula, forms part of the Greater Scarborough gas fields, comprising Scarborough, North Scarborough, Thebe and Jupiter gas fields, of which Woodside Energy Limited (Woodside) is the Operator.

The proposed offshore development, targets commercialising the Scarborough and North Scarborough gas fields, through constructing multiple subsea, high-rate gas wells, tied back to a semi-submersible floating production unit (FPU) moored in approximately 900 m of water close to the Scarborough field. These offshore facilities are proposed to be connected to the mainland through an approximately 430 km trunkline to an onshore facility. Woodside's preferred concept is to process Scarborough gas through a brownfield expansion of the existing Pluto LNG onshore facility (Pluto Train 2).

The pre-lay dredging works associated with installing the export trunkline involves dredging a 2.5 m to 4.5 m deep trench along the export trunkline route. It is anticipated that stabilisation is generally required in water depths shallower than 40 m, which corresponds to a location about 50 km offshore from the Pluto LNG Plant. Accordingly, it is anticipated that this section of export trunkline (from the shoreline to approximately KP 50) will require trenching and stabilisation. Where the dredged material is not used to backfill the trench, it will be disposed at existing spoil grounds within the region (Spoil Grounds A/B, 2B and/or 5A).

Spoil disposal is planned to occur in accordance with a Sea Dumping Permit to be obtained under the *Environment Protection (Sea Dumping) Act 1981* (the Act).

Consistent with the *National Assessment Guidelines for Dredging 2009*, a Sampling and Analysis Plan (SAP) was prepared and approved by the Commonwealth Department of Environment and Energy (DoEE) (Woodside 2019) to investigate whether spoil was suitable for unconfined ocean disposal under the Act. All sediments were sampled and analysed in accordance with the approved SAP (Woodside 2019). The implementation of the approved SAP was completed between the 16th and 31st of March 2019, this report presents the results of this survey.

Sediment samples were collected using a gravity corer from 36 locations along the trunkline alignment. Of the contaminants of concern tested, no concentrations exceeded the sediment quality screening levels presented in Table 2 of the NAGD 2009. Concentrations of organotin compounds were all below the limit of reporting for all locations tested.

On this basis, sediments from the Nearshore, NWSV Channel and Outer Mermaid Sound Zones are considered clean and are suitable for unconfined ocean disposal.

1 Introduction

1.1 Background

The pre-lay dredging works associated with installing the Scarborough export trunkline involves dredging a 2.5 m to 4.5 m deep trench along the export trunkline route. It is anticipated that stabilisation is generally required in water depths shallower than 40 m, which corresponds to a location about 50 km offshore from the Pluto LNG Plant. Accordingly, it is anticipated that this section of export trunkline (from the shoreline to approximately KP 50) will require trenching and stabilisation. Where the dredged material is not used to backfill the trench, it will be disposed at existing spoil grounds within the region (Spoil Grounds A/B, 2B and/or 5A).

Spoil disposal is planned to occur in accordance with a Sea Dumping Permit to be obtained under the *Environment Protection (Sea Dumping) Act 1981* (the Act).

Consistent with the *National Assessment Guidelines for Dredging 2009*, a Sampling and Analysis Plan (SAP) was prepared and approved by the Commonwealth Department of Environment and Energy (DoEE) (Woodside 2019) to investigate whether spoil was suitable for unconfined ocean disposal under the Act. This report details the implementation of the approved SAP.

1.2 Objective

The objective of this report is to investigate sediment quality within the proposed dredging area and to determine whether the dredged material is suitable for unconfined ocean disposal at the designated spoil grounds.

The approved SAP was implemented in accordance with the NAGD 2009. Consistent with the recommended approach for assessment in the NAGD, the objectives of this report are to:

(a) describe the implementation of the sediment sampling and analysis program

(b) analyse the sediment results for a range of physical and chemical properties

(c) compare chemical concentrations against the NAGD screening levels

(d) determine the suitability of sediment for unconfined ocean disposal.

2 Description of Existing Environment

During the past two decades there have been numerous investigations of sediment quality within Mermaid Sound, thus providing a good understanding of the physical and chemical parameters of the sediments of the area. A summary of these investigations into sediment quality (that are relevant to the SAP) within Mermaid Sound is provided in the Scarborough Project – Sediment Sampling Analysis Plan (Woodside 2019) (Appendix A).

2.1 Environmental Conditions

Mermaid Sound is located on the western side of the Burrup Peninsula on the west Pilbara coastline, approximately 20 km west of Karratha. Dampier Port within Mermaid Sound consists of ten port terminals with separate navigational channels, which facilitate the export of iron ore, salt, liquefied natural gas, anhydrous ammonia as well as imports of project cargo, fuels, break bulk and general cargo. The inshore waters of Mermaid Sound are relatively calm with turbid environments that are sheltered by the 42 islands of the Dampier Archipelago and Burrup Peninsula. Offshore areas are influenced by clearer oceanic waters and rougher seas.

Due to its diversity of environmental conditions, Mermaid Sound supports a wide range of marine habitat types including mangroves, rocky shores, sand and mud shores, seagrass meadows, macroalgal communities and coral reefs. Within these habitats there is a high diversity of marine fauna including species of special significance including migratory humpback whales, migratory shorebirds and marine turtles.

2.2 Geological Conditions

The geology of the Port of Dampier consists of basaltic rocks, overlain by calcarenite, consolidated marine sediments and fine unconsolidated sediments, of which the top 0.3 m to 0.5 m is in a constant state of disturbance from currents and/or wave action. The top metre of material is largely very loose siliceous carbonate sands, silty sands, and sandy silts with some calcarenite gravel, shells and shell fragments. Sediments have low levels of organic carbon but frequently have a high percentage of fine sediments/silts.

2.3 Contaminants of Concern

There have been a wide range of investigations of the sediments in and around the Port of Dampier over the past thirty years indicating that there is a good understanding the physical and chemical parameters of the sediments of the area.

The results of the recent relevant sampling programs are included in the SAP (Woodside 2019) (Appendix A) and are summarised below:

- Metals (except for chromium and nickel) in the sediments have been below the relevant NAGD (low) screening levels in all sampling programs. The elevated levels of nickel and chromium found in the sediments in and around the Port of Dampier, when analysed in detail, have always been considered to be naturally-occurring. In 2006 a study of the marine sediments across the Pilbara (DEC, 2006) found that these metals occurred in many places at levels in excess of their respective NAGD (low) screening level.

- Organotins were occasionally found in the sediment surveys implemented in the early 2000s but have not been detected in the sediment sampling programs implemented within the past five years.

- Total Recoverable Hydrocarbons (TRH) and Polycyclic Aromatic Hydrocarbons (PAH) have not been detected at levels exceeding the NAGD (low) screening levels at any time and in fact, if they are detected the concentrations are low with most recent sampling programs recording no values above the NAGD PQL.

The evidence from previous surveys shows that any contaminants in sediments are expected to be present at very low levels if detected and there is no evidence of any significant anthropogenic contamination.

3 Sampling and Analysis

3.1 Sampling Design and Rationale

The sampling design implemented was in accordance with the approved SAP (Woodside 2019), prepared for Woodside by Advisian and approved by DoEE prior to implementation. Minor deviations from the approved SAP included relocation of seven sampling locations due to accessibility restrictions. No sample was recovered due to hard substrate at the primary and relocated locations at five sites between KP 4.6 and KP 5.2. These deviations are further described in Section 3.3. The rationale for the sampling design is presented in the approved SAP (Woodside 2019) (Appendix A).

An exemption from testing sediments between KP 15 and KP 50 was granted by the DoEE on the basis that sediments within this zone were sufficiently far removed from known existing and historical sources of pollution providing assurance that they were uncontaminated (Appendix A).

3.2 Timing

The sampling campaign was undertaken between the 16th to 20th March and 29th to 31st March 2019 (inclusively). The gap between the two survey campaigns was due to the passage of Tropical Cyclone Veronica. Personnel and the vessel were demobilised between the two campaigns.

3.3 Sample Locations and Recovery

Sampling was attempted at a total of 41 locations as per the approved SAP (Woodside 2019) (Appendix A). Refusal with no sample was encountered at five locations. At locations where there was sample refusal on the first attempt the sample location was moved 20 – 50 m. Refusal was also encountered on all secondary sample attempts. Successful sampling of sediment occurred at the remaining 36 locations. Table 3-1 provides a summary of the number of sampling locations and the QA/QC samples that were collected from each of the zones.

Due to access restrictions at the restricted maritime zone during sampling, locations N1 to N7 (Figure 3-1) within the exclusion zone were relocated close to the boundary of the restricted zone. All relocated sample locations remained within the Nearshore Zone. Actual sampling locations are shown in Figure 3-2.

Samples were limited to approximately the top 0.5 m at some locations within the Nearshore and NWSV Channel Zones, due to a consolidated or coarse gravel layer underlying the top layer of silty sand. This occurred at five locations in the Nearshore Zone (N16, N17, N19, N20 and N22) and three locations in the NWSV Channel Zone (C3, C4 and C5). Full sampling penetration (to 1 m depth) was achieved at all other sampling locations.

Where sample numbers within a zone were reduced due to refusal or reduced sample penetration, the original number of QA/QC samples as defined in the SAP were retained. Where field QA/QC samples were planned to be collected at sites that experienced refusal, the QA/QC samples were collected at an alternate location within the same zone.

Table 3-1: Number of sampling locations for each dredge area

KP	Classification	Volume of potentially contaminated material (m³) + 20% contingency	No. of Sampling Locations from the SAP (Woodside 2019)	No. of Triplicate Locations from the SAP (Woodside 2019)	No. of Field Split Locations from the SAP (Woodside 2019)
Nearshore Zone					
KP 0 to 3.6	Suspect	129,600	19	2	2
KP 4.6 to 6.2	Probably clean	57,600	7[1]	1	0
NWSV Channel Zone					
KP 3.6 to 4.6	Probably clean	36,000	5	1	1
Outer Mermaid Sound Zone					
KP 11 to 15	Probably clean	144,000	10	1	1

[1] *Total refusal occurred at five locations and sample material was unable to be obtained.*

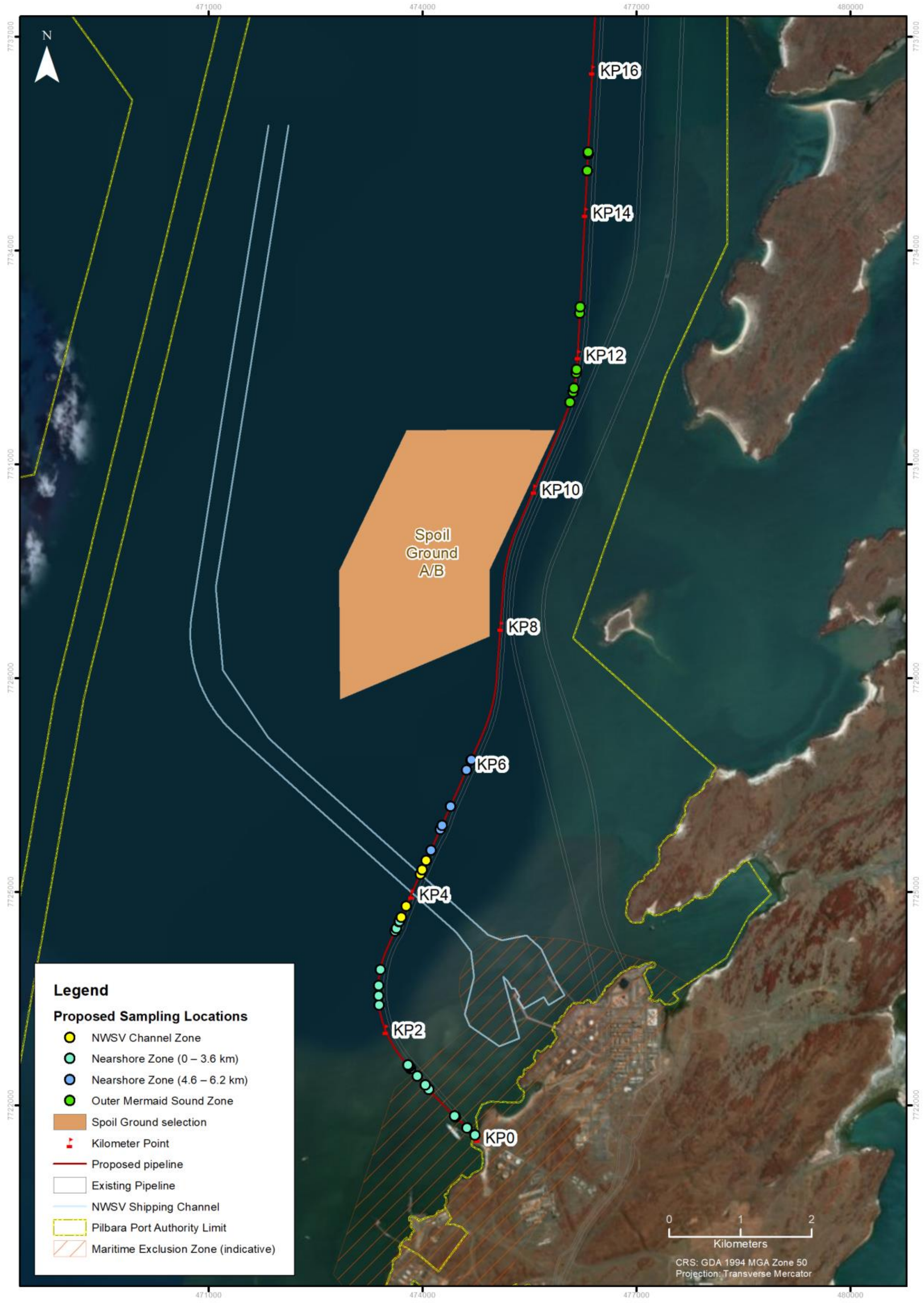

Figure 3-1: SAP implementation proposed sampling locations

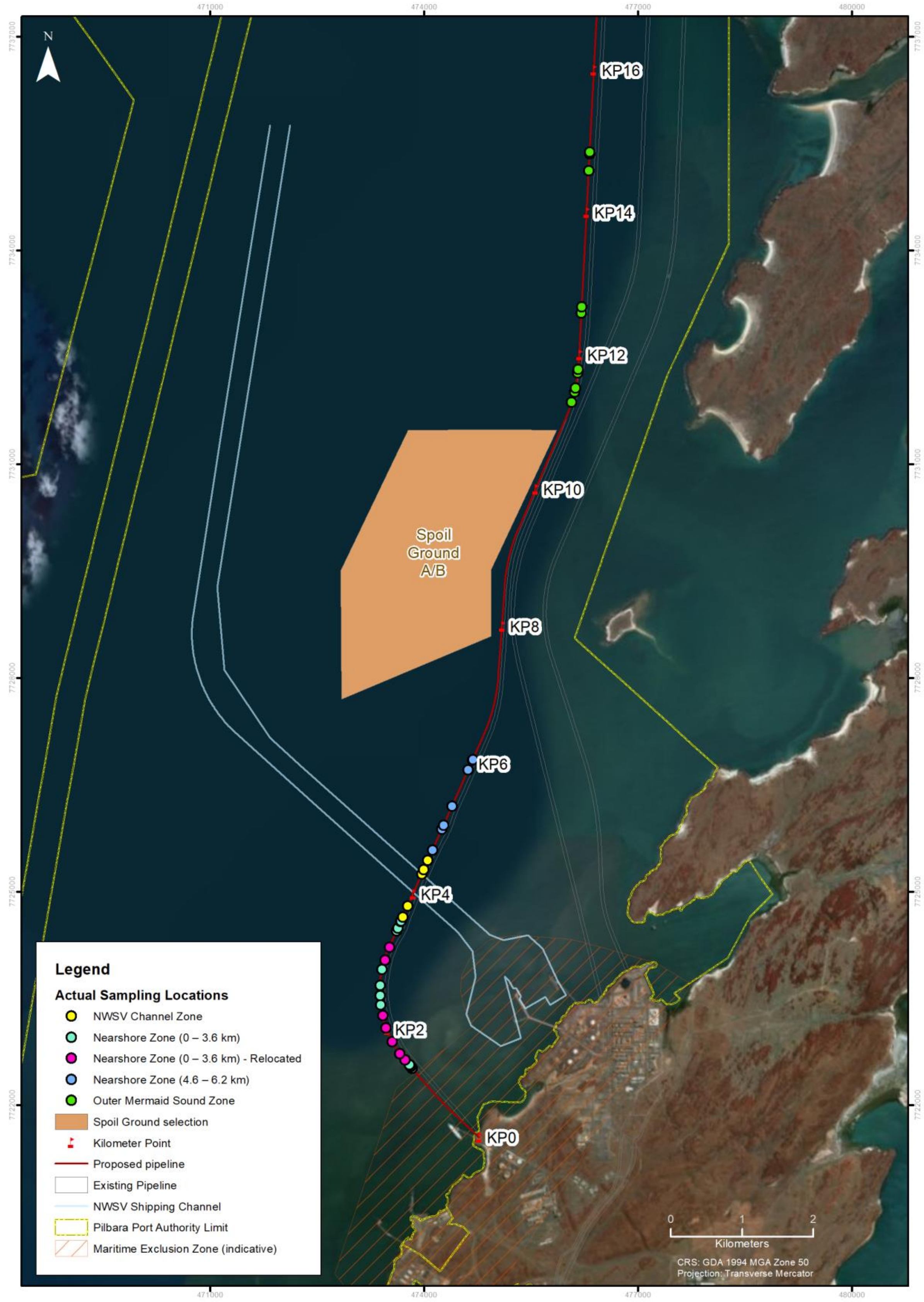

Figure 3-2: SAP implementation actual sampling locations, March 2019

3.4 Contaminant List

A list of potential contaminants was developed in the SAP prior to implementation as per Appendix A (page 27) of the NAGD 2009.

The potential list of contaminants was developed based on the assessment of previous investigations of sediment quality, the materials handled at the port and other potential contaminants associated with the maritime industry. Particle size distribution (PSD) was also determined to provide physical characterisation of the top 1 m of sediments within the dredge footprint. The testing suite and associated limits of reporting are listed in Table 3-2.

Table 3-2 Analyte Testing Suite and Laboratory Limits of Reporting

Analyte	Unit	Limit of Reporting (LoR)
Aluminium	mg/kg	50.0
Antimony	mg/kg	0.50
Arsenic	mg/kg	1.0
Cadmium	mg/kg	0.1
Chromium	mg/kg	1.0
Copper	mg/kg	1.0
Iron	mg/kg	50.0
Lead	mg/kg	1.0
Mercury	mg/kg	0.01
Nickel	mg/kg	1.0
Silver	mg/kg	0.1
Zinc	mg/kg	1.0
Organotins (TBT, DBT, MBT)	µgSn/kg	(0.5, 1.0, 1.0)
Total Organic Carbon (TOC)	%	0.02
Particle Size Distribution (sieve and hydrometer)	%	1

3.5 Sampling Procedure

3.5.1 Vessel and Equipment

Sediment sampling was conducted using a gravity corer deployed from the vessel, *En-Rybo Kae*. *En-Rybo Kae* is a 21 m utility vessel serviced and provisioned through Bhagwan Marine. The vessel provided a stable platform and suitable lifting capability for gravity coring. During mobilisation, the working space on deck was cleared of potential contamination sources and a clean plasma rope was installed on the main winch to reduce the risk of sample contamination.

The gravity corer used to conduct sampling had a nominal bore of 80 mm and the capacity to recover samples up to 1600 mm in length. The core was lined with lay flat tubing, that was changed between each sampling attempt. The lay flat tubing was held in place at the base of the corer by the core catcher, which was fitted with stainless steel nuts and bolts. The gravity corer was integrated with an acoustic release to provide a controlled release approximately 5 m above the seabed.

3.5.2 Field Sampling Procedures

Samples were collected by experienced environmental scientists using a gravity corer. The sampling procedure implemented is summarised below:

1. The vessel was positioned using the vessel's onboard GPS and cross-checked against a portable Garmin GPSMap62. When refusal was encountered, sampling at an alternative location (usually within 20 m of the original location) was attempted. Total sample refusal was encountered at the following sample locations: N21, N23, N24, N25 and N26. No sample was able to be recovered at these locations on multiple attempts. Details are provided in the field data sheets in Appendix B.
2. Once a sample was retrieved in the corer, the sample was extracted in the lay flat tubing and photographed. The bottom and top 50 cm of sample were deposited into separate glass mixing bowls for photography and processing. Each sample was photographed prior to mixing and a visual description made in accordance with AS 1726 – Geotechnical site investigations. Recorded characteristics included physical appearance and other relevant features and are provided in Appendix B.
3. The sediment was homogenised in the glass bowl using nitrile gloved hands.
4. Sediment was then placed directly into pre-treated (solvent washed, acid rinsed glass jars with Teflon lined lids) laboratory supplied jars and air tight zip lock bags. All sediment designated for contaminant testing was placed in glass jars, whereas samples designated for PSD assessment were placed in zip lock bags. Sediment was placed into jars with zero headspace.
5. All processing of sediment samples was undertaken on the vessel (at sea). Duplicate, replicate and triplicate samples were also collected in accordance with the requirements of NAGD. New gloves were used for each sample to avoid potential cross-contamination and all sampling equipment was decontaminated using distilled water and Decon-90: The sample processing area was decontaminated (washed with phosphate-free detergent and rinsed off with water) before use daily.
6. Sample containers were appropriately labelled (using indelible ink to write the sample location number and date on the label) and stored in the freezer onboard the vessel or cooler boxes with ice packs. At the end of each field day, samples were transferred into a refrigerator at <4 °C. The samples were dispatched in person by Advisian personnel to the analytical laboratory (in Perth) on return from the field work.
7. At the end of each day, one piece of sampling equipment was decontaminated and used to collect rinsate samples. The decontaminated item was rinsed with specific water supplied by the laboratory. After rinsing the equipment, the water was then poured directly into appropriate sample containers and stored chilled before being dispatched to the laboratory with the sediment samples. A different piece of equipment was rinsed each day to isolate any potential contamination introduced through sampling equipment.

3.5.3 Sample Details

Sediment samples were logged and processed on board the sampling vessel. At each sampling location, a site log sheet was completed. Information was collected about:

- name of client
- sampling date
- general location and sample identifiers assigned
- name of the sample collector
- weather conditions at the time of sampling
- sea state at the time of sampling
- general comments (e.g. level of shipping traffic)
- GPS location
- time of sampling
- photograph of each sediment sample was taken with a sample photo sheet in the frame.

3.5.4 Laboratory Analysis

A summary of the laboratory analysis methods is given in the laboratory QA/QC reports in Appendix C.

3.6 Quality Control

3.6.1 Field QA/QC

Quality control during field sampling was ensured by:

- using suitably qualified environmental staff experienced in sediment sampling, field supervision and sediment logging
- logs being completed for each sample collected including time, location, initials of sampler, duplicate type, chemical analyses to be performed and site observations
- completing chain-of-custody (CoC) forms identifying (for each sample) the sampler, nature of the sample, collection date and time, analyses to be performed, sample preservation method and departure time from the site
- using a survey vessel that was thoroughly inspected and washed down
- samples being contained in appropriately cleaned, pre-treated and labelled sample containers
- samples being kept cool (<4 °C) after sampling and during transport, stored in eskies with pre-frozen ice bricks
- transporting samples under CoC documentation
- generating additional samples in accordance with the NAGD
- decontaminating all sampling equipment, including mixing bowls, between sampling locations via a decontamination procedure involving a wash with ambient seawater or distilled water and a laboratory grade detergent and successive rinsing with distilled water

- at the end of each day, decontaminating a component of the equipment used to undertake the field sampling and using it to obtain rinsate samples that were later analysed at the laboratory for the same suite of analytes as the sediments.

Consistent with NAGD requirements, the following quality control measures were also implemented:

- Field triplicates (three separate samples taken at the same location) were collected at 10% of locations, to determine the variability of the sediment physical and chemical characteristics.
- Field split triplicates (one sample split into three containers) were collected at 5% of locations, to assess variation in results between laboratory analysis method and process and variation between laboratory associated with sub-sample handling.

All laboratory results and certificates from the quality testing of sediments is also included in Appendix C.

3.6.2 Laboratory QA/QC

For the analysis of marine sediment, ALS Environmental was used as the primary laboratory and Symbio Laboratories was used as the secondary laboratory to assess the inter-laboratory variability of the analytical results. Both ALS and Symbio are NATA accredited.

The laboratory quality assurance program included analysing the following quality controls to ensure analytical procedures were conducted properly and produced reliable results:

- one laboratory blank sample
- one Standard Reference Material (SRM); that is, a sample of certified composition such as MESS-1 or BCSS-1, or BEST-1 (for mercury)
- one sample spiked with the parameters being determined (or a surrogate spike for certain organics) at a concentration within the range of the method being employed
- one replicate sample to determine the precision of the analysis; the standard deviation and coefficient of variation to be documented.

Validation of the analytical data obtained was done in accordance with Appendix F of the NAGD to confirm it was of appropriate quality for assessing the dredge material’s suitability for unconfined ocean disposal. This validation included consideration of results for blanks, standards and spikes, and replicate and duplicate samples. Relative percent differences (RPDs) and relative standard deviations (RSDs) between quality control duplicate and triplicate samples were compared against relevant criteria.

3.6.3 Data Analysis

Contaminant levels for sediments were compared against the NAGD screening level concentrations listed in Appendix A, Table 2 of the NAGD and to determine if further testing or investigations were required (e.g. elutriate, bioavailability and/or direct toxicity assessment). As all total concentrations for contaminants of concern were less than their respective screening levels, the upper 95 per cent confidence limit was not calculated. The assessment of total concentrations against the screening levels is considered conservative.

4 Results

4.1 Nearshore Zone KP 0 to KP 3.6

Locations N1 to N7 of the SAP (Woodside 2019) were relocated due to access restrictions relating to the operational areas near the LNG wharves (Section 3.1). The relocated locations were given the prefix 'R' and are presented as R1 to R7 in Table 4-1 and Table 4-2.

4.1.1 Metals

Total metals concentrations were low at all locations within this zone, Table 4-1 to Table 4-4. Antimony, cadmium, mercury and silver were all below the limits of reporting (LoR) at all locations, with the exception of cadmium in sample N14 (0.5–1 m), which had a concentration at the limit of reporting (0.1 mg/kg) (Table 4-3). All total metals concentrations were below the respective NAGD screening levels in this zone.

Table 4-1: Summary of metals levels in the top 0.5 m and bottom 0.5 m, Nearshore Zone (KP 0 to KP 3.6), Locations R1 to R5, March 2019

				Location ID:	**R1**	**R1**	**R2**	**R2**	**R3**	**R3**	**R4**	**R4**	**R5**	**R5**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Metals	Aluminium	mg/kg	50.0	No Value	4330	3730	4280	3970	4700	4060	4880	4300	4670	4120
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	16.0	13.2	11.6	10.1	11.5	10.8	14.0	8.99	12.4	11.9
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
	Chromium	mg/kg	1.0	80	30.3	25.7	26.7	24.9	27.6	24.8	47.8	27.3	29.9	26.9
	Copper	mg/kg	1.0	65	3.3	2.7	3.2	2.9	3.6	3.0	6.7	3.3	3.6	3.0
	Iron	mg/kg	50.0	No Value	12100	10000	10900	9730	12400	11000	12700	10400	12200	11300
	Lead	mg/kg	1.0	50	3.4	2.9	3.4	2.9	3.5	3.0	5.7	2.9	3.5	3.2
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	9.7	8.3	9.3	9.0	10.0	9.0	16.5	9.8	10.3	9.5
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Zinc	mg/kg	1.0	200	9.0	7.0	8.9	6.9	9.6	7.5	15.4	8.0	9.9	8.3

Table 4-2: Summary of metals levels in the top 50 cm and bottom 50 cm, Nearshore Zone (KP 0 to KP 3.6), Locations R6 to R7 and N8 to N10, March 2019

				Location ID:	**R6**	**R6**	**R7**	**R7**	**N8**	**N8**	**N9**	**N9**	**N10**	**N10**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Metals	Aluminium	mg/kg	50.0	No Value	7260	5260	6030	4720	6840	4430	6370	4440	6100	4670
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	10.4	10.4	9.00	9.15	11.5	12.1	13.0	11.8	12.5	12.1
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Chromium	mg/kg	1.0	80	44.1	34.3	35.1	28.6	38.8	28.2	35.5	28.5	34.7	28.8
	Copper	mg/kg	1.0	65	7.0	4.2	5.4	3.5	6.2	3.2	6.0	3.2	5.1	3.4
	Iron	mg/kg	50.0	No Value	15400	12300	13200	11100	15500	12400	15100	12200	14900	12500
	Lead	mg/kg	1.0	50	4.2	3.2	4.0	2.9	4.3	3.2	4.4	3.2	4.2	3.3
	Mercury	mg/kg	0.0	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	16.5	12.6	13.4	11.0	14.8	10.2	13.4	10.0	12.8	10.3
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Zinc	mg/kg	1.0	200	16.0	10.1	12.6	8.6	16.1	8.2	13.8	8.6	14.0	8.6

Table 4-3: Summary of metals levels in the top 50 cm and bottom 50 cm, Nearshore Zone (KP 0 to KP 3.6), Locations N11 to N15, March 2019

				Location ID:	**N11**	**N11**	**N12**	**N12**	**N13**	**N13**	**N14**	**N14**	**N15**	**N15**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Metals	Aluminium	mg/kg	50.0	No Value	6210	4170	6660	5020	7110	5020	6280	4700	4530	4270
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	12.9	12.0	10.9	9.96	10.1	9.38	10.2	9.88	10.1	10.1
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
	Chromium	mg/kg	1.0	80	34.9	28.5	41.8	32.3	40.4	30.1	36.4	28.6	28.1	26.8
	Copper	mg/kg	1.0	65	5.2	3.2	5.9	3.8	6.2	3.9	5.1	3.6	3.7	3.2
	Iron	mg/kg	50.0	No Value	15400	11300	14600	11700	15100	11300	13700	10700	10800	10400
	Lead	mg/kg	1.0	50	4.3	3.1	4.1	3.1	4.1	3.1	3.9	3.1	3.4	3.0
	Mercury	mg/kg	0.0	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	12.9	10.1	15.2	11.6	15.3	11.0	13.5	10.4	10.0	9.7
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Zinc	mg/kg	1.0	200	14.1	8.5	14.6	9.2	14.8	9.1	12.9	8.3	9.6	7.8

Table 4-4: Summary of metals levels in the top 50 cm and bottom 50 cm, Nearshore Zone (KP 0 to KP 3.6), Locations N16 to N19, March 2019

				Location ID:	**N16**	**N17**	**N18**	**N18**	**N19**
				Sample Depth:	**Top**	**Top**	**Top**	**Bottom**	**Top**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**					
Metals	Aluminium	mg/kg	50.0	No Value	3660	3570	4070	3140	3940
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	12.6	12.2	12.2	12.1	11.7
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1
	Chromium	mg/kg	1.0	80	26.6	25.7	27.7	22.9	26.8
	Copper	mg/kg	1.0	65	3.2	3.1	3.7	2.8	3.6
	Iron	mg/kg	50.0	No Value	9860	9520	10500	8770	10200
	Lead	mg/kg	1.0	50	2.9	2.8	3.0	2.5	2.9
	Mercury	mg/kg	0.0	0.15	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	8.8	8.7	9.7	7.7	9.1
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1
	Zinc	mg/kg	1.0	200	7.3	7.0	8.3	6.1	8.1

4.1.2 Organotins

Monobutyltin (MBT), dibutyltin (DBT) and tributyltin (TBT) were analysed in all samples. All results for the suite of organotins tested were below the LoR and concentrations of TBT were below the NAGD screening levels at all locations, Table 4-5 and Table 4-6.

Table 4-5: Summary of organotin levels in the top 50 cm and bottom 50 cm, Nearshore Zone (KP 0 to KP 3.6), Locations R1 to R7 and N8 to N10, March 2019

				Location ID:	**R1**	**R1**	**R2**	**R2**	**R3**	**R3**	**R4**	**R4**	**R5**	**R5**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Organics	Total Organic Carbon	%	0.02	-	0.15	0.12	0.12	0.11	0.18	0.11	0.18	0.15	0.19	0.19
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

				Location ID:	**R6**	**R6**	**R7**	**R7**	**N8**	**N8**	**N9**	**N9**	**N10**	**N10**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Organics	Total Organic Carbon	%	0.0	-	0.24	0.17	0.15	0.18	0.24	0.13	0.17	0.12	0.11	0.09
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Table 4-6: Summary of organotin levels in the top 50 cm and bottom 50 cm, Nearshore Zone (KP 0 to KP 3.6), Locations N11 to N19, March 2019)

				Location ID:	**N11**	**N11**	**N12**	**N12**	**N13**	**N13**	**N14**	**N14**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**								
Organics	Total Organic Carbon	%	0.0	-	0.12	0.18	0.20	0.16	0.24	0.12	0.16	0.16
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

				Location ID:	**N15**	**N15**	**N16**	**N17**	**N18**	**N18**	**N19**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Top**	**Top**	**Bottom**	**Top**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**							
Organics	Total Organic Carbon	%	0.0	-	0.16	0.15	0.19	0.17	0.16	0.13	0.17
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

4.1.3 Particle Size Distribution

All the samples collected were also tested for particle size distributions. PSD data was analysed in the six standard categories:

- Gravel (2000–10000 µm)
- Course Sand (500–2000 µm)
- Medium Sand (300–500 µm)
- Fine Sand (60–300 µm)
- Silt (2–60 µm)
- Clay (1–2 µm).

Sand was the dominant fraction of sediments at all locations within this zone. Levels of silt varied a little across locations though generally comprised <30% of sediments and small fractions of clay was present at nine of the 19 locations. Very small amounts of gravel were present at most locations, Figure 4-1.

Laboratory results were unable to be reported for fractions <75 µm at site N18 due to a matrix compatibility issue during laboratory analysis.

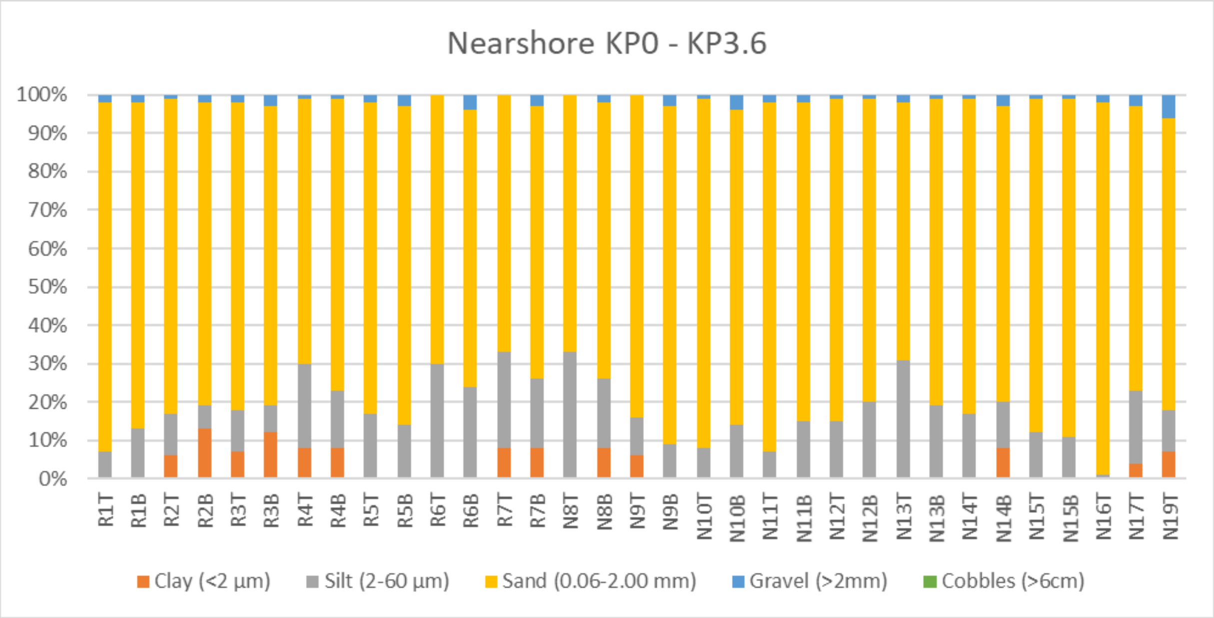

Figure 4-1: Particle size distribution, Nearshore Zone (KP 0 to KP3.6), March 2019

4.2 Nearshore Zone KP 4.6 to KP 6.2

Only the top layer (0–0.5 m) of sediments were able to be sampled at N20 and N22. Refusal occurred at the remainder of the sampling locations in this zone, which were all north east of the NWSV shipping channel.

4.2.1 Metals

Where samples were obtained, total metals concentrations were below the respective NAGD screening levels in this zone, Table 4-7.

Table 4-7: Summary of metals levels in the top 0.5 m and bottom 0.5 m, Nearshore Zone (KP 4.6 to KP 6.2), Locations N20 to N26, March 2019

				Location ID:	N20	N22
				Sample Depth:	Top	Top
Analytical Group	Analyte	Units	LoR	NAGD (ISQG Trigger Value)		
Metals	Aluminium	mg/kg	50.0	No Value	4020	2000
	Antimony	mg/kg	0.5	2	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	9.48	9.30
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1
	Chromium	mg/kg	1.0	80	24.9	21.0
	Copper	mg/kg	1.0	65	3.6	2.6
	Iron	mg/kg	50.0	No Value	9250	8200
	Lead	mg/kg	1.0	50	2.9	2.4
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01
	Nickel	mg/kg	1.0	21	9.1	6.9
	Silver	mg/kg	0.1	1.0	<0.1	<0.1
	Zinc	mg/kg	1.0	200	9.7	8.8

4.2.2 Organotins

Monobutyltin, dibutyltin and tributyltin were analysed in samples obtained in this zone. All results for the suite of organotins tested were below the LoR and concentrations of TBT were below the NAGD screening levels at all locations, Table 4-8.

Table 4-8: Summary of organotin levels in the top 50 cm and bottom 50 cm, Nearshore Zone (KP 4.6 to KP 6.2), Locations N20 to N26, March 2019

				Location ID:	N20	N22
				Sample Depth:	Top	Top
Analytical Group	Analyte	Units	LoR	NAGD (ISQG Trigger Value)		
Organics	Total Organic Carbon	%	0.02	-	0.09	0.08
Organotins	Monobutyltin as Sn	µgSn /kg	1.0	No Value	<1	<1
	Dibutyltin as Sn	µgSn /kg	1.0	No Value	<1	<1
	Tributyltin as Sn	µgSn /kg	0.5	9	<0.5	<0.5

4.2.3 Particle Size Distribution

Silty sand was the dominant sediment at locations where samples were obtained within this zone, Figure 4-2.

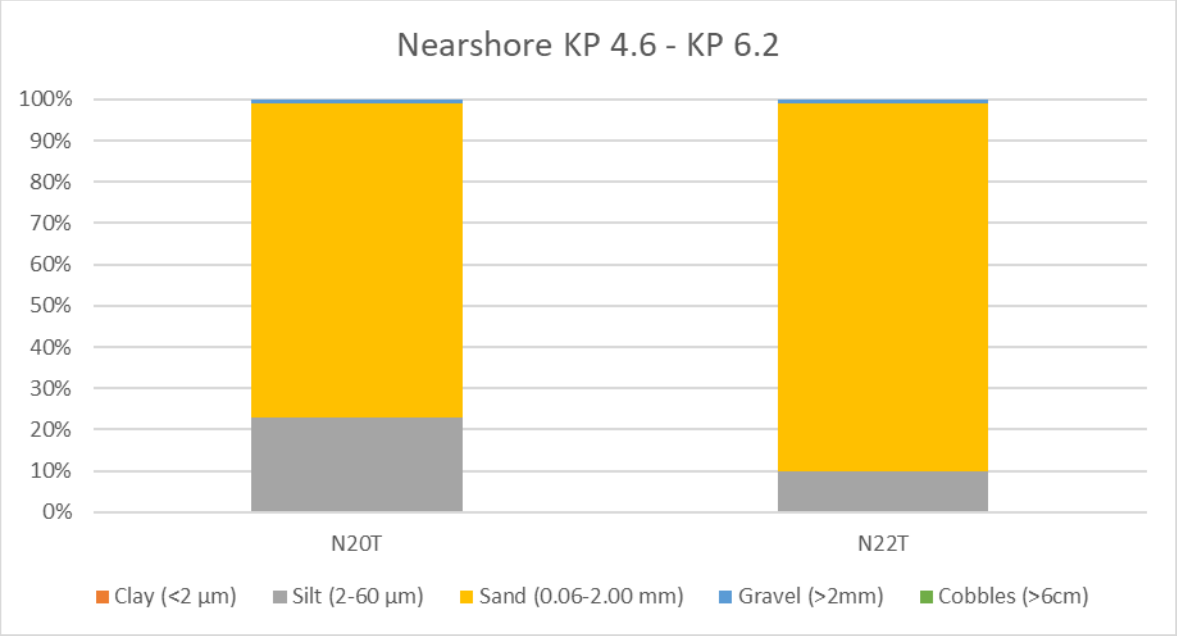

Figure 4-2: Particle size distribution, Nearshore Zone (KP 4.6 to KP 6.2), March 2019

4.3 NWSV Channel Zone KP 3.6 to KP 4.6

Bottom layer (0.5–1 m) samples were unable to be obtained at C3, C4 and C5 due to refusal, Figure 4-3. These locations were in the middle to the north east of the channel.

4.3.1 Metals

Total metals concentrations were low at all locations within this zone, Table 4-9. Antimony, cadmium, mercury and silver were all below the limits of reporting at all locations and all total metals concentrations were below the respective NAGD screening levels in this zone.

Table 4-9: Summary of metals levels in the top 0.5 m and bottom 0.5 m, NWSV Channel Zone (KP 3.6 to KP 4.6), Locations C1 to C5, March 2019

				Location ID:	**C1**	**C1**	**C2**	**C2**	**C3**	**C4**	**C5**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Top**	**Top**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**							
Metals	Aluminium	mg/kg	50.0	No Value	3930	3520	3650	4890	8160	3160	4500
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	12.9	12.5	11.4	11.8	10.3	13.1	10.6
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Chromium	mg/kg	1.0	80	25.6	23.8	24.3	29.2	46.6	21.6	28.4
	Copper	mg/kg	1.0	65	3.6	3.0	3.4	4.5	8.0	3.2	4.7
	Iron	mg/kg	50.0	No Value	10300	9510	9080	11400	17600	10000	11900
	Lead	mg/kg	1.0	50	3.0	2.8	2.8	3.3	3.8	2.4	2.9
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	8.7	7.8	9.0	10.8	17.5	6.5	9.8
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Zinc	mg/kg	1.0	200	8.6	6.2	6.7	8.6	17.7	7.0	10.4

4.3.2 Organotins

Monobutyltin, dibutyltin and tributyltin were analysed in samples obtained in this zone. All results for the suite of organotins tested were below the LoR and concentrations of TBT were below the NAGD screening levels at all locations, Table 4-10.

Table 4-10: Summary of organotin levels in the top 50 cm and bottom 50 cm, NWSV Channel Zone (KP 3.6 to KP 4.6), Locations C1 to C5, March 2019

				Location ID:	**C1**	**C1**	**C2**	**C2**	**C3**	**C4**	**C5**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Top**	**Top**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**							
Organics	Total Organic Carbon	%	0.02	-	0.16	0.15	0.11	0.13	0.22	0.15	0.24
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<.5

4.3.3 Particle Size Distribution

Particle size of sediments was dominated by sand at all locations except for C3, where gravel made up 44% of the sediments in the top sample.

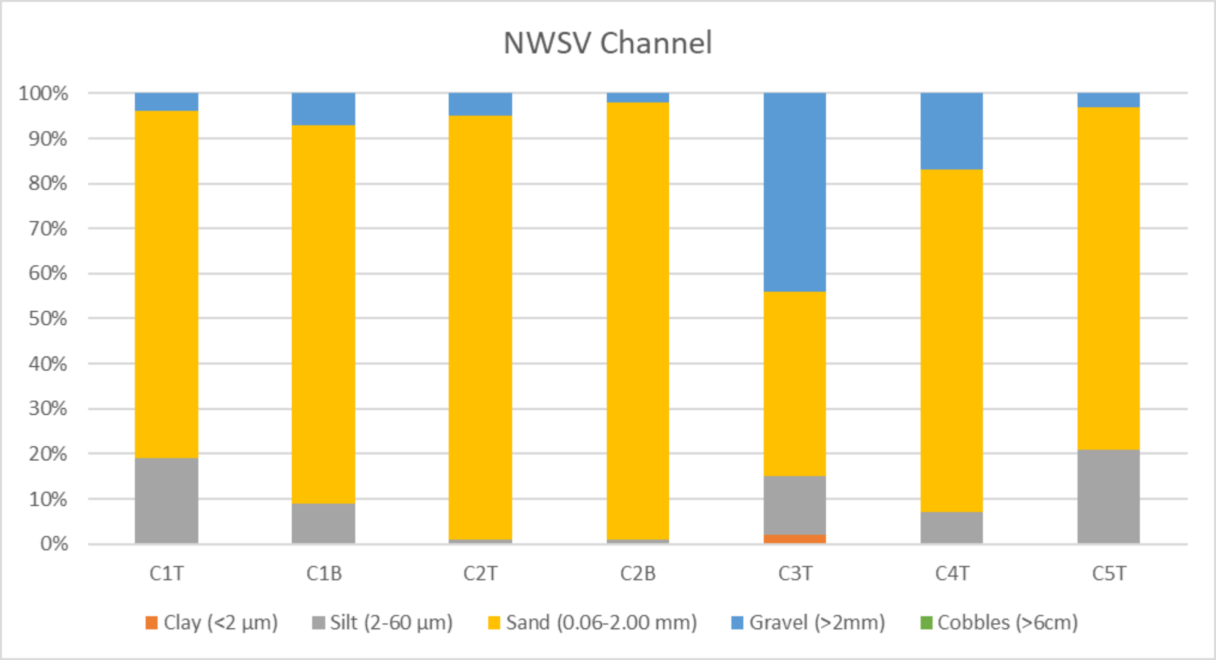

Figure 4-3: Particle size distribution, NWSV Channel Zone (KP 3.6 to KP 4.6), March 2019

4.4 Mermaid Sound Outer Zone KP 11 to KP 15

4.4.1 Metals

Total metals concentrations were generally low at all locations within this zone, Table 4-11 and Table 4-12. Antimony, cadmium, mercury and silver were below the limits of reporting at most locations, though cadmium reached the limit of reporting (0.1 mg/kg) at M4, M5 and M8.

All total metals concentrations were below the respective NAGD screening levels in this zone.

Table 4-11: Summary of metals levels in the top 0.5 m and bottom 0.5 m, Mermaid Sound Outer Zone (KP 11 to KP 15), Locations M1 to M5, March 2019

				Location ID:	**M1**	**M1**	**M2**	**M2**	**M3**	**M3**	**M4**	**M4**	**M5**	**M5**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Metals	Aluminium	mg/kg	50.0	No Value	4110	3690	4440	3890	4210	3640	4640	4540	5480	3920
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	9.95	9.94	8.17	7.97	9.02	8.05	7.91	8.99	8.15	7.25
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1
	Chromium	mg/kg	1.0	80	30.8	27.9	32.7	29.7	31.2	28.1	33.9	33.2	36.9	28.5
	Copper	mg/kg	1.0	65	3.8	3.3	4.2	3.6	4.0	3.4	4.4	4.0	7.0	3.6
	Iron	mg/kg	50.0	No Value	9900	9150	9440	8470	9620	8290	9990	9650	11200	8420
	Lead	mg/kg	1.0	50	2.8	2.7	2.8	2.6	2.7	2.5	2.9	2.8	3.1	2.4
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	10.8	9.5	11.7	10.2	11.0	9.6	12.1	11.6	13.5	9.8
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
	Zinc	mg/kg	1.0	200	8.4	7.5	9.3	7.8	8.9	7.7	9.4	8.5	13.0	7.6

Table 4-12: Summary of metals levels in the top 0.5 m and bottom 0.5 m, Mermaid Sound Outer Zone (KP 11 to KP 15), Locations M6 to M10, March 2019

				Location ID:	**M6**	**M6**	**M7**	**M7**	**M8**	**M8**	**M9**	**M9**	**M10**	**M10**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Metals	Aluminium	mg/kg	50.0	No Value	4680	4060	4810	4280	3700	4000	4200	4010	3700	3780
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
	Arsenic	mg/kg	1.0	20	7.54	7.10	7.21	7.36	7.73	8.13	8.20	7.63	9.31	8.73
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
	Chromium	mg/kg	1.0	80	34.1	29.7	33.2	29.9	26.7	27.9	30.2	28.5	27.9	28.3
	Copper	mg/kg	1.0	65	4.6	3.8	4.4	3.7	3.4	3.5	3.8	3.5	3.6	3.6
	Iron	mg/kg	50.0	No Value	10000	8580	9890	9000	8440	8620	9350	8470	9060	8500
	Lead	mg/kg	1.0	50	2.7	2.4	2.7	2.5	2.4	2.3	2.6	2.3	2.6	2.4
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	mg/kg	1.0	21	12.5	10.6	12.2	10.8	9.4	10.1	10.5	10.1	9.6	9.8
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Zinc	mg/kg	1.0	200	9.9	7.7	9.7	7.8	7.8	7.4	8.7	7.3	8.0	7.1

4.4.2 Organotins

All results for the suite of organotins tested were below the LoR at all locations, Table 4-13.

Table 4-13: Summary of organotin levels in the top 50 cm and bottom 50 cm, Mermaid Sound Outer Zone (KP 11 to KP 15), Locations M1 to M5, March 2019

				Location ID:	**M1**	**M1**	**M2**	**M2**	**M3**	**M3**	**M4**	**M4**	**M5**	**M5**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Organics	Total Organic Carbon	%	0.02	-	0.23	0.21	0.30	0.29	0.27	0.28	0.31	0.29	0.33	0.27
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

				Location ID:	**M6**	**M6**	**M7**	**M7**	**M8**	**M8**	**M9**	**M9**	**M10**	**M10**
				Sample Depth:	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**										
Organics	Total Organic Carbon	%	0.02	-	0.30	0.23	0.31	0.28	0.25	0.31	0.27	0.23	0.22	0.24
Organotins	Monobutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Dibutyltin as Sn	µgSn/kg	1.0	No Value	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
	Tributyltin as Sn	µgSn/kg	0.5	9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

4.4.3 Particle Size Distribution

Particle size of sediments was consistent between the locations sampled in this zone. Silty sand was dominant in this zone, with most locations also having a small fraction (<5%) of gravel, Figure 4-4.

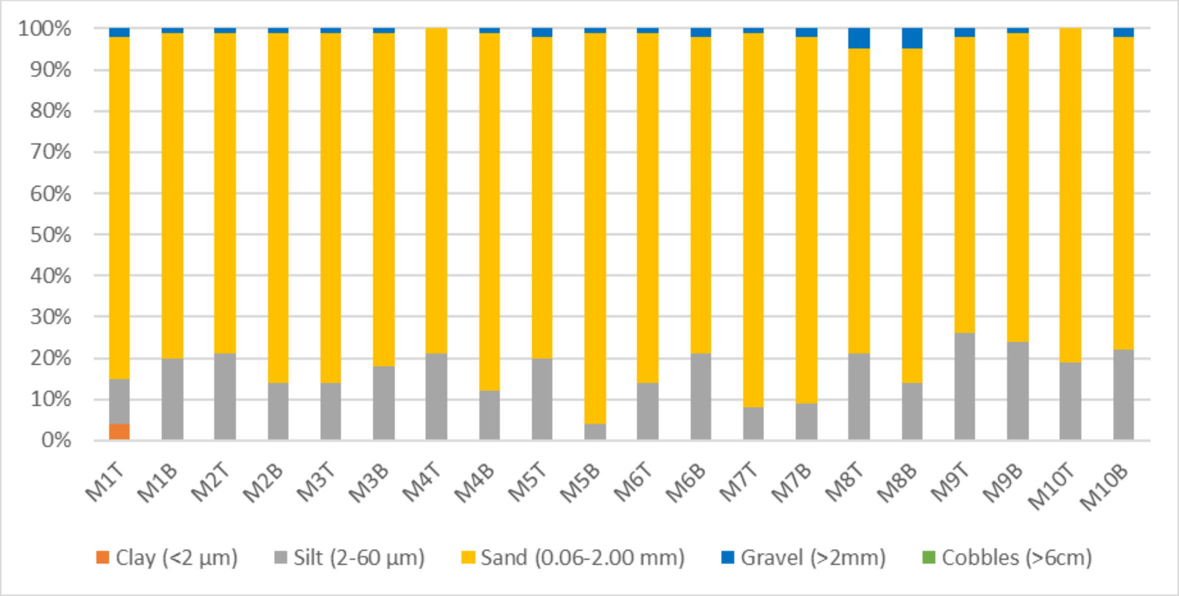

Figure 4-4: Particle size distribution, Mermaid Sound Outer Zone (KP 11 to KP 15), March 2019

4.5 Quality Assurance

4.5.1 Field QA/QC Samples

As part of the field QA/QC procedure, QA/QC samples were collected in accordance with the approved SAP. Field triplicates were collected at 10% of all sample locations and inter-lab duplicates were collected at 5% of all sample locations.

Results from the field triplicates are shown in Table 4-14 to Table 4-17 and results from the inter lab duplicates are shown in Table 4-18. Field triplicate data was consistent between samples (cores) with relative standard deviation well below 50% in all of the samples or analytes tested. This confirms that there was minimal variability in the chemical characteristics of the sediments within locations.

The majority of results from rinsate testing were below the laboratory limit of reporting for most metals analytes. Values exceeded the limit of reporting by small amounts for aluminium, iron and zinc in some samples though these did not correlate with any particular sampling equipment and are considered to be inconsequential with regard to interpretation of the analytical results.

Table 4-14: Field triplicate data, Location R7

				Location ID:	**R7A**	**R7B**	**R7C**		**R7A**	**R7B**	**R7C**	
				Sample Depth:	**Top**	**Top**	**Top**		**Bottom**	**Bottom**	**Bottom**	
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**				**RSD (%)**				**RSD (%)**
Metals	Aluminium	mg/kg	50.0	No Value	6030	6890	6310	6.84	4720	5090	4880	3.79
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50		<0.50	<0.50	<0.50	
	Arsenic	mg/kg	1.0	20	9	10.2	9.76	6.29	9.15	9.36	9.59	2.35
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	
	Chromium	mg/kg	1.0	80	35.1	40.3	36	7.48	28.6	31.4	29.5	4.79
	Copper	mg/kg	1.0	65	5.4	6	5	9.21	3.5	3.8	3.7	4.17
	Iron	mg/kg	50.0	No Value	13200	15100	13900	6.83	11100	11800	11600	3.14
	Lead	mg/kg	1.0	50	4	4.2	3.6	7.77	2.9	3.1	3.2	4.98
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	
	Nickel	mg/kg	1.0	21	13.4	15.2	13.6	7.01	11	11.4	11.1	1.86
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	
	Zinc	mg/kg	1.0	200	12.6	14.1	11.9	8.74	8.6	9	8.4	3.53

Table 4-15: Field triplicate data, Location N14

				Location ID:	N14A	N14B	N14C		N14A	N14B	N14C	
				Sample Depth:	Top	Top	Top		Bottom	Bottom	Bottom	
Analytical Group	Analyte	Units	LoR	NAGD (ISQG Trigger Value)				RSD (%)				RSD (%)
Metals	Aluminium	mg/kg	50.0	No Value	6280	5800	5860	4.37	4700	4430	4710	3.44
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50		<0.50	<0.50	<0.50	
	Arsenic	mg/kg	1.0	20	10.2	9.82	9.56	3.26	9.88	9.62	9.3	3.03
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1		0.1	<0.1	<0.1	
	Chromium	mg/kg	1.0	80	36.4	34.7	34.6	2.87	28.6	28.3	29.4	1.98
	Copper	mg/kg	1.0	65	5.1	5	5	1.15	3.6	3.5	3.7	1.99
	Iron	mg/kg	50.0	No Value	13700	12900	13100	3.15	10700	10500	11000	2.34
	Lead	mg/kg	1.0	50	3.9	3.8	3.6	4.06	3.1	2.9	3.1	3.81
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	
	Nickel	mg/kg	1.0	21	13.5	13.1	13	2.00	10.4	10.2	10.7	2.41
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	
	Zinc	mg/kg	1.0	200	12.9	12.2	12.1	3.52	8.3	8.2	8.7	3.15

Table 4-16: Field triplicate data, Locations N22 (top only) and C2

				Location ID:	**N22A**	**N22B**	**N22C**		**C2A**	**C2B**	**C2C**		**C2A**	**C2B**	**C2C**	
				Sample Depth:	**Top**	**Top**	**Top**		**Top**	**Top**	**Top**		**Bottom**	**Bottom**	**Bottom**	
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**				**RSD (%)**				**RSD (%)**				**RSD (%)**
Metals	Aluminium	mg/kg	50.0	No Value	2000	4090	2810	35.52	3650	4760	4200	13.20	4890	3420	5400	22.50
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50		<0.50	<0.50	<0.50		<0.50	<0.50	<0.50	
	Arsenic	mg/kg	1.0	20	9.3	10.5	12	12.76	11.4	11.7	12.6	5.25	11.8	12.7	12	3.88
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	
	Chromium	mg/kg	1.0	80	21	25.5	19.9	13.41	24.3	28.9	24.7	9.81	29.2	22.8	31.9	16.71
	Copper	mg/kg	1.0	65	2.6	3.4	2.2	22.35	3.4	4.3	3.7	12.06	4.5	2.8	5.2	29.62
	Iron	mg/kg	50.0	No Value	8200	10200	9250	10.85	9080	11600	10600	12.17	11400	9830	12600	12.32
	Lead	mg/kg	1.0	50	2.4	2.7	2.5	6.03	2.8	3.2	3.1	6.86	3.3	2.6	3.5	15.08
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	
	Nickel	mg/kg	1.0	21	6.9	8.7	6	19.09	9	10.3	8.8	8.70	10.8	7.4	12.4	25.03
	Silver	mg/kg	0.1	1.0	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	
	Zinc	mg/kg	1.0	200	8.8	9.1	7	13.68	6.7	10	8.2	19.91	8.6	6.2	9.3	20.24

Table 4-17: Field triplicate data, Locations M5

				Location ID:	**M5A**	**M5B**	**M5C**		**M5A**	**M5B**	**M5C**	
				Sample Depth:	**Top**	**Top**	**Top**		**Bottom**	**Bottom**	**Bottom**	
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**				**RSD (%)**				**RSD (%)**
Metals	Aluminium	mg/kg	50.0	No Value	5480	4750	4260	12.71	3920	3980	4280	4.75
	Antimony	mg/kg	0.5	2	<0.50	<0.50	<0.50		<0.50	<0.50	<0.50	
	Arsenic	mg/kg	1.0	20	8.15	8.56	7.48	6.76	7.25	7.94	8.32	6.92
	Cadmium	mg/kg	0.1	1.5	0.1	<0.1	<0.1		<0.1	<0.1	0.1	
	Chromium	mg/kg	1.0	80	36.9	36	31.3	8.66	28.5	31	31.7	5.53
	Copper	mg/kg	1.0	65	7	4.6	4.2	28.75	3.6	3.7	3.8	2.70
	Iron	mg/kg	50.0	No Value	11200	10200	8990	10.92	8420	8640	9240	4.84
	Lead	mg/kg	1.0	50	3.1	3.2	2.7	8.82	2.4	2.7	2.7	6.66
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	
	Nickel	mg/kg	1.0	21	13.5	12.8	11.3	8.97	9.8	11	11	6.54
	Silver	mg/kg	0.1	1.0	0.1	0.1	0.1		<0.1	<0.1	<0.1	
	Zinc	mg/kg	1.0	200	13	10.6	9.7	15.37	7.6	8	8.2	3.85

4.5.2 Laboratory QA/QC

The laboratory also conducted QA/QC sampling for the samples in accordance with the approved SAP (Woodside 2019). These are presented in Appendix C. All sediment samples were analysed within holding times and although matrix spike outliers were detected, they were deemed acceptable as analyte results were below the limit of reporting. The laboratory duplicates were also within the expected range of values with RPD within recommended limits (Table 4-18).

Results from the inter-lab duplicates were variable between analytes and samples tested (Table 4-19). Results received from ALS were reported as dry weight and results received from Symbio were reported as received (wet weight). All results were converted to wet weight prior to calculating the RPD. The values reported by Symbio were generally lower than those reported by ALS. The majority of analytes within samples that were compared were below ±35% RPD and although some of the values reported by the two labs were significantly different, it is most likely a result of laboratory technique. Furthermore, the values did not exceed the corresponding screening level and are considered to be acceptable for use. A complete set of results and laboratory QA/QC reports are included in Appendix C.

Given that the outliers identified do not alter the outcome of the assessment, Advisian considers that overall the QA/QC completed on the field investigation to be adequate and the analytical data suitable for interpretive purposes.

Table 4-18: Field duplicate data

				Location ID:	**R4T**	**R4T DUP**		**N11T**	**N11T DUP**		**C2T**	**C2T DUP**		**M8T**	**M8T DUP**	
Analytical Group	**Analyte**	**Units**	**LoR**	**NAGD (ISQG Trigger Value)**			**RPD (%)**			**RPD (%)**			**RPD (%)**			**RPD (%)**
Metals	Aluminium	mg/kg	50.0	No Value	4880	6320	25.71	6210	5820	6.48	3650	3490	4.48	3700	4180	12.18
	Antimony	mg/kg	0.5	2	<0.50	<0.50		<0.50	<0.50		<0.50	<0.5		<0.50	<0.50	-
	Arsenic	mg/kg	1.0	20	14.0	14.3	2.12	12.9	12.4	3.95	11.4	11.7	2.60	7.73	8.11	4.80
	Cadmium	mg/kg	0.1	1.5	<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1	
	Chromium	mg/kg	1.0	80	47.8	60.5	23.45	34.9	32.5	7.12	24.3	22.8	6.37	26.7	28.2	5.46
	Copper	mg/kg	1.0	65	6.7	8.0	17.69	5.2	4.8	8.00	3.4	3.5	2.90	3.4	3.9	13.70
	Iron	mg/kg	50.0	No Value	12700	16400	25.43	15400	14400	6.71	9080	9600	5.57	8440	9660	13.48
	Lead	mg/kg	1.0	50	5.7	5.9	3.45	4.3	4.2	2.35	2.8	2.9	3.51	2.4	2.6	8.00
	Mercury	mg/kg	0.01	0.15	<0.01	<0.01		<0.01	<0.01		<0.01	<0.01		<0.01	<0.01	
	Nickel	mg/kg	1.0	21	16.5	17.5	5.88	12.9	12	7.23	9	8.3	8.09	9.4	10.1	7.18
	Silver	mg/kg	0.1	1.0	<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1	
	Zinc	mg/kg	1.0	200	15.4	16.5	6.90	14.1	12.7	10.45	6.7	6.6	1.50	7.8	8.1	3.77

Table 4-19: Interlaboratory duplicate data

					Location ID:	R4	R4		N11	N11		C2	C2		M8	M8	
			Lab:			ALS	Symb		ALS	Symb		ALS	Symb		ALS	Symb	
Analytical Group	**Analyte**	**Units**	**LoR (ALS)**	**LoR (Symb)**	**NAGD (ISQG Trigger Value)**			**RPD (%)**			**RPD (%)**			**RPD (%)**			**RPD (%)**
Metals	Aluminium	mg/kg	50.0	1.0	No Value	3289.1	3610.0	9	3980.6	4000	0	2507.6	2830	12	2408.7	2470	3
	Antimony	mg/kg	0.5	0.1	2	<0.50	<0.1		<0.50	0.1		<0.50	0.2		<0.50	<0.1	
	Arsenic	mg/kg	1.0	0.5	20	9.4	4.0	81	8.3	5.2	46	7.8	6.2	23	5	3.7	31
	Cadmium	mg/kg	0.1	0.1	1.5	<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1	
	Chromium	mg/kg	1.0	0.5	80	32.2	22.0	38	22.4	20	11	16.7	19	13	17.4	18	3
	Copper	mg/kg	1.0	0.5	65	4.5	1.8	86	3.3	1.8	60	2.3	1.7	32	2.2	1.7	26
	Iron	mg/kg	50.0	2.0	No Value	8559.8	10300.0	18	9871.4	9090	8	6238	6660	7	5494.4	5080	8
	Lead	mg/kg	1.0	0.1	50	3.8	2.2	54	2.8	2.4	14	1.9	2.1	9	1.6	1.5	4
	Mercury	mg/kg	0.01	0.1	0.15	<0.01	<0.10		<0.01	<0.1		<0.01	<0.1		<0.01	<0.1	
	Nickel	mg/kg	1.0	0.1	21	11.1	4.6	83	8.3	4.3	63	6.2	4.8	25	6.1	4.7	26
	Silver	mg/kg	0.1	0.1	1.0	<0.1	<0.1		<0.1	<0.1		<0.1	<0.1		<0.1	<0.1	
	Zinc	mg/kg	1.0	0.5	200	10.4	4.3	83	9	4.5	67	4.6	3.4	30	5.1	3.4	40

5 Conclusions

Sampling and testing of sediments from the proposed trunkline alignment confirmed that metal concentrations were very low and below the limits of reporting for many analytes. Concentrations of organotin compounds were also very low and below the limit of reporting for all locations tested.

Sample refusal was confined to the five locations in the Nearshore Zone to the North of the NWSV Channel. Coarse gravel was noted to be present in the core catcher at these locations. In accordance with the NAGD, materials of this nature do not require further chemical testing. Refusal at these locations has not affected the interpretation of the material classification in this zone as the remaining locations provide ample spatial coverage that is representative of the material that may be dredged. Furthermore, all contaminants of concern are present at very low concentrations that are either less than the limits of reporting or at levels that are well below the NAGD screening levels.

Where sampling locations were relocated due to the access restrictions in the Maritime Exclusion Zone, the sample locations that were subsequently sampled were representative of sediments that may be dredged as part of the trunkline installation. This conclusion is supported by the long-term data set from the Woodside ChEMMS program, which involves testing of sediments near the Dampier coast, adjacent to the Karratha Gas Plant (KGP) and King Bay Supply Base. Analytes that were tested in the ChEMMS program were compared against ANZECC/ARMCANZ trigger levels, which were the same or more conservative than the NAGD screening levels for the analytes tested. Aside from slightly elevated nickel concentrations at some locations, sediments tested for the ChEMMS program in late 2018, from within the maritime exclusion zone, were found to be below the relevant ANZECC/ARMCANZ trigger levels (Advisian 2018). Although nickel concentrations in this zone were above the respective trigger value when assessed against ANZECC/ARMCANZ, the 95% UCL was 17.5 mg/kg, which is below the NAGD screening level of 21 mg/kg.

Overall, sediment quality within the proposed dredging area has been comprehensively assessed based on a statistically robust assessment of the contaminants of concern in representative sediments from each zone. The data indicates that sediments from the Nearshore, NWSV Channel and Outer Mermaid Sound Zones are clean and are suitable for unconfined ocean disposal.

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Appendix A Sediment Sampling Analysis Plan

Scarborough Project

Sediment Sampling Analysis Plan

March 2019

Revision 1 (Addressing DoEE Comments) – For Submission

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Acronyms and Definitions

Acronym	Definition
Al	Aluminium
Ag	Silver
ALS	Analytical Laboratory Services
ANZECC	Australian and New Zealand Environment and Conservation Council
As	Arsenic
BHD	Backhoe Dredge
Cd	Cadmium
Co	Cobalt
CoC	Chain of Custody
Cu	Copper
DEWHA	Department of the Environment, Water, Heritage and the Arts (now DoEE)
DoEE	Commonwealth Department of Environment and Energy
Fe	Iron
FPU	Floating Production Unit
Hg	Mercury
HLO	Heavy Load Out
KGP	Karratha Gas Plant
KP	Kilometre Point
LNG	Liquefied Natural Gas
LOR	Limit of Reporting
Mn	Manganese
NAGD	National Assessment Guidelines for Dredging
NATA	National Association of Testing Authorities
Ni	Nickel
NODGM	National Ocean Disposal Guidelines for Dredged Materials
NWSV	North West Shelf Venture
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PPA	Pilbara Ports Authority
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
PSD	Particle Size Distribution
SAP	Sampling Analysis Plan
Sb	Antimony
SDP	Sea Dumping Permit
Se	Selenium
TBT	Tributyltin
TOC	Total Organic Carbon

Acronym	Definition
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
TSEP	North West Shelf Trunkline Systems Expansion Project
TSHD	Trailing Suction Hopper Dredge
QA/QC	Quality Assurance/Quality Control
UCL	Upper Confidence Limit
V	Vanadium
Zn	Zinc

1 Introduction

The Scarborough gas field is located 380 km west-north-west of the Burrup Peninsula in the north-west of Australia. Woodside Energy Ltd (Woodside) will be the development operator, with BHP Billiton Petroleum (North West Shelf) Pty Ltd (BHP) as joint venture participant.

The Scarborough gas field development (Scarborough Project) includes drilling of a number of subsea gas wells (which includes wells in the Scarborough, Thebe and Jupiter reservoirs) but may also include additional future tiebacks. Wells will be tied back to a semi-submersible Floating Production Unit (FPU) moored in approximately 900 m of water, over the Scarborough field. The FPU topsides has processing facilities for gas dehydration and compression to transport the gas through an approximately 430 km trunkline to the Woodside-operated Pluto Liquified Natural Gas (LNG) facility on the Burrup Peninsula. Woodside is proposing the brownfield expansion of Pluto LNG to process third-party gas, which will require brownfield expansion to process the Scarborough gas trunkline. Trenching (via dredging), pipelay and backfill activities are required for the installation of the trunkline. The proposed trunkline alignment will run approximately 10–200 m to the south-east of the existing Pluto Trunkline.

This Sediment Sampling Analysis Plan (SAP) forms part of the process required for an application for a Sea Dumping Permit (SDP) relating to dredging activities. It outlines the requirements for an assessment of the physical and chemical properties of the marine sediments to be dredged as required for trunkline construction (“the Project”) in order to assess the suitability of the dredge spoil for unconfined ocean disposal.

1.1 Framework

Dredging and disposal activities will be undertaken as directed through the *Commonwealth Environment Protection (Sea Dumping) Act 1981*. The framework for implementing the Act is the National Assessment Guidelines for Dredging (NAGD) (DEWHA 2009).

This SAP has been prepared in accordance with the requirements of the NAGD (DEWHA 2009) and will be submitted for approval to the Commonwealth Department of Environment and Energy (DoEE) as part of the process for an application for a Sea Dumping Permit.

1.2 SAP Objectives

The aim of this SAP is to describe the list of procedures that will be used for collecting, analysing and reporting on the physico-chemical properties of sediments that may be dredged in relation to the Project. Specific objectives of the SAP are to:

- provide a summary of the proposed dredging operations
- provide a review of existing information that has guided the sampling program described herein
- identify a contaminants list for testing of sediments, based on potential contaminant sources and results of prior testing
- identify the number of samples to be taken in order to provide an adequate and statistically robust representation of the contaminants of concern in the sediments
- describe the methodology for the collection and handling of samples

- describe the:
  - laboratory analyses required
  - quality assurance and quality control (QA/QC) procedures for the collection, handling and laboratory analysis of the samples
  - the statistical techniques to be used to analyse the contaminants within the sediments.
- describe the reporting framework for communicating the results of the implementation of the SAP to address the requirements of the NAGD and DoEE.

2 Location and Description of Proposed Dredging Activities

The Scarborough gas field is located 380 km west-northwest of the Burrup Peninsula, in the northwest of Australia. It is located within offshore permit WA-1-R. The trunkline will run approximately 10–200 m to the south-west of the existing Pluto Trunkline, from the FPU topside located in Commonwealth waters and pass through State waters to the onshore Pluto LNG Facility (Figure 2-1). Due to proximity, the geotechnical conditions along the Scarborough trunkline route are anticipated to be largely similar to those of the existing Pluto Foundation Project trunkline system.

Where trenching is required, it is anticipated that the width of the trench will be about 30 m wide. Dredging will not occur in some areas; for example, adjacent to Spoil Ground A/B due to the rocky nature of the substrate, where instead, the trunkline will lay on top of the substrate (as per the Pluto Foundation Project trunkline). The material encountered while dredging the Pluto trenches during the Pluto LNG Facility foundation project was predominantly calcareous marine sediments and clays. No nearshore blasting or cutter suction dredge works will be required.

The position of the trunkline is discussed relative to Kilometre Point (KP) 0 which represents the approximate position of high water mark. All other KP values discussed below should be considered approximate. The trunkline lies within the Pilbara Port Authority (PPA) Limits between KP 0 and KP 36 (Figure 2-1), and consists of an intertidal zone (KP 0 to KP 0.1), nearshore shore approach (KP 0.1 to KP 3.6), the crossing of the North West Shelf Venture (NWSV) shipping channel (KP 3.6 to KP 4.6) and the shore approach within State waters (KP 4.6 to KP 32 and within Commonwealth waters (KP 32 to KP 36) (Table 2-2). Dredging in the offshore Commonwealth waters zone (that is, the trunkline route outside of the Pilbara Port Authority Limits) is located between KP 36 and KP 50. No dredging is proposed beyond KP 50.

Table 2-1 summarises the proposed dredging activities along the trunkline alignment and estimated maximum volumes, while Table 2-2 details the proposed dredging activities to be undertaken. Construction is expected to involve dredging via both a backhoe dredge (BHD) (and associated barges) and a trailing suction hopper dredge (TSHD) (Table 2-2), depending on the location. The constructed trunkline will also require backfill and/or stabilisation along various sections of the route, which will involve the use of rock or sand. The details of the final dredging program and methods used will be dependent on the final engineering design.

Table 2-1: Estimated maximum volumes to be dredged

Activity	Estimated maximum volumes[1]
State waters trenching	~1,612,584 m^3
Commonwealth waters trenching	~1,169,111 m^3
Total Trenching	**~2,781,695 m^3**

Dredged material may be disposed at a combination of three spoil grounds; Spoil Ground A/B and 2B in State waters, and Spoil Ground 5A in Commonwealth waters (Figure 2-1). Coordinates for each of the spoil grounds are shown in Table 2-3.

It is proposed that Spoil Ground A/B will be used for the nearshore dredge spoil, which comprises soft sand sediment habitat with few sessile invertebrates and algae present (Woodside 2007) while material from the Outer Mermaid Sound zone is planned to be disposed at Spoil Ground 2B. This is where most of the material from the Pluto Foundation Project was disposed (SD2006/0033). Sampling of Spoil Ground 2B (SKM 2008) indicates that the ground is comprised of sand with patches of coarse gravel, is uncontaminated and contains sparse levels of infauna (comprising largely of crustaceans). Spoil Ground 5A runs adjacent to the Pluto Foundation Trunkline (at a

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[1] All trenching volumes are based on ‘in situ’ measurement (i.e. confirmed by hydrographic survey techniques)

distance of about 1–2 km), and material is considered to be similar in nature to that encountered along the existing trunkline (Woodside 2007).

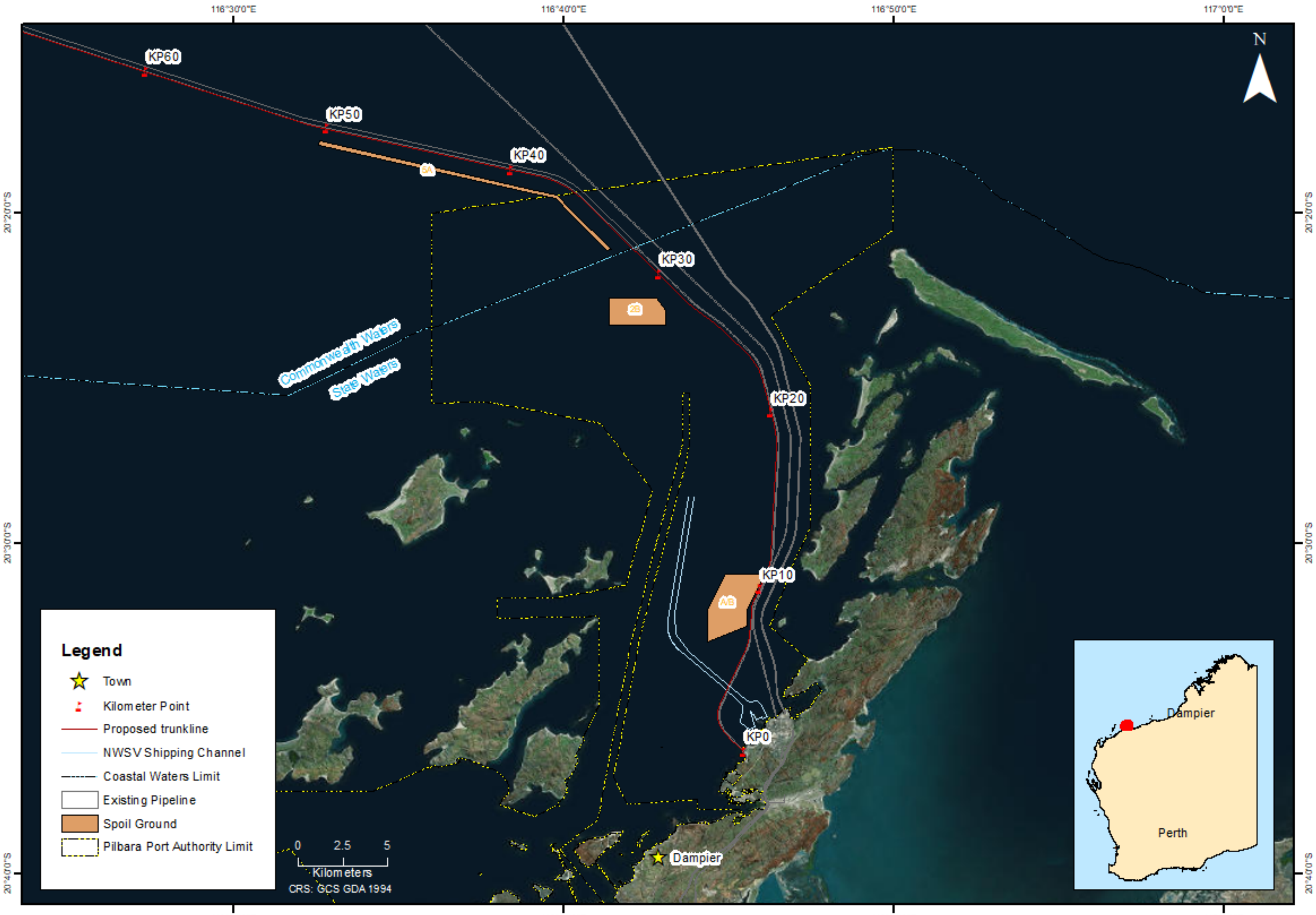

Figure 2-1: Location of proposed trunkline route and its proximity to spoil grounds (Note: no dredging will occur beyond KP 50 and therefore the remainder of the route is not shown)

Table 2-2: Proposed trunkline dredging activities

Section	Area	Primary pipeline design focus	Vessel Types Pre lay Works	Vessel Types Post lay Works
KP0 to KP0.1	Intertidal Zone	Protection	Excavation: Backhoe dredge; Land based long reach excavator	Land based long reach excavator (rock backfill)
KP0.1 to KP3.6	Shore Approach	Protection/ Stabilisation	Excavation: Back hoe dredge and barges; Trailing Suction Hopper Dredge	Trailing Suction Hopper Dredge (sand backfill); Rock Dump Vessel in discrete locations
KP3.6 to KP4.6	NWSV Channel Crossing	Protection	Trailing Suction Hopper Dredge	Rock Dump Vessel in discrete locations
KP4.6 to KP32.7	Shore Approach – State waters	Stabilisation	Trailing Suction Hopper Dredge; Backhoe Dredge (possible)	Trailing Suction Hopper Dredge (sand backfill); Rock Dump Vessel in discrete locations
KP32.7 to KP50	Shore Approach – Commonwealth waters[2]	Stabilisation (if required)	Trailing Suction Hopper Dredge	Sand backfill: Trailing Suction Hopper Dredge

Table 2-3: Locations of spoil grounds (GDA 94, Zone 50)

Spoil Ground	Easting	Northing
Spoil Ground A/B	473780	7731500
	475880	7731500
	474940	7729490
	474940	7728570
	472830	7727690
	472830	7729490
Spoil Ground 2B	467620	7746890
	470120	7746890
	470610	7746180
	470610	7745390
	467620	7745390
Spoil Ground 5A	450340	7756100
	464870	7752420
	467790	7749600
	466780	7749220
	464370	7751550
	450340	7755040

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[2] All activities in Commonwealth waters will be assessed separately as part of an Offshore Project Proposal (OPP) to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)

Woodside is investigating the use of two potential borrow grounds for backfill and stabilisation activities; one located within State waters and one located within Commonwealth waters (Figure 2-1).

2.1 Offshore material displacement

Approximately 2,500m3 – 7,500m3 of material will be displaced to allow safe pipelay operations to be conducted at KP 210 in approximately 580m water depth. This seabed material relocation will be completed using a potential combination of Mass Flow Excavation, ROV based material relocation or a grader. Any displaced material would not be recovered to the surface.

Given there are no known contamination sources at this deepwater location and the area is likely to be subject to oceanic currents that resuspend fine sediments it is not expected that this activity would expose or relocate any contaminated material and as such is excluded from further assessment in this SAP.

3 Review of Existing Information (Phase I)

3.1 History of Dampier

Multiple dredging programs within Mermaid Sound has resulted in a long history of sediment testing in the region, however, limited data is available within the previous five years. Past studies have rarely found contaminants in sediments of the Dampier Archipelago. This is considered attributable to the lack of riverine inputs and controls on discharges associated with low levels of industrial development (MScience 2004). Long-term data, from the 1960's to 2012 is discussed in detail in the SAPs for the Pilbara Iron Long Term Dredging Permit for the Port of Dampier (MScience 2016) and the Woodside Pluto Train 3 Expansion (MScience 2010), and is summarised below:

- The geology of the Port of Dampier consists of basaltic rocks, overlain by calcarenite, consolidated marine sediments and fine unconsolidated sediments, of which the top 0.3 m to 0.5 m is in a constant state of disturbance from currents and/or wave action.
- The top metre of material is largely very loose siliceous carbonate sands, silty sands, and sandy silts with some calcarenite gravel, shells and shell fragments.
- Sediments have low levels of organic carbon but frequently have a high percentage of fine sediments/silts.
- Nearshore areas along the Burrup Peninsula experience strong tidal currents during spring tides and as a result, where there is accumulation of contaminants of concern, nearshore areas are likely to lose fine sediments to the deeper basins in the middle of the Port of Dampier (and Mermaid Sound).
- Organotins and some metals are found primarily within or around existing berth load out areas, however have reduced significantly since being banned on larger vessels.
- Organotins may result from passing vessels in areas away from existing berths (e.g. navigation channel slopes).
- The potential distribution of contaminants has been confined largely to the fine sediments in the upper strata (0.5 m).
- Consolidated sediments underlying upper soft strata are very unlikely to contain contaminants above screening levels.
- Recent testing found no traces of Total Recoverable Hydrocarbons (TRHs).

3.2 Past Studies

Historically, sediments in Mermaid Sound have been considered to be generally clean (in that they were below screening levels of NODGM, with Tributyltin (TBT) the only contaminant of concern (Woodside 2007; DEC 2006).

More recent studies undertaken throughout the Archipelago, within Port limits have indicated that surficial sediments (upper 1 m of sediment) were still considered generally clean. The only analytes to exceed NAGD screening levels were arsenic and nickel and only at a small subset of sampling locations (Advisian 2018; Jacobs 2015; GHD 2016). These elevated levels were considered attributable to the natural geology of the region, which is in line with findings of studies conducted in 2006 (DEC 2006; Woodside 2007). The GHD study also determined that locations with the smallest particle grain size had higher adsorption potential and generally had higher concentrations of metals, metalloids and total organic carbon (GHD 2016). The analysis for the intermediate suite of parameters of sediments at the three sites sampled by Jacobs (2015) recorded no detectable concentrations of hydrocarbons, phenols/phenolics or chlorobenzenes. Similarly, there were no detectable concentrations of pesticides, PCBs, herbicides or cyanides recorded as part of the analysis for the detailed suite of parameters.

To support a proposal for maintenance dredging within the berth, swing basin and shipping channels associated with the Karratha Gas Plant (KGP) (and King Bay Supply Base), sediment analysis was undertaken in 2016 (MScience 2016). Material was shown to contain concentrations below NAGD screening levels for TBT, Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAHs). Similarly, metals were below the 95% UCLs for all surveyed (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Zn) with the exception of nickel. Nickel concentrations were elevated at sites located around the berths. Analysis of the data, when normalising nickel concentrations to reference sites (adjacent to Spoil Grounds A/B and 2B) concentrations indicated nickel concentrations were below the screening levels when using either aluminium or iron as a normalising parameter. The implementation report (MScience 2016) concludes that nickel concentrations are not only correlated with aluminosilicate clays, but that it is also likely to be tightly bound to the material due to the fine nature of the sediments (clays). This conclusion is also supported in the report through reference to previous bioavailability testing. Therefore, it was considered nickel is unlikely to become bioavailable during dredging and disposal activities. Nickel concentrations within the KGP shipping channel were also shown to be slightly elevated (21.5 mg/kg 95% UCL, compared to the NAGD screening level of 21 mg/kg).

The sediment assessment undertaken to support the Pluto LNG development and trunkline installation (SKM 2006) identified that in the upper layers of sediment, TBT was the only contaminant of concern that was present at concentrations above respective screening levels. Laboratory analysis showed only two of the samples returned results above detection limits (20 and 3.85 µg Sn/kg, normalised to 1% TOC), of which both were located at the outer end of the proposed navigation channel. Both results were within the top 0.5 m of the sample whereas lower sections of the same sample were clean. Results along the proposed route were shown to be below detection limits. The 95% UCL were all below screening levels for TBT. The lower seabed contaminants of concern, metals (Sb, As, Ca, Cr, Cu, Pb, Hg, Ni, Ag, Zn) and hydrocarbons (TPH, PAH and BTEX) were sampled from the geotechnical assessment as part of the development and sampled from 1 m to a maximum of 4 m depth. Results indicated that all potential contaminants were also below the 95% UCLs. The dredge material was shown to be suitable for unconfined ocean disposal.

3.2.1 Grain Size

Seabed sediment grain size in the Dampier Archipelago region is highly variable, due to the presence of strong tidal currents, periodic cyclones, protected embayments and sediment-producing organisms such as coral reefs (Talbot and Creagh 1985). Analysis of particle size distribution sediment survey for the Pluto LNG Facility dredging footprint in January 2006, found sediments adjacent to Holden Point to be predominately sand (particle size of 0.06–2.0 mm). Further offshore, within the navigation channel the sediments were comprised of sand (particle size of 0.06–2.0 mm); silt (0.002–0.06 mm) and clay (≤0.002 mm) (Woodside 2007). Similarly, most sites sampled by Jacobs (2015) within Mermaid Sound were dominated by silt and clay.

3.3 Classification of Proposed Survey Areas

The NAGD classifies projects as maintenance or capital dredging. While this Project does not fall neatly into either of these categories, it is considered most akin to capital dredging. According to the NAGD, rather than total dredge volume, the number of sample locations should be based on the volume of contaminated and potentially contaminated dredge material. Therefore, the dredge area has been split into various zones for the purpose of classifying the dredge material. The following sections describe the likely contamination status ('probably contaminated', 'suspect', 'probably clean'), the rationale for the likely contaminants of concern and the testing status for each of the various zones to be dredged.

As there is a long history of dredging at the Port of Dampier, there are long-term datasets of sediment quality which are highly relevant in describing the contamination status of marine sediments within the Port. As the industrial use within the port has remained unchanged for more than a decade. In the absence of any major pollution events, data collected from more than five years ago remains relevant and has been referenced in the following sections, together with more recent data that has been collected in the last five years.

The results from previous studies and the environmental factors of each area are considered in the following sections and then summarised within Table 3-1.

3.3.1 Nearshore Zone (except NWSV Channel)

The Port of Dampier is remote from any catchment influences such as agricultural or rural runoff, due to its location on the Burrup Peninsula. The trunkline intersects the mainland adjacent to the existing Pluto LNG jetty, and the NWSV LNG jetty and the Dampier Heavy Load Out (HLO) Wharf lie about 1.2 km to the north and south, respectively. Areas within ports and adjacent to berth pockets are potentially contaminated due to shipping related activities. As a result, likely contaminants may include trace metals and TBT (from antifoulant coatings).

Sediment sampling within the immediate vicinity of the proposed trunkline route (SKM 2006) confirmed that TBT, metals and hydrocarbons within the material were below the 95% UCLs. However, while sand was the predominant seabed material, there were high proportions of silts and clays present.

More recent sediment assessments completed by Jacobs (2015) and GHD (2016) at the Port of Dampier identified elevated levels of TBT, nickel and arsenic in the nearshore areas (the general port, and King Bay) and also around East Intercourse Island. Furthermore, the Dampier Maintenance Dredging assessment indicated high levels of nickel adjacent to berths at the Karratha Gas Plant (KGP). Annual chemical and ecological monitoring of Mermaid Sound (ChEMMS) by Woodside has been continuing around the KGP for more than 20 years. The most recent monitoring results from marine sediments sampled adjacent to the shipping berths also confirm the presence of very low levels of selected contaminants, that are well below screening levels, with the exception of low level exceedances of nickel.

It is therefore possible that the material nearshore to the Port is ‘suspect’, while the general nearshore zone is ‘probably clean’ in accordance with Appendix D of the NAGD. As a result, screening of potential contaminants (trace metals and TBT) will be conducted in the upper sediments (0–1 m) of this zone.

3.3.2 NWSV Channel Crossing Zone

The trunkline crosses the NWSV shipping channel zone between KP 3.6 and KP 4.6. Maintenance dredging is required within the channel of which data from the Pluto Foundation Project (Woodside 2007) and by the Dampier Port Authority (WorleyParsons 2009), indicated no exceedances of the NAGD guidelines. However, as described in Section 3.2, nickel concentrations have been shown to be elevated in the area when tested recently (MScience 2016). Due to the recent results, the proximity to shipping activity, and the potential for contaminant accumulation due to deeper maintained depths, the material while characterised as ‘probably clean’ in accordance with the NAGD, screening of potential contaminants (trace metals and TBT) will still be conducted in the upper sediments (0–1 m) of this zone.

3.3.3 Outer Mermaid Sound Zone

The long sediment characterisation history, as described in MScience (2010), indicates that the only previous contaminant of concern outside the immediate area of existing shipping berths has been TBT. Sampling in 1998 along the TSEP trunkline indicated sediments were free of TBT and suitable for unconfined ocean disposal and sampling in 2006 for the Pluto trunkline installation demonstrated that only a single sample was above the TBT screening level (20 µg Sn/kg, normalised to 1% TOC) (SKM 2006). Sediments below 1 m were sampled for metals, and overall the 95% UCL for all metals were found to be below screening limits (although some samples were occasionally above limits for some metals; arsenic, chromium, nickel and silver).

Sampling between KP 4.6 to KP 15 within this zone will be undertaken for trace metals and TBT, given historic information indicates the material to be dredged in this area may be classified as ‘suspect’.

As the Outer Mermaid Sound seabed area is impacted significantly by oceanic swells that resuspend sediments within the area, it is considered unlikely that the area will accumulate toxicants. Further, given a borrow ground is located at the trunkline route at about KP 15, it is likely that the material within this area is suitable for ocean use/disposal and likely to be categorised as “probably clean”.

An exemption was granted on 5 March 2019 from testing between KP 15 and KP 36 due to the material being classified as ‘probably clean’ in accordance with Appendix D of the NAGD.

3.3.4 Offshore Zone

Similar to the Outer Mermaid Sound zone, exemption was granted from testing between KP 36 and KP 50 due to the following:

- There are no known contamination sources outside Mermaid Sound, with the exception of shipping and dredging for the Pluto trunkline installation (which occurred more than ten years ago), in which sediment testing at the time demonstrated material in this area was not contaminated and suitable for open water ocean disposal (Woodside 2007).
- TBT is unlikely to be present as there is less shipping activity concentrated in this zone and the seabed is subject to the influence of oceanic swells and currents.
- The spoil from this zone will be disposed into Spoil Ground 5A, which runs parallel to the trunkline route and therefore will have similar chemical and physical characteristics.

3.3.5 Summary of Survey Area Classifications

Table 3-1: Summary of each dredging and disposal area

Area	Proposed Use	Contaminants of Concern	Classification	Testing Status	Justification
Nearshore Zone					
KP 0 to 3.6	Dredging and disposal to Spoil Ground A/B	TBT/metals	Suspect	Top sediments (0–1.0 m) to be sampled.	Areas within and adjacent to Ports/berths are considered to be potentially contaminated and previously show elevated levels of nickel (MScience 2016).
KP 4.6 to 6.2	Dredging and disposal to Spoil Ground A/B	TBT/metals	Probably clean	Top sediments (0–1.0 m) to be sampled. Propose number of sampling locations to be halved.	Given previous sediment sampling indicates the material is “probably clean”, the NAGD allows for the number of sampling locations to be halved.
KP 6.2 to 11.0	*No dredging required*				

Area	Proposed Use	Contaminants of Concern	Classification	Testing Status	Justification
NWSV Channel Zone					
KP 3.6 to 4.6	Dredging of pre-excavated trench and disposal to Spoil Ground A/B	TBT/metals	Probably clean	Top sediments (0–1.0 m) to be sampled.	N/A
Outer Mermaid Sound Zone					
KP 11 to 15	Dredging and disposal to Spoil Ground A/B	TBT/metals	Probably clean	Top sediments (0–1.0 m) to be sampled. Proposed number of sampling locations to be halved.	Given previous sediment sampling indicates the material is "probably clean", the NAGD allows for the number of sampling locations to be halved.
KP 15 to 18.4	Dredging and disposal to Spoil Ground A/B	N/A	Probably clean	Granted exemption	Adjacent to/within existing borrow ground.
KP 18.4 to 36	Dredging and disposal to Spoil Ground 2B	N/A	Probably clean	Granted exemption	Offshore area with no known contamination sources. Sediments clean when sampled for the Pluto trunkline installation.
Offshore Zone (beyond PPA limits)					
KP 36 to 50	Dredging and disposal to Spoil Ground 5A	N/A	Probably clean	Granted exemption,	Offshore area with no known contamination sources. Sediments clean when sampled for the Pluto trunkline installation and being disposed of at adjacent spoil ground where material is likely to be similar in nature.
KP 50 to 433	*No dredging required*				

3.4 Potential Sources of Contamination

Several ports are located within the vicinity of the Pluto LNG jetty and the wider Mermaid Sound region. Areas within ports and adjacent to berth pockets are potentially contaminated due to shipping related activities, with likely contaminants near the Pluto LNG jetty being trace metals and TBT (from antifoulant coatings). TBT however, may no longer continue to be of significant concern given the phasing out of the substance under International Maritime Organisation (IMO) guidelines, the Protection of the Sea (Harmful Anti-fouling Systems) Act 2006, and further, the International Convention on the Control of Harmful Anti-fouling Systems on Ships has prohibited the use of TBT since 2008. Therefore, it is likely that as sources of TBT reduce, the residual TBT found in sediments will degrade over time. Given the proximity to a high shipping area, particularly nearshore and within the NWSV Channel, TBT is still proposed to be tested against the NAGD screening levels given it was found nearby in the sediment assessment for the Pluto LNG trunkline development (SKM 2006).

Organic compounds such as Total Recoverable Hydrocarbons (TRHs) and Polycyclic Aromatic Hydrocarbons (PAHs) can accumulate in sediments following releases of fuel or oils to water. While some incidents have been reported in the area between 2010 and 2012, none of them resulted in a significant spill of such compounds. As a result, it is considered highly unlikely that these contaminants would be present along the trunkline route. Additionally, they have never been found above the NAGD (low) screening levels.

Trace metals are considered likely to be present, particularly within proximity to berths due to spillage while loading/unloading of product (such as iron ore). Subsequently, it is considered unlikely that contamination would be present more than 500 m from berths. Previous studies have detected however, some levels of trace metals (such as arsenic, chromium, nickel and silver). Therefore, key trace metals will still be assessed and analysed in this SAP.

The full list of contaminants of concern that will be tested as part of this SAP is contained within Section 4.3.

4 Sampling Plan (Phase II)

4.1 Number of Sample Sites

The proposed zones for dredging have been divided up into areas based on the sections of trunkline requiring dredging, and the likelihood of contamination (Section 3.3). In accordance with the NAGD (Appendix D), the number of sample locations for capital dredging projects is based on the volume of contaminated and potentially contaminated material, excluding the volume of underlying natural geological materials (given they are expected to be uncontaminated). As a result, the volumes calculated for the Dredging zones are to 1 m depth. These volumes, their contamination classification and number of sampling sites (including QA/QC samples – see Section 4.7) are shown in Table 4-1. It should be noted that areas in which an exemption was granted have been excluded from Table 4-1.

Table 4-1: Number of sampling sites for each dredge area

KP	Classification	Volume of potentially contaminated material (m^3) + 20% contingency	No. of Sampling Sites	No. of Triplicate Sites	No. of Field Split Sites
Nearshore Zone					
KP 0 to 3.6	Suspect	129,600	19	2	1
KP 4.6 to 6.2	Probably clean	57,600	7*	1	1
NWSV Channel Zone					
KP 3.6 to 4.6	Probably clean	36,000	5*	1	1
Outer Mermaid Sound Zone					
KP 11 to 15	Probably clean	144,000	10*	1	1

** The NAGD states that where there is good quality current data to support the classification, the number of sample locations in the 'probably contaminated' and 'probably clean' categories may be halved.*

4.2 Sample Locations

Given the width of the trench at its widest location is expected to only be 30 m (Section 2), rather than lay a grid over the area to randomly select sample locations (as suggested by the NAGD), a random number generator (within Microsoft Excel) was used to output random distances along the trunkline for each of the areas in Table 4-1. Triplicate and Field Split sites were also chosen randomly using the same methodology. The resulting sample locations are listed in Table 4-2.

Table 4-2: Location of sampling sites (GDA 94, zone 50)

Zone	Site No.	KP	Easting	Northing	Triplicate Site	Field Split Site
Nearshore Zone						
KP 0 to 3.6	N1	0.05	474731.517	7721585.259		
	N2	0.20	474622.173	7721687.943		
	N3	0.42	474461.803	7721838.546		
	N4	0.44	474447.223	7721852.237		
	N5	0.96	474087.306	7722226.785		
	N6	1.04	474034.920	7722287.248		
	N7	1.21	473923.599	7722415.730	✓	
	N8	1.35	473831.924	7722521.539		
	N9	1.38	473812.279	7722544.212		
	N10	1.39	473805.731	7722551.770		✓
	N11	1.41	473792.634	7722566.886		
	N12	2.36	473391.202	7723410.990		
	N13	2.49	473380.076	7723540.472		
	N14	2.63	473380.674	7723680.420	✓	
	N15	2.86	473409.917	7723908.326		
	N16	3.44	473613.185	7724450.016		
	N17	3.48	473629.423	7724486.572		
	N18	3.58	473670.019	7724577.961		
	N19	3.59	473674.078	7724587.100		
KP 4.6 to 6.2	N20	4.68	474116.567	7725583.244		
	N21	5.00	474246.472	7725875.690		
	N22	5.06	474270.829	7725930.524	✓	
	N23	5.35	474388.556	7726195.553		
	N24	5.91	474615.890	7726707.334		
	N25	6.06	474676.783	7726844.418		✓
	N26	6.07	474680.842	7726853.557		
NWSV Channel Zone						
KP 3.6 to 4.6	C1	3.65	473698.435	7724641.934		
	C2	3.82	473767.447	7724797.296	✓	✓
	C3	4.31	473966.364	7725245.103		
	C4	4.38	473994.781	7725309.076		
	C5	4.52	474051.615	7725437.021		

Zone	Site No.	KP	Easting	Northing	Triplicate Site	Field Split Site
Outer Mermaid Sound Zone						
KP 11 to 15	M1	11.33	476068.386	7731872.300		
	M2	11.47	476106.812	7732014.167		
	M3	11.53	476118.612	7732065.836		
	M4	11.75	476155.801	7732282.598		
	M5	11.80	476161.583	7732332.261	✓	
	M6	12.59	476205.612	7733120.973		
	M7	12.68	476210.200	7733210.856		
	M8	14.59	476307.558	7735118.373		✓
	M9	14.83	476319.791	7735358.061		
	M10	14.85	476320.811	7735378.035		

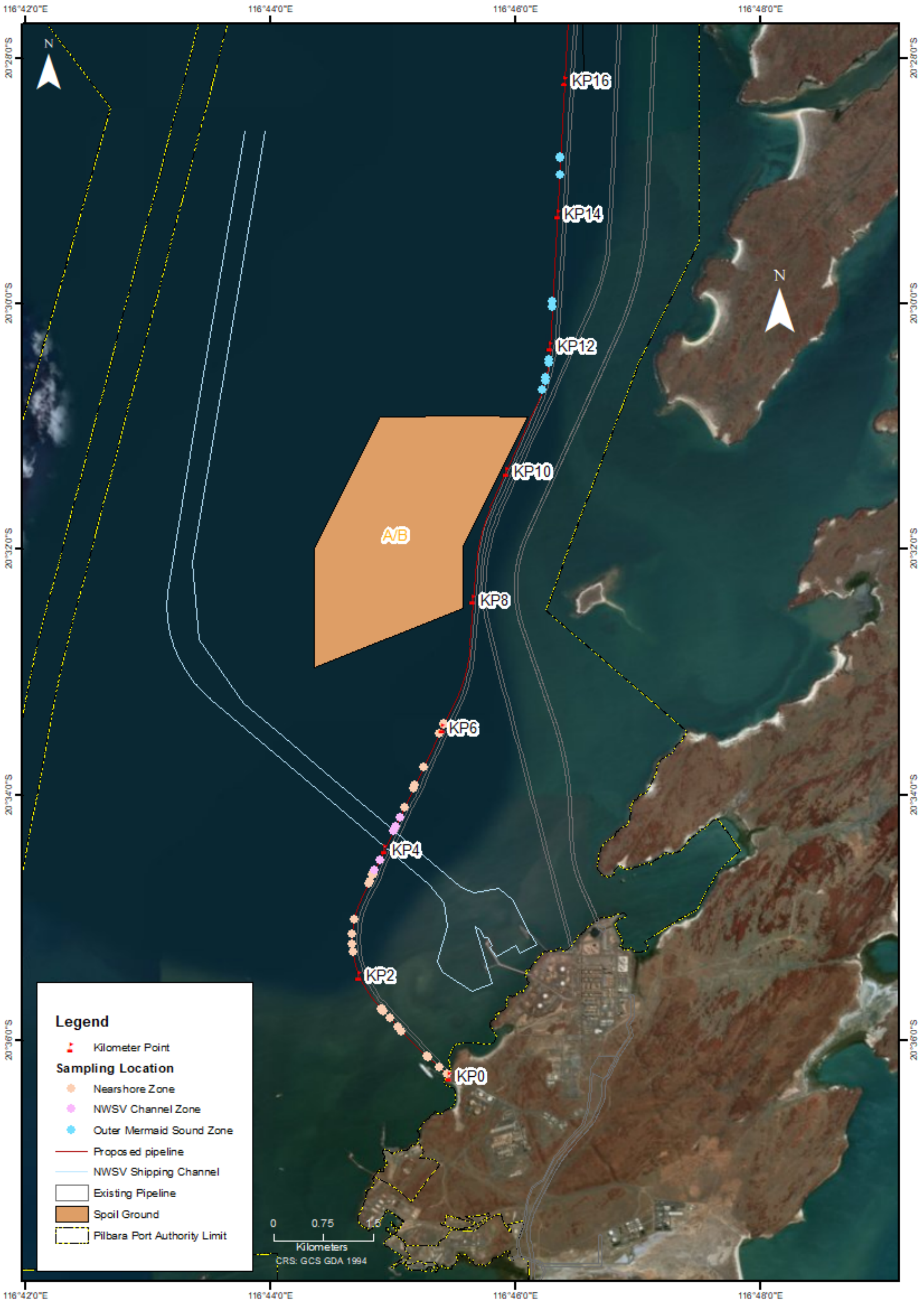

Figure 4-1: Location of sampling sites

4.3 Contaminants List

Following consideration of the history of Dampier and the dredge area, and the possible sources of contamination (Section 3), the proposed analytes for sediment samples to be analysed are:

- particle size distribution (PSD)
- total organic carbon (TOC)
- organotins (TBT)
- trace metals (Cu, Pb, Zn, Cr, Ni, Cd, Hg, As, Ag, Al, Fe and Sb).

4.4 General Sampling Procedures

Samples will be collected by either diver-based hand coring or remotely using a piston corer. Prior to each sample being collected, equipment will be washed with diluted decontamination solution (decon 90) and rinsed in seawater. For hand coring, divers will use a hand-held GPS to swim to the sample site, prior to driving a Polycarbonate tube (1 m long and at least 50 mm in diameter) into the seabed for the full length of the tube, or until refusal. The tube will then be capped and recovered back to the vessel. For piston coring, the vessel will use its GPS system to position the vessel as close as possible to the sample site, prior to collecting the core. Piston corers will be capable of recovering a core 1 m long and at least 50 mm in diameter. Where insufficient material is collected additional cores will be taken 1 m from the initial sample (or as close as possible, in the case of piston coring). The same process will be followed at sites where triplicate samples are required, ensuring samples are taken in a triangular/circular pattern at 1 m distances.

Upon recovery of the cores to the vessel, the samples will be described and photographed prior to the top 50 cm of the core being placed into a glass bowl (previously cleaned with decon 90) and briefly mixed with either wooden or Teflon coated spoons. A second sample from the 50–100 cm interval will also be taken. Sample containers will be completely filled with sample, or where insufficient sample exists, filled with water from the site the sample was taken. Sub-samples will then be labelled clearly with a unique identifier, placed into the appropriate laboratory-provided sample containers and then stored in eskies with fresh ice. At the end of each day, samples will be transferred to a fridge on land. At the completion of the sampling, samples will be sent chilled, to the laboratory in Perth. All samples, at all times, will be accompanied by an appropriate Chain of Custody (CoC) form.

The NAGD provides a guide to the storage conditions and durations in Appendix H. These, along with the volumes required (replicated from NAGD, Appendix D, Table 5) for each test are summarised in Table 4-3. Where procedures, volumes or preservation requirements are uncertain, they will be checked with the receiving laboratory.

Table 4-3: Sample volumes and preservation requirements (reproduced from DEWHA 2009)

Test	Volume required (grams, w/w)	Storage container	Preservation technique	Storage conditions	Storage duration
PSD	50–200	Whirlpac bag	Refrigerate	<4°C	Undetermined
TOC	10–50	Heat-treated glass vial with Teflon-lined lid	Dry ice or freezer for extended storage, otherwise refrigerate	<20°C	Undetermined
Organotin	100–250	Solvent rinsed glass jar with Teflon lid	Dry ice or freezer for extended storage, otherwise refrigerate	<4°C, in the dark	14 days if refrigerated
Metals	10–100	Pre-cleaned, pre-weighed polyethylene jar	Dry ice or freezer for extended storage, otherwise refrigerate	≤4°C	Hg – 28 days unless frozen. Others – 6 months

4.5 Laboratory Methods

The laboratories contracted to undertake the analyses will be accredited by National Association of Testing Authorities (NATA) and capable of meeting the practical quantitation limits (also referred to as limits of reporting (LOR)) detailed in Section 4.6. The primary laboratory will undertake the bulk of the sampling, while a secondary laboratory will complete testing of split samples. Testing methods will be acceptable methods that provide the necessary performance characteristics and are validated on the USEPA methods using standard reference materials.

4.6 Practical Quantitation Limits

The laboratory contracted to undertake the analyses will be NATA accredited and capable of meeting the practical quantitation limits (also referred to as LORs) set out in Table 1, Appendix A of the NAGD. These have been replicated for the contaminants list (Section 4.3) in Table 4-4.

Table 4-4: Practical quantitation limits (PQL) (Source: Table 1, DEWHA 2009)

Parameter	PQL
Basic Sediment Characteristics	
Moisture Content	0.1%
Total organic carbon	0.1%
Particle size and settlement rate	Size distribution (sieve + hydrometer) and rates of settlement after 50% and 90% of settlement, in seawater if possible
Organic Compounds	
Organotin compounds	1 µgSn/kg
Inorganic Compounds	
Copper	1 mg/kg
Lead	1 mg/kg
Zinc	1 mg/kg
Chromium	1 mg/kg
Nickel	1 mg/kg
Cadmium	0.1 mg/kg
Mercury	0.01 mg/kg
Arsenic	1 mg/kg
Silver	0.1 mg/kg
Aluminium	200 mg/kg
Iron	100 mg/kg
Antimony	0.5 mg/kg

4.7 Quality Assurance and Quality Control

4.7.1 Field QA/QC

The following QA/QC measures will be undertaken during sampling:

- Sample containers will be sourced from the laboratory.
- Prior to use, any evidence of or sources of contamination will be cleaned and either removed from the vessel or covered to ensure contamination does not occur.
- Disposable, powder-free gloves will be used for handling of samples and changed after each sample.
- Equipment will be decontaminated between the collection of each sample.
- Chain of Custody forms will accompany samples and each stage of handling will be recorded.

Field QA/QC samples will be collected and analysed, as per those outlined in Table 4-5.

Table 4-5: Field QA/QC sample detail

QA/QC sample	Description
Field Triplicate	Field triplicate samples are three separate samples collected at the same location and analysed to determine variability of sediment characteristics
Inter Laboratory Field Duplicate (Field Split)	Inter laboratory field duplicate samples are two subsamples from a homogenised sample collected from the same location and analysed to identify any variation in analytical protocol of the primary laboratory.
Intra Laboratory Field Duplicate	Intra laboratory field duplicate samples are two subsamples from a homogenised sample collected from the same location and analysed to identify variation associated with sub sample handling.
Rinsate Blank	One sample for each day of sampling. Collect rinsate sample from the sampling bowl and/or utensil used to fill sample jars with sediment.

4.7.2 Laboratory QA/QC details

NATA accredited laboratories are required to incorporate QA/QC methods to ensure the accuracy of results. This includes internal laboratory QA/QC samples as per Table 4-6.

QA/QC procedures for the analysis of sediment will be carried out in accordance with the requirements of Appendix F of the NAGD and include the following:

- Provision of appropriate sample containers
- COC documentation
- Sample Receipt Notification
- NATA accredited analyses
- Appropriate storage of samples
- Analyses within recommended holding times
- Internal laboratory QA/QC analyses (laboratory blanks, standards, duplicate and spike samples)

Table 4-6: Laboratory internal QA/QC testing requirements

QA/QC test	Description
Laboratory Standard (control)	A known matrix is spiked with target analytes and tested to verify the accuracy of the performance of the test.
Laboratory Blank	Identifies any cross contamination during laboratory preparation, extraction or analysis. A 'blank' matrix is taken through the entire test method to monitor the response and variability. The data quality limit for the blank is equal to the detection limit for the particular contaminant.
Laboratory Surrogate	Used for organic analyses to indicate the ability of the laboratory testing method to extract a specific contaminant from the sample. A known quantity of a compound, similar in nature to the composition of the target analyte, is added to the matrix prior to extraction.
Laboratory Matrix Spike	Quantifies the level of interference from the sediment matrix on the contaminant recovery. A known amount of target analytes are added to a split field-collected sample.
Laboratory Duplicates	A sample is tested and analysed in duplicate to assess the variance in the testing method (including laboratory sub-sampling and analysis). Results will be compared with a Relative Percentage Difference of less than 35% between samples.

Review and validation of laboratory QA/QC results will be undertaken according to the requirements of the NAGD to identify any unusual results reported and will be presented in the final report (see Section 5).

4.7.3 Data Validation

Analytical data validation will be undertaken to assess the degree of compliance with the project specific sampling and analysis protocols and whether the data is of a suitable quality to fulfil the project objectives.

This will include the following data quality criteria for field samples and laboratory samples as shown in Table 4-7 and Table 4-8 respectively.

Table 4-7: Data Quality Criteria for Field QA/QC samples

Data Type	Number of Samples	Data Quality Limit
Field Triplicate	10% of all sample locations (Table 4-2)	<+/- 50% RPD
Field Split (intra lab and inter lab duplicates)	5% of all locations (Table 4-2)	<+/- 50% RPD
Rinsate Blank	One sample for each day of sampling.	Samples tested for all contaminants listed in Section 4.3 should be below LOR

Upon receipt of laboratory results, QA/QC results will be checked and reviewed for inconsistencies or outliers. Validation of the laboratory data and field QA/QC samples will be undertaken according to the requirements of the NAGD and will be presented in the SAP implementation report.

Table 4-8: Data Quality Criteria for Laboratory QA/QC samples

Data Type	Number of Samples	Data Quality Limit
Laboratory Blank	1 sample per batch (of 20 samples) or fewer	At or near the LOR used
Laboratory Surrogate	1 sample per batch (of 20 samples) or fewer	Recovery limit of 80-120%
Laboratory Matrix Spike	1 sample per batch (of 20 samples) or fewer	Recovery limit of 75-125%
Laboratory Duplicates	1 sample per batch (of 10 samples) or fewer	RPD within 35%

4.8 Data Assessment

Data analysis of the laboratory results will involve determining the mean, standard deviation and 95% UCLs of each parameter for each dredging area. These results will then be compared to the screening levels in Table 4-9 (refer to Table 2, Appendix A of the NAGD). A result will be considered an exceedance where the 95% UCL for a contaminant exceeds the value specified in Table 2. The exceedance will then be compared to ambient baseline concentrations as outlined in Appendix A of the NAGD. Given the history of dredging in the region, ambient baseline concentrations may be difficult to ascertain when comparing data from “reference” sites elsewhere in the Port. If this is not possible, ambient baseline levels will be determined by normalising to a reference element such as aluminium, which enables a better determination of ambient baseline level to be made, particularly where grainsize and TOC are not comparable between samples.

Exploratory data analysis will also be undertaken to understand any spatial heterogeneity within each area.

Organics such as TBT will be normalised to 1% TOC as recommended in Table 2, Appendix A of the NAGD.

Table 4-9: Screening levels, from Table 2, Appendix A of the NAGD

Parameter	Screening Level (mg/kg)
Metals and Metalloids	
Antimony	2 mg/kg
Arsenic	20 mg/kg
Cadmium	1.5 mg/kg
Chromium	80 mg/kg
Copper	65 mg/kg
Lead	50 mg/kg
Mercury	0.15 mg/kg
Nickel	21 mg/kg
Silver	1 mg/kg
Zinc	200 mg/kg

4.9 Elutriate and Bioavailability Testing (Phase III)

Where an identified 95% UCL values exceed the screening levels and the mean concentration is above the 80th percentile of ambient baseline concentrations, Phase III investigations, elutriate and bioavailability testing, as described in the NAGD will be required to determine if a bioavailable fraction is present that may impact the marine environment and to demonstrate if material is suitable for unconfined ocean disposal. Phase III investigations, if required, will be the subject of a Supplementary SAP.

4.10 Vessel and Personnel Requirements

The vessel shall be a survey vessel that has an appropriate storage and sample area for samples. The work area must be free from debris and residue, and any contaminants (i.e. sunscreen, zinc anodes, oils, etc.) to minimise the risk of cross contamination. The work area will be decontaminated prior to use.

Field personnel will be experienced in the procedures for collection of marine sediments and understand the requirements of this SAP. All field personnel will partake in a pre-start meeting/training prior to mobilisation to ensure they are competent with the equipment and procedures required.

The materials expected to be required are:

- vessel GPS
- hand-held GPS
- polycarbonate tube
- Grab Sampler
- clean sample containers (provided by the nominated laboratories)
- eskies and ice blocks
- Pyrex glass bowls
- Teflon-coated or wooden spoons
- decon 90

- digital camera
- waterproof paper, pens and pencils
- personal protective equipment (PPE), including inert gloves
- field log sheets and CoC forms.

4.11 Health and Safety

All sampling activities will be conducted under a Health and Safety Management Plan to be developed by the sampling contractor and agreed with Woodside prior to the commencement of any field work associated with this SAP. The plan will detail diving health and safety procedures, operational procedures for simultaneous operations, developed in consultation with Woodside and PPA (and NWSV where relevant), particularly for nearshore works and work undertaken within the NWSV shipping channel.

A Job Hazard Analysis will also be undertaken prior to the commencement of sampling to address specific risks associated with the field survey.

Field personnel involved in handling sediments shall wear appropriate PPE at all times, including, safety boots, glasses, inert gloves and coveralls.

4.12 Contingency Planning

Unforeseen poor weather (such as strong winds or other weather-related sea conditions), or unavailability of critical equipment (i.e. vessel) would result in postponement of the program and the sampling vessel and team will return to shore where conditions prevent safe sampling, until such time that it is safe/possible to resume. In the case of extended delays, any samples already collected would be submitted to the laboratory for analysis, within the prescribed recommended holding times.

For nearshore works, sufficient notice shall be provided to the relevant authorities (i.e. Harbour Master and PPA) to reduce delay due to shipping movements. Logistics of operations around busy port areas (particularly within the NWSV shipping channel) will be addressed as part of the Health and Safety Management Plan, prior to the commencement of sampling.

Where possible, sufficient redundancy of equipment should be made available to accommodate for breakages and losses to ensure sampling productivity.

5 Reporting

A SAP Implementation Report will be required to be prepared in accordance with the NAGD and shall contain the following as a minimum:

- Executive Summary
- Introduction
- Methodology, including sampling and analysis procedures, figures demonstrating sampling locations, sample numbers and include detail of QA/QC samples
- Results, including:
  - colour graphical representations of results across depths and sites with the reference to the ANZECC screening levels
  - a comparison of the contaminant levels detected with background levels from previous programs
  - tabulated analytical results, highlighting any exceedances of the screening levels.
- Conclusions as to the acceptability or otherwise, of the spoil for open water disposal and/or recommendations as to any further work required
- Appendices:
  - sample photographs
  - CoC records
  - official laboratory reports (including QA/QC samples and results).

6 References

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GHD (2016). Port of Dampier Sediment Sampling and Analysis: Chemical Analysis. Report prepared for the Pilbara Ports Authority.

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SKM (2006). Pluto LNG Development: Sampling and Analysis Plan Implementation Report. Sinclair Knight Merz prepared for Woodside Burrup Pty Limited.

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Talbot, V. and Creagh, S. (1985). Mineralogical variation within the marine sediments of the Dampier region: a dynamic approach. Department of Conservation and Environment Western Australia.

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WorleyParsons (2009). DPA Dampier Marine Services Facility: Assessment on Referral Information. Produced for the Dampier Port Authority's DMSF Development.

Appendix B Field Images and Logs


30/3/19
R1
Bottom


30/3/19
R2
Bottom


31/3/19
R3 Relocated
Top
Bottom


31/3/19
R4
Top
Bottom


29/3/19
R5
TOP
Bottom


29/3/19
R6
TOP
Bottom


31/3/19
R7A
TOP
BOTTOM


31/3/19


31/3/19
R7C
TOP
BOTTOM


29/3/19
TOP
BOTTOM


27/3/19
N9
TOP
BOTTOM


29/3/19
N10
TOP
BOTTOM


31/3/19
N11
TOP
BOTTOM


29/3/19
N12
TOP
BOTTOM


Date: 30/3/19
Sampling Site: N13
TOP
Bottom


N14A


N14B

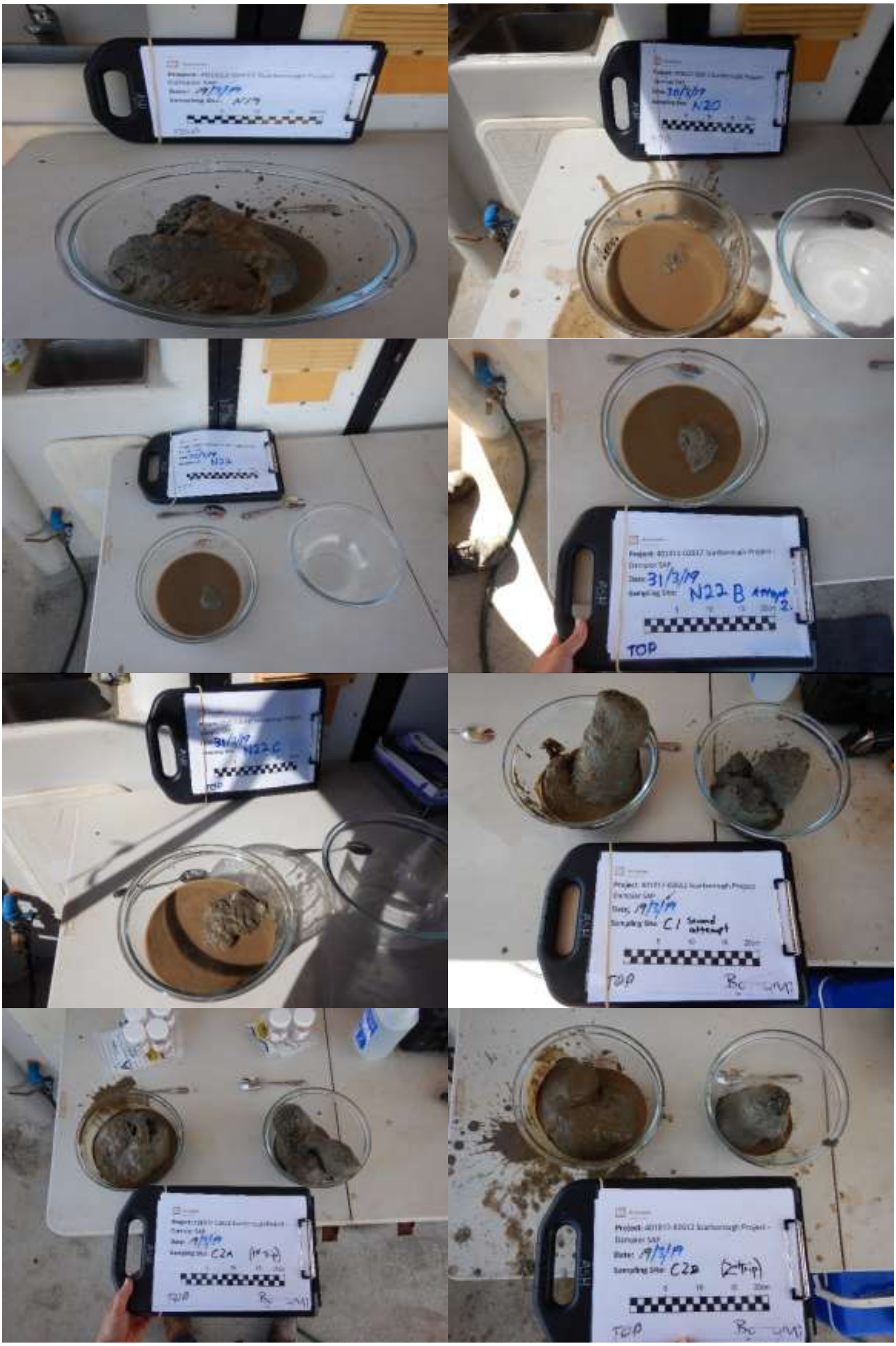

CREW ONLY
N14C


N15


Date: 19/4/19
Sampling Site: N16
TOP


Project: 401012-80812 Scarborough Project – Dampier SAP
Date: 19/4/19
Sampling Site: N17
TOP


Project: 401012-80812 Scarborough Project – Dampier SAP
Date: 19/4/19
Sampling Site: N18
TOP
BOTTOM


19/3/19
N19
TOP
30/3/19
N20
N22
Project: 401013-02017 Scarborough Project - Dampier SAP
Date: 31/3/19
Sampling Site: N22 B Attempt 2
TOP
31/3/19
N22C
TOP
Project: 401013-02017 Scarborough Project
Dampier SAP
Date: 19/3/19
Sampling Site: C1 Second attempt
TOP
BC
Date: 19/3/19
Sampling Site: C2A (1st trip)
TOP
BC
Project: 401013-02017 Scarborough Project - Dampier SAP
Date: 19/3/19
Sampling Site: C2B (2nd trip)
TOP
BC


Date: 20/3/19
Sampling Site: C 4
TOP
18/4/19
M1
TOP
BOTTOM
18/4/19
M2
TOP
BOTTOM
18/4/19
M4
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M5A
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M5B
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M5C
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M6
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M7
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M8
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M9
TOP
BOTTOM


Date: 17/3/19
Sampling Site: M10
TOP
BOTTOM

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: [illegible]/3/19 **TIME:** 0918 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	M10
Sample Id's assigned	M10T M10B
Easting/Longitude of core location (from onboard GPS)	~~0476324~~ ~~7735337~~
Northing/Latitude of core location (from onboard GPS)	0476324 7735372
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	calm
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	8KTS W no traffic
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	silt					0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 17/3/19 **TIME:** 1230 **LOCATION:** MERMAID SOUND

General location of core of sampling location	
Site/location number	M9
Sample Id's assigned	M9T M9B
Easting/Longitude of core location (from onboard GPS)	0476309
Northing/Latitude of core location (from onboard GPS)	7735193
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm <10kt W
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	silty sand	W	VG	F	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 17/3/19 **TIME:** 1135 **LOCATION:** MS

General location of core of sampling location	
Site/location number	M8
Sample Id's assigned	M8T M8I M8B
Easting/Longitude of core location (from onboard GPS)	0476322 WP 384
Northing/Latitude of core location (from onboard GPS)	7735104
Water depth at core location	13.5 - 14

Sample collector	AL / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	N/A
General comments	TOP SAMPLE QUITE WATERY DUE TO EXCESS WATER IN LAY FLAT TUBING

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Silty Sand	VW	VG	Fine	T.? mod/low B-high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 17/3/19 TIME: 1320 LOCATION: MS

General location of core of sampling location	
Site/location number	M7
Sample Id's assigned	M7T M7B
Easting/Longitude of core location (from onboard GPS)	04 76211 wp 385
Northing/Latitude of core location (from onboard GPS)	7733 209
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM 10KT N
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Sandy Silt	W	VG	F	HIGH	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 17/3/19 **TIME:** 1424 **LOCATION:** MS

General location of core of sampling location	
Site/location number	M6
Sample Id's assigned	M6T M6B
Easting/Longitude of core location (from onboard GPS)	4076206 wp 386
Northing/Latitude of core location (from onboard GPS)	7733120
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM 10 KT W
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	GREY	SANDY SILT	W	VG	F	High	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 17/3/19 **TIME:** 1527 **LOCATION:** MS

General location of core of sampling location	
Site/location number	M5A
Sample Id's assigned	M5AT M5AB
Easting/Longitude of core location (from onboard GPS)	OL 76168 UP 387
Northing/Latitude of core location (from onboard GPS)	7732321
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM 0.5m 10 kt
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Sandy silt	W	VG	F	HIGH	0	~~[illegible]~~ 2%	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** 0805 **LOCATION:** MS

General location of core of sampling location	
Site/location number	MSB
Sample Id's assigned	MSBT MSBB
Easting/Longitude of core location (from onboard GPS)	0476168 WP 388
Northing/Latitude of core location (from onboard GPS)	7732317
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM <10KT
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Sandy silt	W	VG	F	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** 0913 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	M5C
Sample Id's assigned	M5CT M5CB
Easting/Longitude of core location (from onboard GPS)	0476132 WP 389
Northing/Latitude of core location (from onboard GPS)	7732346
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm <10 kts
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	Lots of water in top 50cm from tubing

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Sandy Silt	W	VG	F	high	0	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** 1030 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	M4
Sample Id's assigned	M4T M4B
Easting/Longitude of core location (from onboard GPS)	0476153 wt 390
Northing/Latitude of core location (from onboard GPS)	7732276
Water depth at core location	13-14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm <10 kts
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	Some red-brown fines in top sample

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Silty Sand	M	VG	F	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** 1130 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	M3
Sample Id's assigned	M3T M3B
Easting/Longitude of core location (from onboard GPS)	0476117 WP 391
Northing/Latitude of core location (from onboard GPS)	7732069
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM 5KTS
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	Some red/brown fines in top sample

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey T + Brown	Sandy silt	W	VG	F	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** 1329 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	M2
Sample Id's assigned	M2T M2B
Easting/Longitude of core location (from onboard GPS)	0476105 WP 392
Northing/Latitude of core location (from onboard GPS)	7732004
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM LIGHT
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Silty Sand	W	VG	F	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** 1430 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	M1
Sample Id's assigned	M1T M1B
Easting/Longitude of core location (from onboard GPS)	0476069 WP 393
Northing/Latitude of core location (from onboard GPS)	7731870
Water depth at core location	14m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm < 10KTS
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey	Sandy Silt	M	VG	F	High	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 18/3/19 **TIME:** ______ **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N26
Sample Id's assigned	
Easting/Longitude of core location (from onboard GPS)	
Northing/Latitude of core location (from onboard GPS)	
Water depth at core location	

Sample collector	AL / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	
General comments	

WP 394 15:47 0474680 7726860 Refusal - handful of large coral rubble

WP 395 0474679 7726857 1609 same again

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 0850 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N16
Sample Id's assigned	N16T
Easting/Longitude of core location (from onboard GPS)	0473605 (wp 398)
Northing/Latitude of core location (from onboard GPS)	7724457
Water depth at core location	9.5m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM < 10kt
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	TOP portion only no penetration past 40cm or no sample >40cm,

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey brown	Sandy silt	M	VG	F	high	2%	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 0940 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N17
Sample Id's assigned	N17T
Easting/Longitude of core location (from onboard GPS)	0473606 WP 399
Northing/Latitude of core location (from onboard GPS)	7724489
Water depth at core location	9.5m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	Top 50cm sample recovered only. SG at bottom = refusal - Watery brown fines

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Grey/brown	Sandy silt	M	VG	F	high	<5%	SG <5%	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 1027 (1025) **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N18
Sample Id's assigned	N18T N18B
Easting/Longitude of core location (from onboard GPS)	0473676 WP 400
Northing/Latitude of core location (from onboard GPS)	7724581
Water depth at core location	9.5m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM 5KTS
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments Core line had split along 10cm of bottom section (N18B) - care was taken not to contact sample with anything other than sub sampling equipment.	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Top: grey-brown B: grey	Sandy silt	m	VG	F	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 1115 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N19
Sample Id's assigned	N19T
Easting/Longitude of core location (from onboard GPS)	0473654 WP 401
Northing/Latitude of core location (from onboard GPS)	7724584
Water depth at core location	9.5m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM 5 KTS
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments Refusal @ ~30cm top sample only	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	mottled red/gray	Silty sand	W	M	F-M	Med	0	at base of sample SG	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 1300 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	C1
Sample Id's assigned	C1T C1B
Easting/Longitude of core location (from onboard GPS)	0473664 WP 403
Northing/Latitude of core location (from onboard GPS)	7724634
Water depth at core location	~~95m~~ 8.9m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m 10-12 KTS W
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	
General comments Second attempt ok first attempt refusal.	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T: Red/Grey B: Grey	Sandy Silt	W	VG	F-M	high	2%	SG	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 1355 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	C2A (1st TRIP) + Split
Sample Id's assigned	C2AT C2AI C2AB
Easting/Longitude of core location (from onboard GPS)	0473768 WP 404
Northing/Latitude of core location (from onboard GPS)	7724812
Water depth at core location	~8m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	05m 12-KTS W
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Gas tanker movement ~20mins prior to sample
General comments Lab split on upper sample	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T- Red/Brown/Grey B- Grey	Silty Sand	W	VG	F	high	0	SG~5%	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 19/3/19 **TIME:** 1505 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	C2B (2nd Trip)
Sample Id's assigned	C2BT C2BB
Easting/Longitude of core location (from onboard GPS)	0473734 WP ~~[illegible]~~
Northing/Latitude of core location (from onboard GPS)	7724808 No WP
Water depth at core location	~8m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5 12-15kt
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Gas tanker movement ~ 50 mins prior
General comments Small tear in liner for top sample: some skin contacted sample water.	Sample not very long ~ 60-65cm not much bottom sample.

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Red-Brown/grey	Sandy silt	W	~~[illegible]~~ G	F	high	0	2%	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 20/3/19 TIME: ~~0817~~ 0840 LOCATION: Mermaid Sound

General location of core of sampling location	
Site/location number	C2C (3rd Trip)
Sample Id's assigned	C2CT C2CB
Easting/Longitude of core location (from onboard GPS)	0473761 WP 405
Northing/Latitude of core location (from onboard GPS)	7724803
Water depth at core location	~11-12m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM no wind
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T: Brown B:	Sandy silt	W	VG	F	MOD high	0	SG <2%	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 20/3/19 **TIME:** 0950 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	C3
Sample Id's assigned	C3T
Easting/Longitude of core location (from onboard GPS)	0473971 WP 407
Northing/Latitude of core location (from onboard GPS)	7725245
Water depth at core location	17.5m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm <5kts
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Nil
General comments Sample location @ edge of shipping channel	V. watery sample large rocks sand & globs of clay present

* Note: Only 1 × 500mL bag for sediment

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Brown	mixture	Water - vwet	poor	Var.	NIL	~40%	56	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 20/3/19 **TIME:** 1050 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	C4
Sample Id's assigned	C4T
Easting/Longitude of core location (from onboard GPS)	0474002 WP 408
Northing/Latitude of core location (from onboard GPS)	7725313
Water depth at core location	15.9

Sample collector	AL / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	CALM <5 KTS
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments Penetration to 50cm bottom of sample has shells, grit & stones - refusal at this point	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Brown	Sand / Gravel	W	M	M	Mod	~2%	SG	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 20/3/19 **TIME:** 1150 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	C5
Sample Id's assigned	C5T
Easting/Longitude of core location (from onboard GPS)	0474049 WP 409
Northing/Latitude of core location (from onboard GPS)	7725434
Water depth at core location	10.9 m

Sample collector	[✓ AL] / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	Calm <10knts
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	NIL
General comments ~30-40cm penetration coarse material @ bottom of sample ∴ refusal	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Brown	Sand w some silt	W	G	M	low	<2%	SG<2%	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** ______ **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R3
Sample Id's assigned	
Easting/Longitude of core location (from onboard GPS)	
Northing/Latitude of core location (from onboard GPS)	
Water depth at core location	

Sample collector	AL / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	

General comments

1345- Attempt 1: wp 425 0474204 7725751
SG at base of sample clay on top refusal @ ~15cm
1406 Attempt 2: wp 426 0474149 7725718
Same result as first attempt.

Move ~50m & try again.

NO SAMPLE - REFUSAL

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** ________ **LOCATION:** MERMAID COVE

General location of core of sampling location	
Site/location number	N21
Sample Id's assigned	
Easting/Longitude of core location (from onboard GPS)	
Northing/Latitude of core location (from onboard GPS)	
Water depth at core location	

Sample collector	AL / ~~PN~~ JH
Type of core sampler	Drop / Gravity
Sea state at time of coring	
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	
General comments 0474247 14:25 Attempt 1; WP427 7725875 • Sand Grain and Shells at Catch. Top Refusal approx 15 cm 14:50 Attempt 2: WP428 0474233 7725880 Same as Attempt 1. No Sample : Refusal.	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/3/19 **TIME:** 1005 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N8
Sample Id's assigned	N8T N8B
Easting/Longitude of core location (from onboard GPS)	0473831 WP 412
Northing/Latitude of core location (from onboard GPS)	7722522
Water depth at core location	9m

Sample collector	[✓ AL] ~~FRN~~ [✓ JHC]
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Calm ~ 10-12KTS W
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red / Grey / Brown B Grey	SILT	W	VG	VF	High	0%	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/03/19 **TIME:** 1115 **LOCATION:** MERMAID ~~COVE~~ Sound

General location of core of sampling location	
Site/location number	N9
Sample Id's assigned	N9T N9B
Easting/Longitude of core location (from onboard GPS)	0473797 W412
Northing/Latitude of core location (from onboard GPS)	7722548
Water depth at core location	9m

Sample collector	AL / ~~PN~~ JH
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5 m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Calm 10–12knots
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red/brown / B GREY	SILTY/CLAY	W	VG	VF	high	0%	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/3/19 **TIME:** 11 55 **LOCATION:** MERMAID COVE

General location of core of sampling location	
Site/location number	N10
Sample Id's assigned	N10T N10B
Easting/Longitude of core location (from onboard GPS)	0473796 ~~W473~~ NO GPS
Northing/Latitude of core location (from onboard GPS)	7722555
Water depth at core location	9.5

Sample collector	AL / ~~PN~~ JH
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Calm 10 - 12 knots
General comments	

Sediment Description								
GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red/~~Grey~~ Brown B Grey	SILTY CLAY	W	VG	VF	High	0%	0%	N

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/3/19 **TIME:** 1320 **LOCATION:** Mermaid Sound

General location of core of sampling location		
Site/location number	N11	N11T-I ④
Sample Id's assigned	N11T	N11B
Easting/Longitude of core location (from onboard GPS)	0473790	N11T DUP NO GPS
Northing/Latitude of core location (from onboard GPS)	7722571	
Water depth at core location	10m	

Sample collector	[✓ AL] / PN JHC
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12 KTS W
General comments	only 1 bag for PSD bottom sample All samples only 1 x bag ea.

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red Brown B Grey	Silty Clay	W	VG	VF	HIGH	0%	T – 0% B – <5% Shell	N

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/3/19 **TIME:** 1420 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R5
Sample Id's assigned	R5T R5B
Easting/Longitude of core location (from onboard GPS)	0473656 WP 413
Northing/Latitude of core location (from onboard GPS)	7722728
Water depth at core location	10m

Sample collector	AL / ~~PN~~ JHC
Type of core sampler	Drop / Gravity
Sea state at time of coring	<0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	10 kts
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Brown grey B Red mottled grey	SILTY SAND	W	VG	F	High	0%	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/3/19 **TIME:** 1500 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R6
Sample Id's assigned	R6T R6B
Easting/Longitude of core location (from onboard GPS)	0473466 WP 414
Northing/Latitude of core location (from onboard GPS)	772304
Water depth at core location	10.5m

Sample collector	AL ~~LPN~~ JH.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	<0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	Calm ~10kts W
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red / Grey B Grey	Sandy Silt	W	VG	F	MOD high	0%	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 29/3/19 **TIME:** 1545 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N12
Sample Id's assigned	N12T N12B
Easting/Longitude of core location (from onboard GPS)	0473381 wp 415
Northing/Latitude of core location (from onboard GPS)	7723416
Water depth at core location	10.5m

Sample collector	AL / ~~PN~~ JHC
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12 kts W
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T BROWN B MOTTLED BROWN GREY	SANDY SILT	W	VG	F	HIGH	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** 0800 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N13
Sample Id's assigned	N13T N13B
Easting/Longitude of core location (from onboard GPS)	0473381 wp 416
Northing/Latitude of core location (from onboard GPS)	7723541
Water depth at core location	10m

Sample collector	AL / ~~BR~~ JH.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5 - 1.0
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12-15 kt E
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Mottled brown grey B grey	Sandy Silt	W	VG	F	med high	0%	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 20/3/19 **TIME:** 0835 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N14A (1st triplicate)
Sample Id's assigned	N14AT N14AB
Easting/Longitude of core location (from onboard GPS)	0473385 WP 417
Northing/Latitude of core location (from onboard GPS)	7723670
Water depth at core location	10m

Sample collector	AL / ~~PN~~ JH.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5 - 1.0
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	15 kt E
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red / Brown B √ Grey mottled red	~~Sandy~~ silty clay	W	VG.	F/VF	high	0%	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*
**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** 09/10 **LOCATION:** Mermaid Sand

General location of core of sampling location	
Site/location number	N14B (2nd triplicate)
Sample Id's assigned	N14BT N14BB
Easting/Longitude of core location (from onboard GPS)	0473392 wp 418
Northing/Latitude of core location (from onboard GPS)	7723669
Water depth at core location	10 m

Sample collector	AL / ~~PN~~ JH. C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5 - 1.0
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	15kt E
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red Brown B Grey	Silty Clay	W	VG	VF	High ~~VG~~	0	NiL	NiL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** 0940 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	N14C (3rd Triplicate
Sample Id's assigned	N14CT N14CB
Easting/Longitude of core location (from onboard GPS)	0473394 WP 419
Northing/Latitude of core location (from onboard GPS)	7723675
Water depth at core location	10m

Sample collector	AL / ~~RN~~ JH-C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5 - 1.0
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	15 kt NE
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T- brown B- mottled brown grey	Silty clay	Wd	VG	VF	High	0	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** 1025 **LOCATION:** MERMAID COVE

General location of core of sampling location	
Site/location number	N15
Sample Id's assigned	N15T N15B
Easting/Longitude of core location (from onboard GPS)	0473420 420
Northing/Latitude of core location (from onboard GPS)	7723904
Water depth at core location	9m

Sample collector	AL ~~LPN~~ JH
Type of core sampler	Drop / Gravity
Sea state at time of coring	~~0.5 10 knots~~ 0.5–1.0
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	15 knt N.E
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red Brown Grey B Grey	Silty Gravy	W	VG	VF	HIGH	0	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 20/3/19 **TIME:** 1100 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R2 (replace N2)
Sample Id's assigned	R2T R2B
Easting/Longitude of core location (from onboard GPS)	0473452 wp 421
Northing/Latitude of core location (from onboard GPS)	7724040
Water depth at core location	9 m

Sample collector	AL ~~TPN~~ JHC
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12 kt NE
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red Brown Grey B Grey	Silty Clay	M	VG	VF	High	0	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** 1135 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R1 (replace N1)
Sample Id's assigned	R1T R1B
Easting/Longitude of core location (from onboard GPS)	0473515 WP 422
Northing/Latitude of core location (from onboard GPS)	7724217
Water depth at core location	8.7m

Sample collector	AL / ~~PN~~ JH. C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12kT NE
General comments B: 1 x Bag for PSD only	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T Red brown grey	silty clay	W	VG	VF	high	0%	NIL	NIL
	B mottled Brown grey	Sandy silt			F				

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 TIME: 1320 LOCATION: Mermaid Sound

General location of core of sampling location	
Site/location number	N20
Sample Id's assigned	N20T
Easting/Longitude of core location (from onboard GPS)	0474125 WP 424
Northing/Latitude of core location (from onboard GPS)	7725578
Water depth at core location	9m

Sample collector	AL / ~~PN~~ JH-C
Type of core sampler	Drop / Gravity
Sea state at time of coring	< 0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	10 kt NE
General comments 1300 - Attempt 1: WP 423 0474118 7725559 very small sample Attempt 2 - Refusal @ ~20cm hard shell grit at base of sample 1 x PSD bag only	Sample mostly water.

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	brown	Sand/silt/clay	Vw	P	C to F	V. low	0%	SG	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

wp429

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 30/3/19 **TIME:** 1515 **LOCATION:** MERMAID COVE

General location of core of sampling location	
Site/location number	N22 (1st triplicate)
Sample Id's assigned Note Not used 'A'	N22 T
Easting/Longitude of core location (from onboard GPS)	0474274 ~~7725933~~ WP429
Northing/Latitude of core location (from onboard GPS)	7725933
Water depth at core location	8.9m

1x bag only

Sample collector	AL / ~~PN~~ JH
Type of core sampler	Drop / Gravity
Sea state at time of coring	< 0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	10 kt NE
General comments	

- Mostly water

1537: 2nd attempt ~30m away' wp430 0474250 7725915 refusal @ ~ 10-20cm insufficient sample

- SG at base, coarse sandy material.

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T	Sandy / Silt	VW	P	C to F	Low	0	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** 0830 **LOCATION:** MERMAID COVE

General location of core of sampling location	TOP ONLY
Site/location number	N22B (2nd Triplicate)
Sample Id's assigned	N22 BT
Easting/Longitude of core location (from onboard GPS)	0474270 WP 432
Northing/Latitude of core location (from onboard GPS)	7725928
Water depth at core location	9m

Sample collector	AL / ~~PN~~ JA
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12-15 kt E
General comments	1 Bag only

- 8.07AM: 0474272 WP431
7725928
Fail Attempt: only 10-15 cm of Sand Grain (Attempt 1)

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Brown	Sandy silt	VW	P	M-F	low	0%	SG @ base	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** 0900 **LOCATION:** Mermaid Sound

General location of core of sampling location	TOP ONLY RECOVERED
Site/location number	N22C (3rd trip)
Sample Id's assigned	N22CT
Easting/Longitude of core location (from onboard GPS)	0474282 WP 433
Northing/Latitude of core location (from onboard GPS)	7725933
Water depth at core location	9m

Sample collector	AL / ~~PN~~ JH.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12kt E
General comments	1 x bag only

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	Brown	Sandy silt	VW	poor	M-F	low	0	SG at base	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** ________ **LOCATION:** MERMAID SOUND

General location of core of sampling location	
Site/location number	R4
Sample Id's assigned	
Easting/Longitude of core location (from onboard GPS)	
Northing/Latitude of core location (from onboard GPS)	
Water depth at core location	8.3

Sample collector	AL / ~~PN~~ JB
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12 knt
General comments ⓸434 0474482 - ~~R~~ Attempt 1: 09:26 7726400 No samples. (Coarse Sand approx 10cm) - Attempt 2: 09:52 0474465 7726407 (435) No Samples (Coarse Sand approx 15cm)	

Sediment Description									
GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** ______ **LOCATION:** MERMAID Sound

General location of core of sampling location	
Site/location number	N23
Sample Id's assigned	
Easting/Longitude of core location (from onboard GPS)	
Northing/Latitude of core location (from onboard GPS)	
Water depth at core location	

Sample collector	AL / ~~PN~~ JH
Type of core sampler	Drop / Gravity
Sea state at time of coring	
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	
General comments - Attempt 1. 10:19am 0474338 7726199 (436) 15cm core sand. No samples Final Attempt	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

INTERLAB + SPLIT in lieu of N25

DATE: 31/3/19 **TIME:** 1055 **LOCATION:** Mermaid Sand

General location of core of sampling location	
Site/location number	R4 - repositioned
Sample Id's assigned	R4T R4T-I R4B
Easting/Longitude of core location (from onboard GPS)	0473553 WP 437
Northing/Latitude of core location (from onboard GPS)	7722894
Water depth at core location	10m

Sample collector	AL / ~~PN~~ J H.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12-15 kt E
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T brown B mottled brown grey	silty clay	W	Vb	VF	high	0	Nil	Nil

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** 1135 **LOCATION:** Mermaid Sound

General location of core of sampling location	Replace N7
Site/location number	R7A (#/1ST TRIP)
Sample Id's assigned	R7AT R7AB
Easting/Longitude of core location (from onboard GPS)	0473423 WP 438
Northing/Latitude of core location (from onboard GPS)	7723260
Water depth at core location	10 m

Sample collector	AL / ~~PN~~ JH. C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	15 kt E
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T BROWN B GREY	SILTY CLAY	W	VG	F/VF	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** 1205 **LOCATION:** Mermaid Sound

General location of core of sampling location	replace N7
Site/location number	R7B (2nd triplicate)
Sample Id's assigned	R7BT R7BB
Easting/Longitude of core location (from onboard GPS)	0473409 WP 439
Northing/Latitude of core location (from onboard GPS)	7723257
Water depth at core location	10m

Sample collector	AL / ~~PN~~ JH.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	< 0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	15 kT ENE
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T. Brown / Grey B. Grey	SILTY CLAY	W	VG	VF	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** 1240 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R7C (3rd triplicate)
Sample Id's assigned	R7CT R7CB
Easting/Longitude of core location (from onboard GPS)	0473412 WP 440
Northing/Latitude of core location (from onboard GPS)	7723254
Water depth at core location	10m

Sample collector	AL / ~~PN~~ JH.C
Type of core sampler	Drop / Gravity
Sea state at time of coring	0.5
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12 kt ENE
General comments	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T brown grey B grey	SILTY CLAY	W	VG	F/VF	high	0	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Scarborough Project SAP Implementation - 2019
Client: Woodside

DATE: 31/3/19 **TIME:** 1305 **LOCATION:** Mermaid Sound

General location of core of sampling location	
Site/location number	R3 (replace N3)
Sample Id's assigned	R3T R3B
Easting/Longitude of core location (from onboard GPS)	0473733 WP 441
Northing/Latitude of core location (from onboard GPS)	7722635
Water depth at core location	10m.

Sample collector	AL / PN
Type of core sampler	Drop / Gravity
Sea state at time of coring	<0.5m
Conditions (e.g. weather, sea state, wind speed, level of shipping traffic)	12 kt ENE
General comments * Moved from other side of channel, where refusal was occurring.	

Sediment Description

GRAB	Colour* (refer AS1726)	Field texture**	Moist.	Consist	Sand grain size	Plasticity	% stones	Shell/grit and/or biota	Odour
	T - Brown B - Grey	Sand / Silt / Clay	W	VG	M-VF	Mod high	0%	NIL	NIL

* Colour: black, white, grey, red, brown, orange, yellow, green, blue. Pale, dark, mottled. *e.g. grey mottled red-brown clay.*

**Field Texture: clay, silt, sand, gravel, etc

Appendix C Laboratory Reports

QUALITY CONTROL REPORT

Certificate Number	B771692-A	**Page**	1 of 4
Client	Advisian	**Laboratory**	Brisbane
Contact	Ashley Lemmon	**Address**	52 Brandl Street, Eight Mile Plains, QLD 4113
Address	Level 4 Signet House 600 Murray Street	**Contact**	Customer Service Team
	WEST PERTH, WA 6005	**Email**	admin@symbiolabs.com.au
Telephone		**Telephone**	1300 703 166
Order Number		**Date Samples Received**	02/04/2019
Client Job Reference		**Date Analysis Commenced**	02/04/2019
No of Samples Received	2		
No of Samples Analysed	2	**Issue Date**	09/04/2019

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

1. Method Blank (MB) Report; Limit of Detection and QC Result
2. Method Laboratory Control Sample (LCS) Report; QC Result and Acceptance Criteria
3. Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits

General Comments

The analytical methods used by the Environmental Department have been developed from established internationally recognized methods such as those published by the USEPA, APHA, AS and NEPM. In-house developed analytical methods are employed in the absence of documented standards or by client request.

Where a reported less than (<) result is higher than the LOD, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOD of a reported result differs from standard LOD, this may be due to high moisture content

Abbreviation:

QC Sample = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CRM = Certified Referenced Material; Used to verify in-house LCS
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOD = Limit of detection
RPD = Relative Percentage Difference

Method Blank Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination.

Method:Compound / QC Sample ID	Analyte	LOD	Units	QC Result
Lab Method: ENV009_S (BatchID - 0025603)				
Method Blank - 0025603	Total Organic Carbon	0.005	%w/w	<0.005
Lab Method: IND041 (BatchID - 0025538)				
Method Blank - 0025538	Aluminium	1	mg/kg	<1
Method Blank - 0025538	Boron	5	mg/kg	<5
Method Blank - 0025538	Iron	2	mg/kg	<2
Method Blank - 0025538	Manganese	1	mg/kg	<1
Method Blank - 0025538	Phosphorus	5	mg/kg	<5
Lab Method: IND042 (BatchID - 0025706)				
Method Blank - 0025706	Antimony	100	µg/kg	<100
Method Blank - 0025706	Arsenic	500	µg/kg	<500
Method Blank - 0025706	Cadmium	100	µg/kg	<100
Method Blank - 0025706	Chromium	500	µg/kg	<500
Method Blank - 0025706	Copper	500	µg/kg	<500
Method Blank - 0025706	Lead	100	µg/kg	<100
Method Blank - 0025706	Mercury	100	µg/kg	<100
Method Blank - 0025706	Nickel	100	µg/kg	<100
Method Blank - 0025706	Silver	100	µg/kg	<100
Method Blank - 0025706	Zinc	500	µg/kg	<500

Method Laboratory Control Sample Report

The quality control term Laboratory Control Sample (LCS) refers to a certified reference material (CRM) or a sample with known parameters that have been verified against a CRM. The quality control term Spike (SPK) refers to a known interference free matrix spiked with target analytes. The purpose of these QC parameters is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Method : Compound / QC Sample ID	Analyte	LOD	Units	QC Test Results	Expected Value	QC Recovery	QC Criteria
Lab Method: ENV009_S (BatchID - 0025603 - LCS_EBNE00066)							
LCS_EBNE00066	Total Organic Carbon	0.005	%w/w	0.020	0.019	105%	70% - 130%
Lab Method: IND041 (BatchID - 0025538 - CRM_CBNE00001)							
CRM_CBNE00001	Aluminium	1	mg/kg	7984	8920	89%	50% - 150%
CRM_CBNE00001	Boron	5	mg/kg	17.3	13	133%	30% - 170%
CRM_CBNE00001	Iron	2	mg/kg	16680	16800	99%	80% - 120%
CRM_CBNE00001	Manganese	1	mg/kg	179.1	180	99%	90% - 110%
Lab Method: IND042 (BatchID - 0025706 - SPK_CBNE00020)							
SPK_CBNE00020	Antimony	100	µg/kg	80.2	100	80%	60% - 140%
SPK_CBNE00020	Arsenic	500	µg/kg	92.3	100	92%	80% - 120%
SPK_CBNE00020	Cadmium	100	µg/kg	92.5	100	92%	80% - 120%
SPK_CBNE00020	Chromium	500	µg/kg	95.8	100	95%	80% - 120%
SPK_CBNE00020	Copper	500	µg/kg	102.7	100	102%	80% - 120%
SPK_CBNE00020	Lead	100	µg/kg	82.4	100	82%	80% - 120%
SPK_CBNE00020	Mercury	100	µg/kg	87.9	100	87%	60% - 140%
SPK_CBNE00020	Nickel	100	µg/kg	95.3	100	95%	80% - 120%
SPK_CBNE00020	Silver	100	µg/kg	92.7	100	92%	80% - 120%
SPK_CBNE00020	Zinc	500	µg/kg	81.9	100	81%	80% - 120%

Client	Advisian
Contact	Ashley Lemmon
Certificate Number	B771692-A-R00
Page	4 of 4

Laboratory Duplicate Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in the relavant technical method manuals and are dependent on the magnitude of results in comparison to the level of reporting.

Method : Compound / QC Sample ID	Analyte	LOD	Units	Original Result	Dup Result	RPD	RPD Acceptance Criteria
Lab Method: ENV009_S (BatchID - 0025603)							
Laboratory Duplicate Sample - 0025603	Total Organic Carbon	0.005	%w/w	0.42	0.43	2.4%	<30%
Lab Method: IND041 (BatchID - 0025538)							
Laboratory Duplicate Sample - 0025538	Aluminium	1	mg/kg	1676	1731	3.2%	<30%
Laboratory Duplicate Sample - 0025538	Boron	5	mg/kg	175.0	174.4	0.3%	<30%
Laboratory Duplicate Sample - 0025538	Iron	2	mg/kg	67.7	68.3	0.9%	<30%
Laboratory Duplicate Sample - 0025538	Manganese	1	mg/kg	19.3	20.9	8.0%	<30%
Laboratory Duplicate Sample - 0025538	Phosphorus	5	mg/kg	485.3	497.8	2.5%	<30%
Lab Method: IND042 (BatchID - 0025706)							
Laboratory Duplicate Sample - 0025706	Antimony	100	µg/kg	352.0	339.1	3.7%	No Limit
Laboratory Duplicate Sample - 0025706	Arsenic	500	µg/kg	1239	1290	4.0%	No Limit
Laboratory Duplicate Sample - 0025706	Cadmium	100	µg/kg	<100	<100	-	N/A
Laboratory Duplicate Sample - 0025706	Chromium	500	µg/kg	8179	8549	4.4%	<30%
Laboratory Duplicate Sample - 0025706	Copper	500	µg/kg	5930	6191	4.3%	<30%
Laboratory Duplicate Sample - 0025706	Lead	100	µg/kg	11550	11670	1.0%	<30%
Laboratory Duplicate Sample - 0025706	Mercury	100	µg/kg	<100	<100	-	N/A
Laboratory Duplicate Sample - 0025706	Nickel	100	µg/kg	5752	5972	3.8%	<30%
Laboratory Duplicate Sample - 0025706	Silver	100	µg/kg	<100	<100	-	N/A
Laboratory Duplicate Sample - 0025706	Zinc	500	µg/kg	14210	14750	3.7%	<30%

CERTIFICATE OF ANALYSIS

CERTIFICATE NO.: B771692-A Page 1 of 3

REVISION NO: 01

ISSUE DATE: 9/04/19

This certificate supersedes any previous revisions

CLIENT DETAILS:
Ashley Lemmon
Advisian
Level 4 Signet House 600 Murray Street
WEST PERTH WA 6005

JOB INFORMATION: Sediment - Mermaid Sound

RECEIVE CONDITION: 5.0 ℃

STORAGE CONDITION: 4 ℃

TEST DATE: Sample tested between date received and reported

DATE RECEIVED: 02/04/2019

CLIENT REF. NO:

ORDER NO:

RESULTS OF ANALYSIS:

Test	Method Code	LOR	Unit	B771692-A-1 R4T-I 31/03/2019 10:55	B771692-A-2 N11T-I 29/03/2019 13:20
IND042 Element ICP-MS Routine					
Copper (Cu)*	IND042	0.5	mg/kg	1.8	1.8
Lead (Pb)*	IND042	0.1	mg/kg	2.2	2.4
Zinc (Zn)*	IND042	0.5	mg/kg	4.3	4.5
Chromium (Cr)*	IND042	0.5	mg/kg	22	20
Nickel (Ni)*	IND042	0.1	mg/kg	4.6	4.3
Cadmium (Cd)*	IND042	0.1	mg/kg	<0.1	<0.1
Arsenic (As)*	IND042	0.5	mg/kg	4.0	5.2
Silver (Ag)*	IND042	0.1	mg/kg	<0.1	<0.1
Antimony (Sb)*	IND042	0.1	mg/kg	<0.1	0.1
Mercury (Hg)*	IND042	0.1	mg/kg	<0.10	<0.10
IND041 Elements					
Aluminium (Al)	IND041	1	mg/kg	3,610	4,000

Test	Method Code	LOR	Unit	B771692-A-1 R4T-I 31/03/2019 10:55	B771692-A-2 N11T-I 29/03/2019 13:20
Iron (Fe)	IND041	2	mg/kg	10,300	9,090
General Tests					
Total Organic Carbon (TOC)	ENV009_S	0.02	% w/w	0.42	0.40

DEFINITIONS: < : Less than, > : Greater than, [NT] : Not Tested, DWB : Dry Weight Basis, NA: not applicable, RP: Result Pending, - : Not received / requested / tested, ~ : Estimated, TBA: - to be advised, ∆: reference only holding time exceeded

* Test not covered by NATA scope of accreditation

: The result is derived from a calculation and includes results equal to, or greater than the LOR. Where applicable, results are calculated as sum of reportable isomers.

Please Note: ENV009 result based on Dry Weight Basis

Results were reported on an "as received" basis unless otherwise indicated.

Sampling was conducted by the customer and results reported pertain only to the samples submitted.

Responsibility for representative sampling rests with the customer.

Maxim Kowal, Team Leader
Chemistry (Brisbane)

CERTIFICATE OF ANALYSIS

CERTIFICATE NO.: B771692-B Page 1 of 2

ISSUE DATE: 12/04/19

REVISION NO: 00

This certificate supersedes any previous revisions

CLIENT DETAILS:
Ashley Lemmon
Advisian
Level 4 Signet House 600 Murray Street
WEST PERTH WA 6005

DATE RECEIVED: 02/04/2019

CLIENT REF. NO:

ORDER NO:

JOB INFORMATION: Sediment - Mermaid Sound

RECEIVE CONDITION: 5.0 ℃

STORAGE CONDITION: 4 ℃

TEST DATE: Sample tested between date received and reported

RESULTS OF ANALYSIS:

Test	Method Code	LOR	Unit	B771692-B-1 R4T-I 31/03/2019 10:55	B771692-B-2 N11T-I 29/03/2019 13:20
Particle Size Distribution					
Particle Size Distribution	S023.03	0.1	%	see attached report	see attached report

DEFINITIONS: < : Less than, > : Greater than, [NT] : Not Tested, DWB : Dry Weight Basis, NA: not applicable, RP: Result Pending, - : Not received / requested / tested, ~ : Estimated, TBA: - to be advised, ∆: reference only holding time exceeded

* Test not covered by NATA scope of accreditation

: The result is derived from a calculation and includes results equal to, or greater than the LOR. Where applicable, results are calculated as sum of reportable isomers.

Please note: Testing performed by an external subcontracted Laboratory.

Report No: I0403

Results were reported on an "as received" basis unless otherwise indicated.

Sampling was conducted by the customer and results reported pertain only to the samples submitted.

Responsibility for representative sampling rests with the customer.

Maxim Kowal, Team Leader
Chemistry (Brisbane)

Symbio LABORATORIES

QUALITY CONTROL REPORT

Certificate Number	B771692-C	**Page**	1 of 4
Client	Advisian	**Laboratory**	Brisbane
Contact	Ashley Lemmon	**Address**	52 Brandl Street, Eight Mile Plains, QLD 4113
Address	Level 4 Signet House 600 Murray Street	**Contact**	Customer Service Team
	WEST PERTH, WA 6005	**Email**	admin@symbiolabs.com.au
Telephone		**Telephone**	1300 703 166
Order Number		**Date Samples Received**	03/04/2019
Client Job Reference		**Date Analysis Commenced**	02/04/2019
No of Samples Received	2		
No of Samples Analysed	2	**Issue Date**	10/04/2019

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

1. Method Blank (MB) Report; Limit of Detection and QC Result
2. Method Laboratory Control Sample (LCS) Report; QC Result and Acceptance Criteria
3. Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits

General Comments

The analytical methods used by the Environmental Department have been developed from established internationally recognized methods such as those published by the USEPA, APHA, AS and NEPM. In-house developed analytical methods are employed in the absence of documented standards or by client request.

Where a reported less than (<) result is higher than the LOD, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOD of a reported result differs from standard LOD, this may be due to high moisture content

Abbreviation:

QC Sample = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CRM = Certified Referenced Material; Used to verify in-house LCS
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOD = Limit of detection
RPD = Relative Percentage Difference

Method Blank Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination.

Method:Compound / QC Sample ID	Analyte	LOD	Units	QC Result
Lab Method: 04_004S (BatchID - 0025501)				
Method Blank - 0025501	Moisture	0.1	%	<0.1
Lab Method: E061_0C (BatchID - 0025502)				
Method Blank - 0025502	Dibutyltin dichloride	0.5	µgSn/kg	<0.5
Method Blank - 0025502	Monobutyltin trichloride	0.5	µgSn/kg	<0.5
Method Blank - 0025502	Tributyltin chloride	0.5	µgSn/kg	<0.5

Client	Advisian
Contact	Ashley Lemmon
Certificate Number	B771692-C-R00
Page	3 of 4

Method Laboratory Control Sample Report

The quality control term Laboratory Control Sample (LCS) refers to a certified reference material (CRM) or a sample with known parameters that have been verified against a CRM. The quality control term Spike (SPK) refers to a known interference free matrix spiked with target analytes. The purpose of these QC parameters is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Method : Compound / QC Sample ID	Analyte	LOD	Units	QC Test Results	Expected Value	QC Recovery	QC Criteria
Lab Method: 04_004S (BatchID - 0025501 - SPK_ESYD00001)							
SPK_ESYD00001	Moisture	0.1	%	100.5	100	100%	80% - 120%
Lab Method: E061_0C (BatchID - 0025502 - LCS_ESYD00015)							
LCS_ESYD00015	Dibutyltin dichloride	0.5	µgSn/kg	48.5	40	121%	50% - 150%
LCS_ESYD00015	Monobutyltin trichloride	0.5	µgSn/kg	42.9	40	107%	50% - 150%
LCS_ESYD00015	Tributyltin chloride	0.5	µgSn/kg	52.9	40	132%	50% - 150%
Lab Method: E061_0C (BatchID - 0025502 - LCS_ESYD00019)							
LCS_ESYD00019	Dibutyltin dichloride	0.5	µgSn/kg	3.8	4	95%	50% - 150%
LCS_ESYD00019	Monobutyltin trichloride	0.5	µgSn/kg	5.5	4	137%	50% - 150%
LCS_ESYD00019	Tributyltin chloride	0.5	µgSn/kg	4.9	4	122%	50% - 150%

Laboratory Duplicate Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in the relavant technical method manuals and are dependent on the magnitude of results in comparison to the level of reporting.

Method : Compound / QC Sample ID	Analyte	LOD	Units	Original Result	Dup Result	RPD	RPD Acceptance Criteria
Lab Method: 04_004S (BatchID - 0025501)							
Laboratory Duplicate Sample - 0025501	Moisture	0.1	%	33.1	32.3	2.4%	<30%
Lab Method: E061_0C (BatchID - 0025502)							
Laboratory Duplicate Sample - 0025502	Dibutyltin dichloride	0.5	µgSn/kg	<0.5	<0.5	-	N/A
Laboratory Duplicate Sample - 0025502	Monobutyltin trichloride	0.5	µgSn/kg	<0.5	<0.5	-	N/A
Laboratory Duplicate Sample - 0025502	Tributyltin chloride	0.5	µgSn/kg	<0.5	<0.5	-	N/A

CERTIFICATE OF ANALYSIS

CERTIFICATE NO.: **B771692-C** **REVISION NO.:** **00** **Page 1 of 3**
ISSUE DATE: 10/04/19 This certificate supersedes any previous revisions

CLIENT DETAILS:
Ashley Lemmon
Advisian
Level 4 Signet House 600 Murray Street
WEST PERTH WA 6005

DATE RECEIVED: 03/04/2019
CLIENT JOBREF:
ORDER NO:
TEST DATE: Sample tested between date received and reported.

SAMPLE INFORMATION:

Received Condition (°C): Chilled (0 ~ 5 °C) **Storage Condition:** Refrigerated

Sample No.	Sample Date/Time	Sample Description	Sample Matrix
B771692-C/1	31/03/2019 10:55	R4T-I	Sediment
B771692-C/2	29/03/2019 13:20	N11T-I	Sediment

RESULTS OF ANALYSIS:

	Test Method	LOR	Units	B771692-C/1	B771692-C/2
Moisture Content					
Moisture Content	04-004	0.1	%	33	31
Organotins in Soil & Sediment					
Monobutyltin (MBT)	04-026	4	µgSn/kg	<4.0	<4.0
Dibutyltin (DBT)	04-026	2	µgSn/kg	<2.0	<2.0
Tributyltin (TBT)	04-026	0.5	µgSn/kg	<0.5	<0.5
Tripropyltin (SUR)	04-026		%	60.0	57.0

Feng Shi

Feng Shi, Laboratory Manager
Chemistry (Sydney)

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order : **EP1902664**
Client : **WorleyParsons Services Pty Ltd**
Contact : MR PAUL NICHOLS
Address : LEVEL 4, 600 MURRAY STREET
WEST PERTH WA, AUSTRALIA 6005
Telephone : +61 08 9278 8111
Project : 401012-02698 WEL SCABS
Order number : 401012-02698
C-O-C number : ----
Sampler : ASHLEY LEMMON
Site : ----
Quote number : EP/114/19 V3
No. of samples received : 45
No. of samples analysed : 45

Page : 1 of 22
Laboratory : Environmental Division Perth
Contact : Marnie Thomsett
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : 08 9406 1311
Date Samples Received : 22-Mar-2019 09:30
Date Analysis Commenced : 25-Mar-2019
Issue Date : 30-Apr-2019 16:39

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Peter Keyte	Newcastle Manager	Newcastle - Inorganics, Mayfield West, NSW
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- TOC and Organotins conducted by ALS Brisbane, NATA Site No. 818.
- PSD conducted by ALS Newcastle, NATA accreditation no. 825, site no 1656.
- EP090: Sample 'M5BB' shows poor matrix spike recovery due to matrix interference. Confirmed by re-extraction and re-analysis.
- EP090: High LCS and matrix spike recovery deemed acceptable as all associated analyte results are less than LOR.
- EA150H was conducted using sea water at the client's request. This is not compliant with AS1289.3.6.3 and consequently NATA endorsement does not apply to results <75um . % Clay results may be biased significantly low.
- Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results
- EA150H: The matrix of samples #30 & #31 was incompatible with the sea water matrix and therefore the <75um was unable to be reported.
- EP005 (Organic Carbon): Result for sample 002 ("R2") has been confirmed by re-analysis.
- EP090 Organotin: The LOR for monobutyltin for sample 'R1' has been raised due to laboratory error.

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL**)

			Client sample ID	**M5BT**	**M5BB**	**M5CT**	**M5CB**	**M4T**
			Client sampling date / time	18-Mar-2019 08:05	18-Mar-2019 08:05	18-Mar-2019 09:15	18-Mar-2019 09:15	18-Mar-2019 10:30
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-004**	**EP1902664-005**	**EP1902664-006**	**EP1902664-007**	**EP1902664-008**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**36.8**	**33.9**	**37.8**	**33.2**	**36.0**
EA150: Particle Sizing								
+75µm	----	1	%	**60**	**59**	**56**	**65**	**54**
+150µm	----	1	%	**16**	**24**	**19**	**27**	**20**
+300µm	----	1	%	**6**	**10**	**7**	**13**	**8**
+425µm	----	1	%	**4**	**7**	**4**	**10**	**4**
+600µm	----	1	%	**2**	**5**	**3**	**6**	**2**
+1180µm	----	1	%	<1	**2**	<1	**2**	<1
+2.36mm	----	1	%	<1	<1	<1	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**10**	**14**	**21**	**11**	**21**
Sand (0.06-2.00 mm)	----	1	%	**90**	**85**	**79**	**88**	**79**
Gravel (>2mm)	----	1	%	<1	**1**	<1	**1**	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.67**	**2.70**	**2.68**	**2.72**	**2.68**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4750**	**3980**	**4260**	**4280**	**4640**
Iron	7439-89-6	50	mg/kg	**10200**	**8640**	**8990**	**9240**	**9990**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**8.56**	**7.94**	**7.48**	**8.32**	**7.91**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	**0.1**	<0.1
Chromium	7440-47-3	1.0	mg/kg	**36.0**	**31.0**	**31.3**	**31.7**	**33.9**
Copper	7440-50-8	1.0	mg/kg	**4.6**	**3.7**	**4.2**	**3.8**	**4.4**
Lead	7439-92-1	1.0	mg/kg	**3.2**	**2.7**	**2.7**	**2.7**	**2.9**
Nickel	7440-02-0	1.0	mg/kg	**12.8**	**11.0**	**11.3**	**11.0**	**12.1**
Silver	7440-22-4	0.1	mg/kg	**0.1**	<0.1	**0.1**	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL)**

Compound	CAS Number	LOR	Unit	M5BT	M5BB	M5CT	M5CB	M4T
			Client sampling date / time	18-Mar-2019 08:05	18-Mar-2019 08:05	18-Mar-2019 09:15	18-Mar-2019 09:15	18-Mar-2019 10:30
				EP1902664-004	**EP1902664-005**	**EP1902664-006**	**EP1902664-007**	**EP1902664-008**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**10.6**	**8.0**	**9.7**	**8.2**	**9.4**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.33**	**0.30**	**0.31**	**0.30**	**0.31**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**75.4**	**75.3**	**69.5**	**84.4**	**84.9**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL**)

			Client sample ID	M4B	M3T	M3B	M2T	M2B
			Client sampling date / time	18-Mar-2019 10:30	18-Mar-2019 11:30	18-Mar-2019 11:30	18-Mar-2019 13:30	18-Mar-2019 13:30
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-009**	**EP1902664-010**	**EP1902664-011**	**EP1902664-012**	**EP1902664-013**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**33.0**	**34.6**	**33.9**	**35.2**	**33.2**
EA150: Particle Sizing								
+75µm	----	1	%	**64**	**57**	**62**	**68**	**64**
+150µm	----	1	%	**23**	**26**	**25**	**28**	**28**
+300µm	----	1	%	**10**	**13**	**11**	**11**	**12**
+425µm	----	1	%	**7**	**9**	**8**	**8**	**8**
+600µm	----	1	%	**5**	**6**	**5**	**5**	**5**
+1180µm	----	1	%	**2**	**2**	**2**	**1**	**2**
+2.36mm	----	1	%	<1	<1	**1**	<1	<1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**12**	**14**	**18**	**21**	**14**
Sand (0.06-2.00 mm)	----	1	%	**87**	**85**	**81**	**78**	**85**
Gravel (>2mm)	----	1	%	**1**	**1**	**1**	**1**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.72**	**2.73**	**2.72**	**2.72**	**2.74**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4540**	**4210**	**3640**	**4440**	**3890**
Iron	7439-89-6	50	mg/kg	**9650**	**9620**	**8290**	**9440**	**8470**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**8.99**	**9.02**	**8.05**	**8.17**	**7.97**
Cadmium	7440-43-9	0.1	mg/kg	**0.1**	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**33.2**	**31.2**	**28.1**	**32.7**	**29.7**
Copper	7440-50-8	1.0	mg/kg	**4.0**	**4.0**	**3.4**	**4.2**	**3.6**
Lead	7439-92-1	1.0	mg/kg	**2.8**	**2.7**	**2.5**	**2.8**	**2.6**
Nickel	7440-02-0	1.0	mg/kg	**11.6**	**11.0**	**9.6**	**11.7**	**10.2**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**M4B**	**M3T**	**M3B**	**M2T**	**M2B**
			Client sampling date / time	18-Mar-2019 10:30	18-Mar-2019 11:30	18-Mar-2019 11:30	18-Mar-2019 13:30	18-Mar-2019 13:30
Compound	CAS Number	LOR	Unit	**EP1902664-009**	**EP1902664-010**	**EP1902664-011**	**EP1902664-012**	**EP1902664-013**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.5**	**8.9**	**7.7**	**9.3**	**7.8**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.29**	**0.27**	**0.28**	**0.30**	**0.29**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**90.0**	**68.5**	**81.9**	**67.1**	**79.3**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	**M1T**	**M1B**	**M10T**	**M10B**	**M9T**
			Client sampling date / time	18-Mar-2019 14:30	18-Mar-2019 14:30	17-Mar-2019 09:20	17-Mar-2019 09:20	17-Mar-2019 10:30
Compound	CAS Number	LOR	Unit	**EP1902664-014**	**EP1902664-015**	**EP1902664-016**	**EP1902664-017**	**EP1902664-018**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**34.2**	**32.9**	**31.8**	**32.0**	**32.1**
EA150: Particle Sizing								
+75µm	----	1	%	**84**	**75**	**68**	**63**	**57**
+150µm	----	1	%	**43**	**42**	**41**	**34**	**26**
+300µm	----	1	%	**21**	**20**	**16**	**14**	**9**
+425µm	----	1	%	**14**	**13**	**8**	**8**	**5**
+600µm	----	1	%	**9**	**8**	**4**	**5**	**3**
+1180µm	----	1	%	**3**	**2**	<1	**2**	**2**
+2.36mm	----	1	%	**1**	<1	<1	**2**	**2**
+4.75mm	----	1	%	<1	<1	<1	<1	**2**
+9.5mm	----	1	%	<1	<1	<1	<1	**2**
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**4**	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**11**	**20**	**19**	**22**	**26**
Sand (0.06-2.00 mm)	----	1	%	**83**	**79**	**81**	**76**	**72**
Gravel (>2mm)	----	1	%	**2**	**1**	<1	**2**	**2**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.66**	**2.70**	**2.69**	**2.70**	**2.67**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4110**	**3690**	**3700**	**3780**	**4200**
Iron	7439-89-6	50	mg/kg	**9900**	**9150**	**9060**	**8500**	**9350**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**9.95**	**9.94**	**9.31**	**8.73**	**8.20**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**30.8**	**27.9**	**27.9**	**28.3**	**30.2**
Copper	7440-50-8	1.0	mg/kg	**3.8**	**3.3**	**3.6**	**3.6**	**3.8**
Lead	7439-92-1	1.0	mg/kg	**2.8**	**2.7**	**2.6**	**2.4**	**2.6**
Nickel	7440-02-0	1.0	mg/kg	**10.8**	**9.5**	**9.6**	**9.8**	**10.5**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**M1T**	**M1B**	**M10T**	**M10B**	**M9T**
			Client sampling date / time	18-Mar-2019 14:30	18-Mar-2019 14:30	17-Mar-2019 09:20	17-Mar-2019 09:20	17-Mar-2019 10:30
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-014**	**EP1902664-015**	**EP1902664-016**	**EP1902664-017**	**EP1902664-018**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.4**	**7.5**	**8.0**	**7.1**	**8.7**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.23**	**0.21**	**0.22**	**0.24**	**0.27**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**91.9**	**97.2**	**78.6**	**89.4**	**94.3**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**M9B**	**M8T**	**M8B**	**M7T**	**M7B**
			Client sampling date / time	17-Mar-2019 10:30	17-Mar-2019 11:35	17-Mar-2019 11:35	17-Mar-2019 13:20	17-Mar-2019 13:20
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-019**	**EP1902664-020**	**EP1902664-021**	**EP1902664-022**	**EP1902664-023**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**35.3**	**34.9**	**32.5**	**35.3**	**33.7**
EA150: Particle Sizing								
+75µm	----	1	%	**60**	**65**	**76**	**46**	**55**
+150µm	----	1	%	**31**	**35**	**37**	**17**	**22**
+300µm	----	1	%	**12**	**16**	**17**	**7**	**11**
+425µm	----	1	%	**6**	**11**	**12**	**5**	**8**
+600µm	----	1	%	**4**	**8**	**9**	**4**	**6**
+1180µm	----	1	%	**1**	**5**	**6**	**2**	**2**
+2.36mm	----	1	%	<1	**5**	**4**	<1	**1**
+4.75mm	----	1	%	<1	**4**	**3**	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**24**	**21**	**14**	**8**	**9**
Sand (0.06-2.00 mm)	----	1	%	**75**	**74**	**81**	**91**	**89**
Gravel (>2mm)	----	1	%	**1**	**5**	**5**	**1**	**2**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.72**	**2.70**	**2.71**	**2.70**	**2.70**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4010**	**3700**	**4000**	**4810**	**4280**
Iron	7439-89-6	50	mg/kg	**8470**	**8440**	**8620**	**9890**	**9000**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**7.63**	**7.73**	**8.13**	**7.21**	**7.36**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	**0.1**	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**28.5**	**26.7**	**27.9**	**33.2**	**29.9**
Copper	7440-50-8	1.0	mg/kg	**3.5**	**3.4**	**3.5**	**4.4**	**3.7**
Lead	7439-92-1	1.0	mg/kg	**2.3**	**2.4**	**2.3**	**2.7**	**2.5**
Nickel	7440-02-0	1.0	mg/kg	**10.1**	**9.4**	**10.1**	**12.2**	**10.8**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**M9B**	**M8T**	**M8B**	**M7T**	**M7B**
			Client sampling date / time	17-Mar-2019 10:30	17-Mar-2019 11:35	17-Mar-2019 11:35	17-Mar-2019 13:20	17-Mar-2019 13:20
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-019**	**EP1902664-020**	**EP1902664-021**	**EP1902664-022**	**EP1902664-023**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**7.3**	**7.8**	**7.4**	**9.7**	**7.8**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.23**	**0.25**	**0.31**	**0.31**	**0.28**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**78.6**	**64.2**	**90.1**	**82.3**	**98.0**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL**)

			Client sample ID	**M6T**	**M6B**	**M5AT**	**N16T**	**M5AB**
			Client sampling date / time	17-Mar-2019 14:25	17-Mar-2019 14:25	17-Mar-2019 15:30	19-Mar-2019 08:50	17-Mar-2019 15:30
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-024**	**EP1902664-025**	**EP1902664-026**	**EP1902664-027**	**EP1902664-028**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**35.9**	**35.1**	**37.1**	**28.6**	**32.6**
EA150: Particle Sizing								
+75µm	----	1	%	**46**	**51**	**44**	**41**	**48**
+150µm	----	1	%	**16**	**18**	**12**	**25**	**18**
+300µm	----	1	%	**7**	**7**	**5**	**10**	**8**
+425µm	----	1	%	**5**	**5**	**4**	**7**	**5**
+600µm	----	1	%	**3**	**4**	**3**	**4**	**4**
+1180µm	----	1	%	**1**	**3**	**2**	**3**	**1**
+2.36mm	----	1	%	<1	**2**	**2**	**2**	<1
+4.75mm	----	1	%	<1	**2**	**1**	**1**	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**14**	**21**	**20**	**1**	**4**
Sand (0.06-2.00 mm)	----	1	%	**85**	**77**	**78**	**97**	**95**
Gravel (>2mm)	----	1	%	**1**	**2**	**2**	**2**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.71**	**2.68**	**2.70**	**2.71**	**2.66**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4680**	**4060**	**5480**	**3660**	**3920**
Iron	7439-89-6	50	mg/kg	**10000**	**8580**	**11200**	**9860**	**8420**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**7.54**	**7.10**	**8.15**	**12.6**	**7.25**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	**0.1**	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**34.1**	**29.7**	**36.9**	**26.6**	**28.5**
Copper	7440-50-8	1.0	mg/kg	**4.6**	**3.8**	**7.0**	**3.2**	**3.6**
Lead	7439-92-1	1.0	mg/kg	**2.7**	**2.4**	**3.1**	**2.9**	**2.4**
Nickel	7440-02-0	1.0	mg/kg	**12.5**	**10.6**	**13.5**	**8.8**	**9.8**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	**0.1**	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL)**

			Client sample ID	M6T	M6B	M5AT	N16T	M5AB
			Client sampling date / time	17-Mar-2019 14:25	17-Mar-2019 14:25	17-Mar-2019 15:30	19-Mar-2019 08:50	17-Mar-2019 15:30
Compound	CAS Number	LOR	Unit	EP1902664-024	EP1902664-025	EP1902664-026	EP1902664-027	EP1902664-028
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**9.9**	**7.7**	**13.0**	**7.3**	**7.6**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.30**	**0.23**	**0.33**	**0.19**	**0.27**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**68.7**	**60.9**	**71.5**	**80.3**	**92.8**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**N17T**	**N18T**	**N18B**	**N19T**	**C1T**
			Client sampling date / time	19-Mar-2019 09:40	19-Mar-2019 10:25	19-Mar-2019 10:25	19-Mar-2019 11:15	19-Mar-2019 13:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-029**	**EP1902664-030**	**EP1902664-031**	**EP1902664-032**	**EP1902664-033**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**29.5**	**29.0**	**27.8**	**29.8**	**27.3**
EA150: Particle Sizing								
+75µm	----	1	%	**67**	**89**	**100**	**78**	**60**
+150µm	----	1	%	**41**	**52**	**67**	**50**	**36**
+300µm	----	1	%	**17**	**18**	**35**	**23**	**15**
+425µm	----	1	%	**11**	**10**	**23**	**17**	**12**
+600µm	----	1	%	**7**	**6**	**15**	**13**	**10**
+1180µm	----	1	%	**4**	**1**	**7**	**8**	**6**
+2.36mm	----	1	%	**3**	<1	**4**	**6**	**4**
+4.75mm	----	1	%	**2**	<1	**3**	**3**	**2**
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**4**	----	----	**7**	<1
Silt (2-60 µm)	----	1	%	**19**	----	----	**11**	**19**
Sand (0.06-2.00 mm)	----	1	%	**74**	----	----	**76**	**77**
Gravel (>2mm)	----	1	%	**3**	----	----	**6**	**4**
Cobbles (>6cm)	----	1	%	<1	----	----	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.69**	**2.69**	**2.69**	**2.69**	**2.71**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**3570**	**4070**	**3140**	**3940**	**3930**
Iron	7439-89-6	50	mg/kg	**9520**	**10500**	**8770**	**10200**	**10300**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**12.2**	**12.2**	**12.1**	**11.7**	**12.9**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**25.7**	**27.7**	**22.9**	**26.8**	**25.6**
Copper	7440-50-8	1.0	mg/kg	**3.1**	**3.7**	**2.8**	**3.6**	**3.6**
Lead	7439-92-1	1.0	mg/kg	**2.8**	**3.0**	**2.5**	**2.9**	**3.0**
Nickel	7440-02-0	1.0	mg/kg	**8.7**	**9.7**	**7.7**	**9.1**	**8.7**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			*Client sample ID*	**N17T**	**N18T**	**N18B**	**N19T**	**C1T**
			Client sampling date / time	19-Mar-2019 09:40	19-Mar-2019 10:25	19-Mar-2019 10:25	19-Mar-2019 11:15	19-Mar-2019 13:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-029**	**EP1902664-030**	**EP1902664-031**	**EP1902664-032**	**EP1902664-033**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**7.0**	**8.3**	**6.1**	**8.1**	**8.6**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.17**	**0.16**	**0.13**	**0.17**	**0.16**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**95.3**	**93.4**	**91.5**	**91.0**	**95.5**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**C1B**	**C2AT**	**C2AB**	**C2BT**	**C2BB**
			Client sampling date / time	19-Mar-2019 13:00	19-Mar-2019 13:55	19-Mar-2019 13:55	19-Mar-2019 15:05	19-Mar-2019 15:05
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-034**	**EP1902664-035**	**EP1902664-036**	**EP1902664-037**	**EP1902664-038**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**29.6**	**31.3**	**29.0**	**31.3**	**27.8**
EA150: Particle Sizing								
+75µm	----	1	%	**69**	**56**	**52**	**49**	**65**
+150µm	----	1	%	**48**	**37**	**31**	**27**	**47**
+300µm	----	1	%	**25**	**15**	**12**	**14**	**25**
+425µm	----	1	%	**18**	**11**	**8**	**11**	**20**
+600µm	----	1	%	**14**	**9**	**6**	**10**	**16**
+1180µm	----	1	%	**9**	**6**	**4**	**6**	**10**
+2.36mm	----	1	%	**6**	**4**	**2**	**4**	**4**
+4.75mm	----	1	%	**3**	**2**	<1	**3**	**1**
+9.5mm	----	1	%	**1**	<1	<1	**1**	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**9**	**1**	**1**	**10**	**10**
Sand (0.06-2.00 mm)	----	1	%	**84**	**94**	**97**	**86**	**84**
Gravel (>2mm)	----	1	%	**7**	**5**	**2**	**4**	**6**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.70**	**2.72**	**2.72**	**2.70**	**2.71**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**3520**	**3650**	**4890**	**4760**	**3420**
Iron	7439-89-6	50	mg/kg	**9510**	**9080**	**11400**	**11600**	**9830**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**12.5**	**11.4**	**11.8**	**11.7**	**12.7**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**23.8**	**24.3**	**29.2**	**28.9**	**22.8**
Copper	7440-50-8	1.0	mg/kg	**3.0**	**3.4**	**4.5**	**4.3**	**2.8**
Lead	7439-92-1	1.0	mg/kg	**2.8**	**2.8**	**3.3**	**3.2**	**2.6**
Nickel	7440-02-0	1.0	mg/kg	**7.8**	**9.0**	**10.8**	**10.3**	**7.4**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**C1B**	**C2AT**	**C2AB**	**C2BT**	**C2BB**
			Client sampling date / time	19-Mar-2019 13:00	19-Mar-2019 13:55	19-Mar-2019 13:55	19-Mar-2019 15:05	19-Mar-2019 15:05
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-034**	**EP1902664-035**	**EP1902664-036**	**EP1902664-037**	**EP1902664-038**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**6.2**	**6.7**	**8.6**	**10.0**	**6.2**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.15**	**0.11**	**0.13**	**0.17**	**0.17**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**90.4**	**96.3**	**98.1**	**67.9**	**79.3**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			Client sample ID	**C2CT**	**C2CB**	**C3T**	**C4T**	**C5T**
			Client sampling date / time	20-Mar-2019 08:40	20-Mar-2019 08:40	20-Mar-2019 09:50	20-Mar-2019 10:50	20-Mar-2019 11:50
Compound	CAS Number	LOR	Unit	**EP1902664-039**	**EP1902664-040**	**EP1902664-041**	**EP1902664-042**	**EP1902664-043**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**29.1**	**30.2**	**53.5**	**30.2**	**36.0**
EA150: Particle Sizing								
+75µm	----	1	%	**67**	**69**	**85**	**61**	**50**
+150µm	----	1	%	**38**	**43**	**72**	**57**	**37**
+300µm	----	1	%	**13**	**19**	**59**	**48**	**21**
+425µm	----	1	%	**9**	**15**	**56**	**41**	**13**
+600µm	----	1	%	**7**	**12**	**52**	**36**	**8**
+1180µm	----	1	%	**4**	**9**	**47**	**24**	**4**
+2.36mm	----	1	%	**2**	**5**	**43**	**14**	**2**
+4.75mm	----	1	%	<1	<1	**40**	**8**	**1**
+9.5mm	----	1	%	<1	<1	**34**	**2**	<1
+19.0mm	----	1	%	<1	<1	**26**	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	**7**	**2**	<1	<1
Silt (2-60 µm)	----	1	%	**24**	**20**	**13**	**7**	**21**
Sand (0.06-2.00 mm)	----	1	%	**74**	**67**	**41**	**76**	**76**
Gravel (>2mm)	----	1	%	**2**	**6**	**44**	**17**	**3**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.73**	**2.74**	**2.75**	**2.72**	**2.72**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4200**	**5400**	**8160**	**3160**	**4500**
Iron	7439-89-6	50	mg/kg	**10600**	**12600**	**17600**	**10000**	**11900**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**12.6**	**12.0**	**10.3**	**13.1**	**10.6**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**24.7**	**31.9**	**46.6**	**21.6**	**28.4**
Copper	7440-50-8	1.0	mg/kg	**3.7**	**5.2**	**8.0**	**3.2**	**4.7**
Lead	7439-92-1	1.0	mg/kg	**3.1**	**3.5**	**3.8**	**2.4**	**2.9**
Nickel	7440-02-0	1.0	mg/kg	**8.8**	**12.4**	**17.5**	**6.5**	**9.8**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**C2CT**	**C2CB**	**C3T**	**C4T**	**C5T**
			Client sampling date / time	20-Mar-2019 08:40	20-Mar-2019 08:40	20-Mar-2019 09:50	20-Mar-2019 10:50	20-Mar-2019 11:50
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-039**	**EP1902664-040**	**EP1902664-041**	**EP1902664-042**	**EP1902664-043**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.2**	**9.3**	**17.7**	**7.0**	**10.4**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.13**	**0.14**	**0.22**	**0.15**	**0.24**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**	**EP1902664_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**107**	**98.0**	**108**	**99.1**	**113**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**M8T DUP**	**C2AT DUP**	----	----	----
			Client sampling date / time	17-Mar-2019 11:35	19-Mar-2019 13:55	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902664-044**	**EP1902664-045**	--------	--------	--------
				Result	Result	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**36.2**	**31.4**	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	**52**	**54**	----	----	----
+150µm	----	1	%	**28**	**32**	----	----	----
+300µm	----	1	%	**11**	**12**	----	----	----
+425µm	----	1	%	**7**	**9**	----	----	----
+600µm	----	1	%	**4**	**8**	----	----	----
+1180µm	----	1	%	**2**	**6**	----	----	----
+2.36mm	----	1	%	**1**	**4**	----	----	----
+4.75mm	----	1	%	<1	**2**	----	----	----
+9.5mm	----	1	%	<1	<1	----	----	----
+19.0mm	----	1	%	<1	<1	----	----	----
+37.5mm	----	1	%	<1	<1	----	----	----
+75.0mm	----	1	%	<1	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	----	----	----
Silt (2-60 µm)	----	1	%	**14**	**7**	----	----	----
Sand (0.06-2.00 mm)	----	1	%	**84**	**88**	----	----	----
Gravel (>2mm)	----	1	%	**2**	**5**	----	----	----
Cobbles (>6cm)	----	1	%	<1	<1	----	----	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.75**	**2.72**	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4180**	**3490**	----	----	----
Iron	7439-89-6	50	mg/kg	**9660**	**9600**	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	----	----	----
Arsenic	7440-38-2	1.00	mg/kg	**8.11**	**11.7**	----	----	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	----	----	----
Chromium	7440-47-3	1.0	mg/kg	**28.2**	**22.8**	----	----	----
Copper	7440-50-8	1.0	mg/kg	**3.9**	**3.5**	----	----	----
Lead	7439-92-1	1.0	mg/kg	**2.6**	**2.9**	----	----	----
Nickel	7440-02-0	1.0	mg/kg	**10.1**	**8.3**	----	----	----
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	----	----	----

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**M8T DUP**	**C2AT DUP**	**----**	**----**	**----**
			Client sampling date / time	17-Mar-2019 11:35	19-Mar-2019 13:55	----	----	----
Compound	CAS Number	LOR	Unit	**EP1902664-044**	**EP1902664-045**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.1**	**6.6**	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.25**	**0.13**	----	----	----
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	----	----	----
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	----	----	----
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	----	----	----
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902664_SR**	**EP1902664_SR**	----	----	----
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**123**	**112**	----	----	----

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Client sample ID	**R1**	**R2**	**R3**	**----**	**----**
			Client sampling date / time	17-Mar-2019 16:45	18-Mar-2019 16:45	19-Mar-2019 16:00	----	----
Compound	CAS Number	LOR	Unit	**EP1902664-001**	**EP1902664-002**	**EP1902664-003**	**--------**	**--------**
				Result	Result	Result	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	**0.09**	<0.01	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	**0.006**	**0.050**	<0.005	----	----
Iron	7439-89-6	0.05	mg/L	**0.06**	**0.09**	<0.05	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	**1**	<1	----	----
EP090: Organotin Compounds (Soluble)								
Monobutyltin	78763-54-9	5	ngSn/L	<8	<5	<5	----	----
Dibutyltin	1002-53-5	5	ngSn/L	<5	<5	<5	----	----
Tributyltin	56573-85-4	2	ngSn/L	<2	<2	<2	----	----
EP090S: Organotin Surrogate								
Tripropyltin	----	5	%	**96.0**	**99.8**	**110**	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**

Compound	CAS Number	Recovery Limits (%) Low	Recovery Limits (%) High
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	Recovery Limits (%) High
EP090S: Organotin Surrogate			
Tripropyltin	----	24	116

ALS Environmental

QUALITY CONTROL REPORT

Work Order : **EP1902664**

Client : **WorleyParsons Services Pty Ltd**
Contact : MR PAUL NICHOLS
Address : LEVEL 4, 600 MURRAY STREET
WEST PERTH WA, AUSTRALIA 6005
Telephone : +61 08 9278 8111
Project : 401012-02698 WEL SCABS
Order number : 401012-02698
C-O-C number : ----
Sampler : ASHLEY LEMMON
Site : ----
Quote number : EP/114/19 V3
No. of samples received : 45
No. of samples analysed : 45

Page : 1 of 10

Laboratory : Environmental Division Perth
Contact : Marnie Thomsett
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : 08 9406 1311
Date Samples Received : 22-Mar-2019
Date Analysis Commenced : 25-Mar-2019
Issue Date : 30-Apr-2019

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Peter Keyte	Newcastle Manager	Newcastle - Inorganics, Mayfield West, NSW
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to hig

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2257183)									
EP1902664-004	M5BT	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4750	4380	7.97	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	10200	9290	9.65	0% - 20%
EP1902664-014	M1T	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4110	4030	1.77	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	9900	9660	2.44	0% - 20%
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2257186)									
EP1902664-024	M6T	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4680	5360	13.6	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	10000	10400	3.66	0% - 20%
EP1902664-034	C1B	EG005-SD: Aluminium	7429-90-5	50	mg/kg	3520	3500	0.710	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	9510	9780	2.75	0% - 20%
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2257189)									
EP1902664-044	M8T DUP	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4180	3650	13.4	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	9660	8840	8.80	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2257182)									
EP1902664-004	M5BT	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EP1902664-014	M1T	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2257187)									
EP1902664-024	M6T	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EP1902664-034	C1B	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2257190)									
EP1902664-044	M8T DUP	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2257108)									
EP1902664-004	M5BT	EA055: Moisture Content	----	0.1	%	36.8	36.8	0.00	0% - 20%
EP1902664-013	M2B	EA055: Moisture Content	----	0.1	%	33.2	34.2	3.10	0% - 20%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2257109)									
EP1902664-024	M6T	EA055: Moisture Content	----	0.1	%	35.9	36.6	1.99	0% - 20%
EP1902664-033	C1T	EA055: Moisture Content	----	0.1	%	27.3	29.2	6.64	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2257110)									
EP1902664-044	M8T DUP	EA055: Moisture Content	----	0.1	%	36.2	34.8	3.73	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2257184)									
EP1902664-004	M5BT	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	8.56	8.05	6.19	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	36.0	33.1	8.25	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	4.6	4.4	5.99	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	3.2	2.9	8.04	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	12.8	11.6	9.74	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	10.6	10.6	0.00	0% - 50%
EP1902664-014	M1T	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	9.95	9.37	5.92	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	30.8	30.1	2.21	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	3.8	3.7	0.00	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	2.8	2.7	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	10.8	10.5	2.74	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	8.4	8.6	2.21	No Limit
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2257185)									
EP1902664-024	M6T	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	7.54	6.84	9.72	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	34.1	36.9	7.84	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	4.6	4.9	6.11	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	2.7	2.8	3.69	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	12.5	13.7	9.19	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	9.9	11.1	11.8	0% - 50%
EP1902664-034	C1B	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	12.5	12.4	0.549	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	23.8	22.1	7.09	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	3.0	2.9	0.00	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	2.8	2.6	5.03	No Limit

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2257185) - continued									
EP1902664-034	C1B	EG020-SD: Nickel	7440-02-0	1	mg/kg	7.8	7.4	6.52	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	6.2	5.7	7.66	No Limit
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2257188)									
EP1902664-044	M8T DUP	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	8.11	7.65	5.88	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	28.2	26.5	6.25	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	3.9	3.7	7.40	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	2.6	2.5	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	10.1	9.3	7.98	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	8.1	7.4	9.76	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2266184)									
EP1902664-004	M5BT	EP003: Total Organic Carbon	----	0.02	%	0.33	0.32	0.00	0% - 50%
EP1902664-014	M1T	EP003: Total Organic Carbon	----	0.02	%	0.23	0.25	8.34	0% - 50%
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2266185)									
EP1902664-024	M6T	EP003: Total Organic Carbon	----	0.02	%	0.30	0.25	16.8	0% - 50%
EP1902664-034	C1B	EP003: Total Organic Carbon	----	0.02	%	0.15	0.16	7.94	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2266186)									
EP1902664-044	M8T DUP	EP003: Total Organic Carbon	----	0.02	%	0.25	0.24	6.12	0% - 50%
EP090: Organotin Compounds (QC Lot: 2259415)									
EP1902664-004	M5BT	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP1902664-014	M1T	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP090: Organotin Compounds (QC Lot: 2259416)									
EP1902664-024	M6T	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP1902664-034	C1B	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP090: Organotin Compounds (QC Lot: 2259417)									
EP1902664-044	M8T DUP	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 2256392)									
EP1902654-001	Anonymous	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EP1902726-001	Anonymous	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 2256393)									
EP1902654-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.008	44.1	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.02	<0.01	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.74	0.76	2.09	0% - 50%
EP1902726-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.008	38.5	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	8.90	8.86	0.468	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2253743)									
EP1902643-005	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EP1902665-005	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 2255087)									
EP1902549-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	3	5	43.1	No Limit
EP1902594-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	4	5	25.3	No Limit
EP090: Organotin Compounds (Soluble) (QC Lot: 2260725)									
EP1902664-002	R2	EP090S: Tributyltin	56573-85-4	2	ngSn/L	<2	<2	0.00	No Limit
		EP090S: Monobutyltin	78763-54-9	5	ngSn/L	<5	<8	51.8	No Limit
		EP090S: Dibutyltin	1002-53-5	5	ngSn/L	<5	<5	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257183)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257186)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257189)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2257182)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	115	80	120
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2257187)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	113	80	120
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2257190)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	116	80	120
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257184)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	112	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.6838 mg/kg	111	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	130	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	102	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	108	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	121	81	135
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	128	81	143
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257185)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	100	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.6838 mg/kg	101	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	120	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	93.4	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	99.7	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	112	81	135
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257185) - continued								
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	115	81	143
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257188)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	98.4	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.6838 mg/kg	103	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	110	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	91.1	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	98.3	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	108	81	135
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	115	81	143
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2266184)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.11 %	105	70	130
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2266185)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.11 %	113	70	130
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2266186)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.11 %	111	70	130
EP090: Organotin Compounds (QCLot: 2259415)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	98.9	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	101	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	111	52	139
EP090: Organotin Compounds (QCLot: 2259416)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	101	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	93.8	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	117	52	139
EP090: Organotin Compounds (QCLot: 2259417)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	103	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	109	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	135	52	139

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 2256392)								
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.02 mg/L	116	52	120
EG020T: Total Metals by ICP-MS (QCLot: 2256393)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	103	84	120
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.02 mg/L	99.6	83	120

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2256393) - continued								
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	98.8	85	120
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	100	84	120
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	101	85	120
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	101	83	120
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	98.5	86	120
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	95.1	83	120
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	103	84	120
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	98.3	77	120
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2253743)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	95.7	87	115
EP005: Total Organic Carbon (TOC) (QCLot: 2255087)								
EP005: Total Organic Carbon	----	1	mg/L	<1 <1	10 mg/L 100 mg/L	103 103	79 79	111 111
EP090: Organotin Compounds (Soluble) (QCLot: 2260725)								
EP090S: Monobutyltin	78763-54-9	5	ngSn/L	<5	147 ngSn/L	# 138	45	116
EP090S: Dibutyltin	1002-53-5	5	ngSn/L	<5	147 ngSn/L	# 115	69	111
EP090S: Tributyltin	56573-85-4	2	ngSn/L	<2	147 ngSn/L	95.4	20	125

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257183)							
EP1902664-005	M5BB	EG005-SD: Aluminium	7429-90-5	50 mg/kg	# Not Determined	70	130
		EG005-SD: Iron	7439-89-6	50 mg/kg	# Not Determined	70	130
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257186)							
EP1902664-025	M6B	EG005-SD: Aluminium	7429-90-5	50 mg/kg	# Not Determined	70	130
		EG005-SD: Iron	7439-89-6	50 mg/kg	# Not Determined	70	130
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257189)							
EP1902664-045	C2AT DUP	EG005-SD: Aluminium	7429-90-5	50 mg/kg	# Not Determined	70	130

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	*SpikeRecovery(%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2257189) - continued							
EP1902664-045	C2AT DUP	EG005-SD: Iron	7439-89-6	50 mg/kg	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2257182)							
EP1902664-005	M5BB	EG035T-LL: Mercury	7439-97-6	10 mg/kg	99.9	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2257187)							
EP1902664-025	M6B	EG035T-LL: Mercury	7439-97-6	10 mg/kg	106	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2257190)							
EP1902664-045	C2AT DUP	EG035T-LL: Mercury	7439-97-6	10 mg/kg	116	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257184)							
EP1902664-005	M5BB	EG020-SD: Arsenic	7440-38-2	50 mg/kg	105	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	100	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	102	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	94.5	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	96.9	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	98.4	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	100	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257185)							
EP1902664-025	M6B	EG020-SD: Arsenic	7440-38-2	50 mg/kg	102	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	98.0	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	97.7	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	92.4	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	94.2	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	96.1	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	94.3	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2257188)							
EP1902664-045	C2AT DUP	EG020-SD: Arsenic	7440-38-2	50 mg/kg	97.6	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	97.7	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	96.1	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	89.6	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	94.2	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	93.8	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	91.8	70	130
EP090: Organotin Compounds (QCLot: 2259415)							
EP1902664-005	M5BB	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	# 12.2	20	130
		EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	56.1	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	90.1	20	130

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP090: Organotin Compounds (QCLot: 2259416)							
EP1902664-025	M6B	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	# 18.7	20	130
		EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	59.3	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	81.9	20	130
EP090: Organotin Compounds (QCLot: 2259417)							
EP1902664-045	C2AT DUP	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	68.4	20	130
		EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	106	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	128	20	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2256393)							
EP1902654-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	106	70	130
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	108	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	101	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	106	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	109	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	102	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	107	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2253743)							
EP1902643-006	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	79.3	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2255087)							
EP1902549-002	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	99.5	70	130
EP090: Organotin Compounds (Soluble) (QCLot: 2260725)							
EP1902664-003	R3	EP090S: Monobutyltin	78763-54-9	147 ngSn/L	# 136	20	130
		EP090S: Dibutyltin	1002-53-5	147 ngSn/L	125	20	130
		EP090S: Tributyltin	56573-85-4	147 ngSn/L	103	20	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP1902664**	Page	: 1 of 16
Client	: **WorleyParsons Services Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR PAUL NICHOLS	Telephone	: 08 9406 1311
Project	: 401012-02698 WEL SCABS	Date Samples Received	: 22-Mar-2019
Site	: ----	Issue Date	: 30-Apr-2019
Sampler	: ASHLEY LEMMON	No. of samples received	: 45
Order number	: 401012-02698	No. of samples analysed	: 45

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **Laboratory Control outliers exist - please see following pages for full details.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **NO Quality Control Sample Frequency Outliers exist.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Matrix Spike (MS) Recoveries							
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902664--005	M5BB	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902664--025	M6B	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902664--045	C2AT DUP	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902664--005	M5BB	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902664--025	M6B	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902664--045	C2AT DUP	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP090: Organotin Compounds	EP1902664--005	M5BB	**Monobutyltin**	78763-54-9	12.2 %	20-130%	**Recovery less than lower data quality objective**
EP090: Organotin Compounds	EP1902664--025	M6B	**Monobutyltin**	78763-54-9	18.7 %	20-130%	**Recovery less than lower data quality objective**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Laboratory Control Spike (LCS) Recoveries							
EP090: Organotin Compounds (Soluble)	QC-2260725-002	----	**Monobutyltin**	78763-54-9	138 %	45-116%	**Recovery greater than upper control limit**
EP090: Organotin Compounds (Soluble)	QC-2260725-002	----	**Dibutyltin**	1002-53-5	115 %	69-111%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
EP090: Organotin Compounds (Soluble)	EP1902664--003	R3	**Monobutyltin**	78763-54-9	136 %	20-130%	**Recovery greater than upper data quality objective**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EP090: Organotin Compounds (Soluble)						

Matrix: **WATER**

Method **Container** / Client Sample ID(s)	Extraction / Preparation Date extracted	 Due for extraction	 **Days overdue**	Analysis Date analysed	 Due for analysis	 **Days overdue**
EP090: Organotin Compounds (Soluble) - Analysis Holding Time Compliance						
Amber Glass Bottle - Unpreserved R1	28-Mar-2019	24-Mar-2019	**4**	----	----	----
Amber Glass Bottle - Unpreserved R2	28-Mar-2019	25-Mar-2019	**3**	----	----	----
Amber Glass Bottle - Unpreserved R3	28-Mar-2019	26-Mar-2019	**2**	----	----	----

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** / *Client Sample ID(s)*		***Sample Date***	*Extraction / Preparation* ***Date extracted***	 *Due for extraction*	 *Evaluation*	*Analysis* ***Date analysed***	 *Due for analysis*	 *Evaluation*
EA055: Moisture Content (Dried @ 105-110°C)								
Soil Glass Jar - Unpreserved (EA055) M10T, M9T, M8T, M7T, M6T, M5AT, M8T DUP	 M10B, M9B, M8B, M7B, M6B, M5AB,	**17-Mar-2019**	**----**	----	----	**26-Mar-2019**	31-Mar-2019	✓
Soil Glass Jar - Unpreserved (EA055) M5BT, M5CT, M4T, M3T, M2T, M1T,	 M5BB, M5CB, M4B, M3B, M2B, M1B	**18-Mar-2019**	**----**	----	----	**26-Mar-2019**	01-Apr-2019	✓
Soil Glass Jar - Unpreserved (EA055)								

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*		***Sample Date***	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA055: Moisture Content (Dried @ 105-110°C) - Continued								
N16T, N18T, N19T, C1B, C2AB, C2BB,	N17T, N18B, C1T, C2AT, C2BT, C2AT DUP	**19-Mar-2019**	**----**	----	----	**26-Mar-2019**	02-Apr-2019	✓
Soil Glass Jar - Unpreserved (EA055)								
C2CT, C3T, C5T	C2CB, C4T,	**20-Mar-2019**	**----**	----	----	**26-Mar-2019**	03-Apr-2019	✓
EA150: Particle Sizing								
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H)								
M10T, M9T, M8T, M7T, M6T, M5AT, M8T DUP	M10B, M9B, M8B, M7B, M6B, M5AB,	**17-Mar-2019**	**----**	----	----	**18-Apr-2019**	13-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H)								
M5BT, M5CT, M4T, M3T, M2T, M1T,	M5BB, M5CB, M4B, M3B, M2B, M1B	**18-Mar-2019**	**----**	----	----	**18-Apr-2019**	14-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H)								
N16T, N18T, N19T, C1B, C2AB, C2BB,	N17T, N18B, C1T, C2AT, C2BT, C2AT DUP	**19-Mar-2019**	**----**	----	----	**18-Apr-2019**	15-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H)								
C2CT, C3T, C5T	C2CB, C4T,	**20-Mar-2019**	**----**	----	----	**18-Apr-2019**	16-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA150: Soil Classification based on Particle Size							
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) M10T, M10B, M9T, M9B, M8T, M8B, M7T, M7B, M6T, M6B, M5AT, M5AB, M8T DUP	**17-Mar-2019**	**----**	----	----	**18-Apr-2019**	13-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) M5BT, M5BB, M5CT, M5CB, M4T, M4B, M3T, M3B, M2T, M2B, M1T, M1B	**18-Mar-2019**	**----**	----	----	**18-Apr-2019**	14-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) N16T, N17T, N19T, C1T, C1B, C2AT, C2AB, C2BT, C2BB, C2AT DUP	**19-Mar-2019**	**----**	----	----	**18-Apr-2019**	15-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) C2CT, C2CB, C3T, C4T, C5T	**20-Mar-2019**	**----**	----	----	**18-Apr-2019**	16-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA152: Soil Particle Density							
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152) M10T, M10B, M9T, M9B, M8T, M8B, M7T, M7B, M6T, M6B, M5AT, M5AB, M8T DUP	**17-Mar-2019**	**----**	----	----	**18-Apr-2019**	13-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152) M5BT, M5BB, M5CT, M5CB, M4T, M4B, M3T, M3B, M2T, M2B, M1T, M1B	**18-Mar-2019**	**----**	----	----	**18-Apr-2019**	14-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152) N16T, N17T, N18T, N18B, N19T, C1T, C1B, C2AT, C2AB, C2BT, C2BB, C2AT DUP	**19-Mar-2019**	**----**	----	----	**18-Apr-2019**	15-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152) C2CT, C2CB, C3T, C4T, C5T	**20-Mar-2019**	**----**	----	----	**18-Apr-2019**	16-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Soil Glass Jar - Unpreserved (EG005-SD)								
M10T, M9T, M8T, M7T, M6T, M5AT, M8T DUP	M10B, M9B, M8B, M7B, M6B, M5AB,	**17-Mar-2019**	**28-Mar-2019**	13-Sep-2019	✓	**28-Mar-2019**	13-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD)								
M5BT, M5CT, M4T, M3T, M2T, M1T,	M5BB, M5CB, M4B, M3B, M2B, M1B	**18-Mar-2019**	**28-Mar-2019**	14-Sep-2019	✓	**28-Mar-2019**	14-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD)								
N16T, N18T, N19T, C1B, C2AB, C2BB,	N17T, N18B, C1T, C2AT, C2BT, C2AT DUP	**19-Mar-2019**	**28-Mar-2019**	15-Sep-2019	✓	**28-Mar-2019**	15-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD)								
C2CT, C3T, C5T	C2CB, C4T,	**20-Mar-2019**	**28-Mar-2019**	16-Sep-2019	✓	**28-Mar-2019**	16-Sep-2019	✓

Matrix: **SOIL** Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)	**Sample Date**	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EG020-SD: Total Metals in Sediments by ICPMS							
Soil Glass Jar - Unpreserved (EG020-SD) M10T, M10B, M9T, M9B, M8T, M8B, M7T, M7B, M6T, M6B, M5AT, M5AB, M8T DUP	**17-Mar-2019**	**28-Mar-2019**	13-Sep-2019	✓	**28-Mar-2019**	13-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) M5BT, M5BB, M5CT, M5CB, M4T, M4B, M3T, M3B, M2T, M2B, M1T, M1B	**18-Mar-2019**	**28-Mar-2019**	14-Sep-2019	✓	**28-Mar-2019**	14-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) N16T, N17T, N18T, N18B, N19T, C1T, C1B, C2AT, C2AB, C2BT, C2BB, C2AT DUP	**19-Mar-2019**	**28-Mar-2019**	15-Sep-2019	✓	**28-Mar-2019**	15-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) C2CT, C2CB, C3T, C4T, C5T	**20-Mar-2019**	**28-Mar-2019**	16-Sep-2019	✓	**28-Mar-2019**	16-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)		**Sample Date**	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EG035T: Total Recoverable Mercury by FIMS								
Soil Glass Jar - Unpreserved (EG035T-LL)								
M10T,	M10B,	**17-Mar-2019**	**28-Mar-2019**	14-Apr-2019	✓	**29-Mar-2019**	14-Apr-2019	✓
M9T,	M9B,							
M8T,	M8B,							
M7T,	M7B,							
M6T,	M6B,							
M5AT,	M5AB,							
M8T DUP								
Soil Glass Jar - Unpreserved (EG035T-LL)								
M5BT,	M5BB,	**18-Mar-2019**	**28-Mar-2019**	15-Apr-2019	✓	**29-Mar-2019**	15-Apr-2019	✓
M5CT,	M5CB,							
M4T,	M4B,							
M3T,	M3B,							
M2T,	M2B,							
M1T,	M1B							
Soil Glass Jar - Unpreserved (EG035T-LL)								
N16T,	N17T,	**19-Mar-2019**	**28-Mar-2019**	16-Apr-2019	✓	**29-Mar-2019**	16-Apr-2019	✓
N18T,	N18B,							
N19T,	C1T,							
C1B,	C2AT,							
C2AB,	C2BT,							
C2BB,	C2AT DUP							
Soil Glass Jar - Unpreserved (EG035T-LL)								
C2CT,	C2CB,	**20-Mar-2019**	**28-Mar-2019**	17-Apr-2019	✓	**29-Mar-2019**	17-Apr-2019	✓
C3T,	C4T,							
C5T								

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*		***Sample Date***	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EP003: Total Organic Carbon (TOC) in Soil								
Soil Glass Jar - Unpreserved (EP003)								
M10T, M9T, M8T, M7T, M6T, M5AT, M8T DUP	M10B, M9B, M8B, M7B, M6B, M5AB,	**17-Mar-2019**	**01-Apr-2019**	14-Apr-2019	✓	**01-Apr-2019**	14-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP003)								
M5BT, M5CT, M4T, M3T, M2T, M1T,	M5BB, M5CB, M4B, M3B, M2B, M1B	**18-Mar-2019**	**01-Apr-2019**	15-Apr-2019	✓	**01-Apr-2019**	15-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP003)								
N16T, N18T, N19T, C1B, C2AB, C2BB,	N17T, N18B, C1T, C2AT, C2BT, C2AT DUP	**19-Mar-2019**	**01-Apr-2019**	16-Apr-2019	✓	**01-Apr-2019**	16-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP003)								
C2CT, C3T, C5T	C2CB, C4T,	**20-Mar-2019**	**01-Apr-2019**	17-Apr-2019	✓	**01-Apr-2019**	17-Apr-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EP090: Organotin Compounds							
Soil Glass Jar - Unpreserved (EP090) M6T, M6B, M5AT, M5AB	**17-Mar-2019**	**27-Mar-2019**	31-Mar-2019	✓	**01-Apr-2019**	06-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) M10T, M10B, M9T, M9B, M8T, M8B, M7T, M7B, M8T DUP	**17-Mar-2019**	**27-Mar-2019**	31-Mar-2019	✓	**28-Mar-2019**	06-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) M5BT, M5BB, M5CT, M5CB, M4T, M4B, M3T, M3B, M2T, M2B, M1T, M1B	**18-Mar-2019**	**27-Mar-2019**	01-Apr-2019	✓	**28-Mar-2019**	06-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) N16T, N17T, N18T, N18B, N19T, C1T, C1B, C2AT, C2AB, C2BT, C2BB	**19-Mar-2019**	**27-Mar-2019**	02-Apr-2019	✓	**01-Apr-2019**	06-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) C2AT DUP	**19-Mar-2019**	**27-Mar-2019**	02-Apr-2019	✓	**28-Mar-2019**	06-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) C2CT, C2CB, C3T, C4T, C5T	**20-Mar-2019**	**27-Mar-2019**	03-Apr-2019	✓	**01-Apr-2019**	06-May-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) R1	**17-Mar-2019**	**27-Mar-2019**	13-Sep-2019	✓	**27-Mar-2019**	13-Sep-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) R2	**18-Mar-2019**	**27-Mar-2019**	14-Sep-2019	✓	**27-Mar-2019**	14-Sep-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) R3	**19-Mar-2019**	**27-Mar-2019**	15-Sep-2019	✓	**27-Mar-2019**	15-Sep-2019	✓

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)	**Sample Date**	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) R1	**17-Mar-2019**	**----**	----	----	**25-Mar-2019**	14-Apr-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) R2	**18-Mar-2019**	**----**	----	----	**25-Mar-2019**	15-Apr-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) R3	**19-Mar-2019**	**----**	----	----	**25-Mar-2019**	16-Apr-2019	✓
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid (EP005) R1	**17-Mar-2019**	**----**	----	----	**25-Mar-2019**	14-Apr-2019	✓
Amber TOC Vial - Sulfuric Acid (EP005) R2	**18-Mar-2019**	**----**	----	----	**25-Mar-2019**	15-Apr-2019	✓
Amber TOC Vial - Sulfuric Acid (EP005) R3	**19-Mar-2019**	**----**	----	----	**25-Mar-2019**	16-Apr-2019	✓
EP090: Organotin Compounds (Soluble)							
Amber Glass Bottle - Unpreserved (EP090S) R1	**17-Mar-2019**	**28-Mar-2019**	24-Mar-2019	✗	**28-Mar-2019**	07-May-2019	✓
Amber Glass Bottle - Unpreserved (EP090S) R2	**18-Mar-2019**	**28-Mar-2019**	25-Mar-2019	✗	**28-Mar-2019**	07-May-2019	✓
Amber Glass Bottle - Unpreserved (EP090S) R3	**19-Mar-2019**	**28-Mar-2019**	26-Mar-2019	✗	**28-Mar-2019**	07-May-2019	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Moisture Content	EA055	5	42	**11.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organotin Analysis	EP090	5	42	**11.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Fe and Al in Sediments by ICPAES	EG005-SD	5	42	**11.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	5	42	**11.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	5	42	**11.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	5	42	**11.90**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Organotin Analysis	EP090	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Organotin Analysis	EP090	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Fe and Al in Sediments by ICPAES	EG005-SD	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Organotin Analysis	EP090	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Fe and Al in Sediments by ICPAES	EG005-SD	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	3	**66.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Total Metals by ICP-MS - Suite B	EG020B-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	18	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	18	**5.56**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Settling Rate by Hydrometer	* EA157H	SOIL	Settling Rate calculation from Hydrometer analysis according to AS1289.3.6.3 - 2003
Total Fe and Al in Sediments by ICPAES	EG005-SD	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3). LORs per NODG
Total Metals in Sediments by ICPMS	EG020-SD	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector. Analyte list and LORs per NODG.
Total Mercury by FIMS (Low Level)	EG035T-LL	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a LECO furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO2) is automaticaly measured by infra-red detector.
Organotin Analysis	EP090	SOIL	In house: Referenced to USEPA SW 846 - 8270D Prepared sample extracts are analysed by GC/MS coupled with high volume injection, and quanitified against an established calibration curve.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Organotin Compounds (Soluble)	EP090S	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by GC/MS coupled with high volume injection and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#
Organotin Sample Preparation	ORG35	SOIL	In house: 20g sample is spiked with surrogate and leached in a methanol:acetic acid:UHP water mix and vacuum filtered. Reagents and solvents are added to the sample and the mixture tumbled. The butyltin compounds are simultaneously derivatised and extracted. The extract is further extracted with petroleum ether. The resultant extracts are combined and concentrated for analysis.
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Organotin Sample Preparation	ORG34	WATER	In house. A specified volume of sample is spiked with surrogate, acidified and vacuum filtered. Reagents and solvent are added and the mixture tumbled. The butyltin compounds is derivitisated, extracted and the subtitution reaction completed. The extract is transferred to a separatory funnel and further extracted two times with petroleum ether. The resultant extracts are combined and concentrated for analysis.

CHAIN OF CUSTODY

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CLIENT: ADVISIAN (WORPAR)
OFFICE: PERTH
PROJECT: 401012-02698 WEL Scabs
PURCHASE ORDER NUMBER:
PROJECT MANAGER: Paul Nichols **CONTACT PH:** 0407193644
SAMPLER: Ashley Lemmon **SAMPLER MOBILE:** 0417561445
COC Emailed to ALS? ([✓ YES] / NO) **EDD FORMAT (or default):**
Email Reports to: paul.nichols@advisian.com; ashley.lemmon@advisian.com
Email Invoice to: " "

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)
☑ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EP/114/19 V3
COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: [✓ 1] 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No [✓ N/A]
Free ice / frozen [✓ ice bricks] present upon receipt? [✓ Yes] No N/A
Random Sample Temperature on Receipt: 9.8 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
A. Lemmon	Rhiannon		
DATE/TIME: 22/3/19 0930	DATE/TIME: 22/3/19 930am	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
						SEDIMENT				RINSATE				
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	R1	17/3/19 1645	W	AG, SG, P	4					✓	✓	✓		
2	R2	18/3/19 1645	W	AG, SG, P	4					✓	✓	✓		
3	R3	19/3/19 1600	W	AG, SG, P	4					✓	✓	✓		
					TOTAL 12									

Environmental Division
Perth
Work Order Reference
EP1902664

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Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CHAIN OF CUSTODY

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Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5 Rose Gum Road Warabrook NSW 2304
Ph: 02 4968 9433 E: samples.newcastle@alsglobal.com

☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 02 4423 2063 E: nowra@alsglobal.com

☑PERTH 20 Rigali Way, Wangara WA 6065
Ph: 08 9406 1301 E: samples.perth@alsglobal.com

☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: ADVISIAN (WORPAR)
OFFICE: PERTH
PROJECT: 401012-02689 WEL SCABS
PURCHASE ORDER NUMBER:
PROJECT MANAGER: Paul Nichols **CONTACT PH:** 0407193644
SAMPLER: A. Lemmon **SAMPLER MOBILE:** 0417561445
COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
Email Reports to: paul.nichols@advisian.com; ashley.lemmon@advisian.com
Email Invoice to: " " " " "

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☑ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EP/114/19 V3
COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? [✓ Yes] No N/A
Free ice / frozen ice bricks present upon receipt? [✓ Yes] No N/A
Random Sample Temperature on Receipt: 14.5 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
A. Lemmon	ND		
DATE/TIME: 25/3/19 1145	DATE/TIME: 1220 25/3/19	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
						SEDIMENT				RINSATE				
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES B bags	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
4	M5BT	18/3/19 0805	S	AG, B	4	✓	✓	✓	✓					
5	M5BB	" 0805	S	AG, B	4	✓	✓	✓	✓					
6	M5CT	" 0915	S	AG, B	4	✓	✓	✓	✓					
7	M5CB	" 0915	S	AG, B	4	✓	✓	✓	✓					Environmental Division Perth Work Order Reference EP1902664
8	M4T	" 1030	S	AG, B	4	✓	✓	✓	✓					
9	M4B	" 1030	S	AG, B	4	✓	✓	✓	✓					
10	M3T	" 1130	S	AG, B	4	✓	✓	✓	✓					
11	M3B	" 1130	S	AG, B	4	✓	✓	✓	✓					
12	M2T	" 1330	S	AG, B	4	✓	✓	✓	✓					
13	M2B	" 1330	S	AG, B	4	✓	✓	✓	✓					Telephone : + 61-8-9406 1301
14	M1T	" 1430	S	AG, B	4	✓	✓	✓	✓					
15	M1B	" 1430	S	AG, B	4	✓	✓	✓	✓					additional samples
	~~R2~~	~~18/3/19 1645~~		TOTAL	48									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 32 Shand Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
Ph: 07 7471 5600 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com
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Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: ADVISIAN (WORPAR)
OFFICE: PERTH
PROJECT:
PURCHASE ORDER NUMBER:
PROJECT MANAGER: **CONTACT PH:**
SAMPLER: **SAMPLER MOBILE:**
COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
Email Reports to:
Email Invoice to:

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☑ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**
ALS QUOTE NO.: EP/114/19 V3
COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)
COC: 1 [✓ 2] 3 4 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
A. Lemmon			
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required)								Additional Information
						SEDIMENT				RINSATE				
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES & bags	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
16	M10T	17/3/19 0920	S	AG, B	4	✓	✓	✓	✓					
17	M10B	" 0920	S	AG, B	4	✓	✓	✓	✓					
18	M9T	" 1030	S	AG, B	4	✓	✓	✓	✓					
19	M9B	" 1030	S	AG, B	4	✓	✓	✓	✓					#44
20	M8T	" 1135	S	AG, B	4	✓	✓	✓	✓					SPLIT REQUIRED
21	M8B	" 1135	S	AG, B	4	✓	✓	✓	✓					
–	~~M8I~~	~~" 1135~~	~~S~~	~~AG, B~~	~~4~~									
22	M7T	" 1320	S	AG, B	4	✓	✓	✓	✓					
23	M7B	" 1320	S	AG, B	4	✓	✓	✓	✓					
24	M6T	" 1425	S	AG, B	4	✓	✓	✓	✓					
25	M6B	" 1425	S	AG, B	4	✓	✓	✓	✓					
26	M5AT	" 1530	S	AG, B	4	✓	✓	✓	✓					
	~~M5AB~~	~~" 1530~~		TOTAL	44									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

ENFM (204/10)

~~721~~

CHAIN OF CUSTODY

ALS Laboratory: please tick →

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☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: ADVISIAN (WORPAR)

OFFICE: PERTH

PROJECT:

PURCHASE ORDER NUMBER:

PROJECT MANAGER: **CONTACT PH:**

SAMPLER: **SAMPLER MOBILE:**

COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to:

Email Invoice to:

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☑ Standard TAT **(List due date):**

☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EP/114/19 V3

COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)

COC: 1 2 [✓ 3] 4 5 6 7

OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:	°C		
Other comment:			

RELINQUISHED BY: A. Lemmon	**RECEIVED BY:**	**RELINQUISHED BY:**	**RECEIVED BY:**
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
						SEDIMENT				RINSATE				
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES & bags	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
27	N16T	19/3/19 0850	S	AG, B	4	✓	✓	✓	✓					
28	M5AB	17/3/19 1530	S	AG, B	4	✓	✓	✓	✓					
29	N17T	19/3/19 0940	S	AG, B	4	✓	✓	✓	✓					
30	N18T	19/3/19 1025	S	AG, B	4	✓	✓	✓	✓					
31	N18B	19/3/19 1025	S	AG, B	4	✓	✓	✓	✓					
32	N19T	19/3/19 1115	S	AG, B	4	✓	✓	✓	✓					
33	C1T	19/3/19 1300	S	AG, B	4	✓	✓	✓	✓					
34	C1B	19/3/19 1300	S	AG, B	4	✓	✓	✓	✓					#45
35	C2AT	19/3/19 1355	S	AG, B	4	✓	✓	✓	✓					SPLIT REQUIRED
36	C2AB	19/3/19 1355	S	AG, B	4	✓	✓	✓	✓					
37	C2BT	19/3/19 1505	S	AG, B	4	✓	✓	✓	✓					
38	C2BB	19/3/19 1505	S	AG, B	4	✓	✓	✓	✓					
				TOTAL	48									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CHAIN OF CUSTODY

*ALS Laboratory: **please tick** →*

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☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: ADVISIAN (WORPAR)
OFFICE: PERTH
PROJECT:
PURCHASE ORDER NUMBER:
PROJECT MANAGER: **CONTACT PH:**
SAMPLER: **SAMPLER MOBILE:**
COC Emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
Email Reports to:
Email Invoice to:

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EP/114/19 V3
COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 [✓ 4] 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME:	DATE/TIME:	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
						SEDIMENT				RINSATE				
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
39	~~C2T~~ C2CT	20/3/19 0840	S	AG, B	4	✓	✓	✓	✓					
40	C2CB	20/3/19 0840	S	AG, B	4	✓	✓	✓	✓					
41	C3T	20/3/19 0950	S	AG, B	3	✓	✓	✓	✓					ONLY 1x 500mL Sed bag
42	C4T	20/3/19 1050	S	AG, B	4	✓	✓	✓	✓					
43	C5T	20/3/19 1150	S	AG, B	4	✓	✓	✓	✓					
				TOTAL	19									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
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Certificate of Analysis

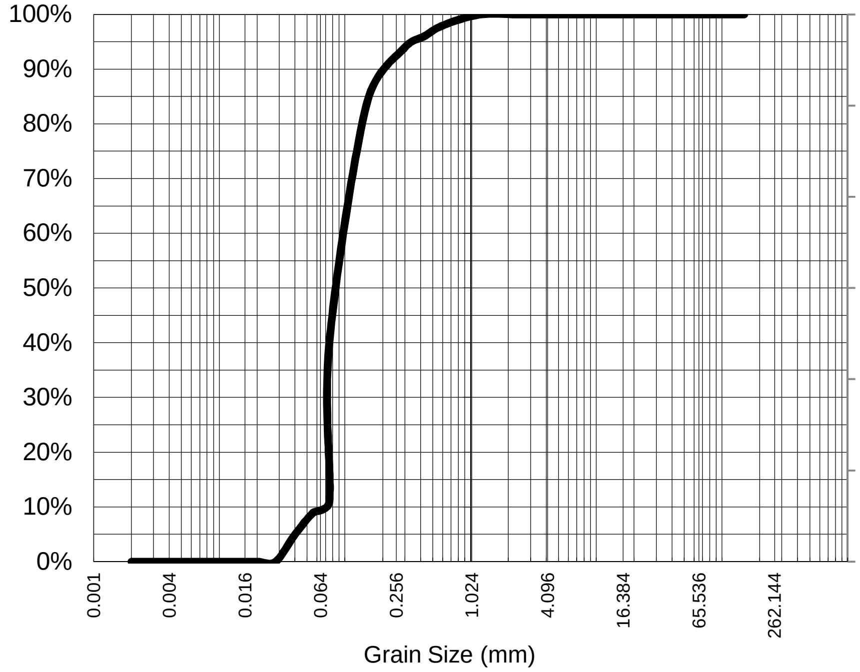
ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-004 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M5BT

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	98%
0.425	96%
0.300	94%
0.150	84%
0.075	40%
Particle Size (microns)	
56	9%
40	5%
28	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.092

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.67

NATA Accreditation: 825 Site: Newcastle
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Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

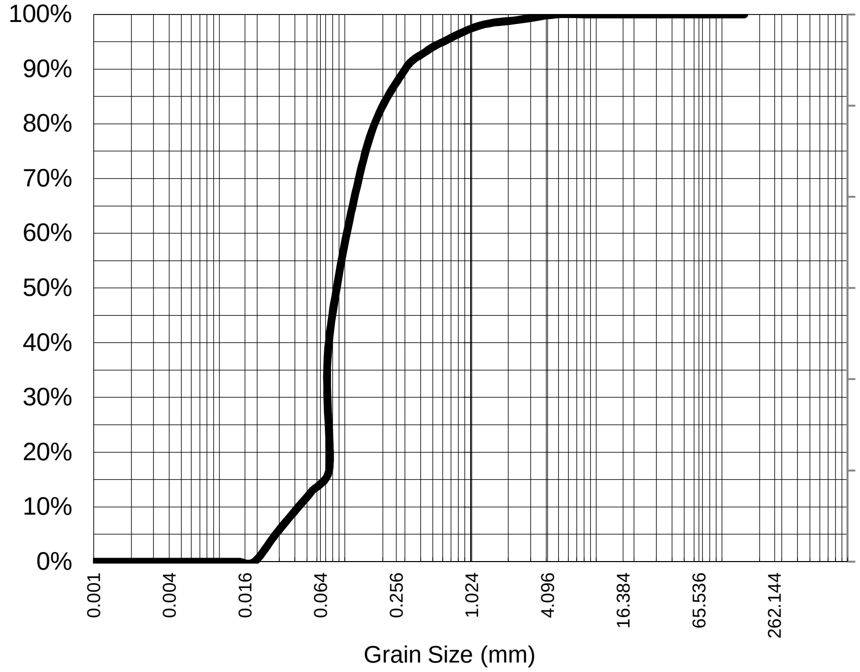
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-005 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M5BB

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	95%
0.425	93%
0.300	90%
0.150	76%
0.075	41%
Particle Size (microns)	
55	13%
39	9%
28	5%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.094

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.7

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

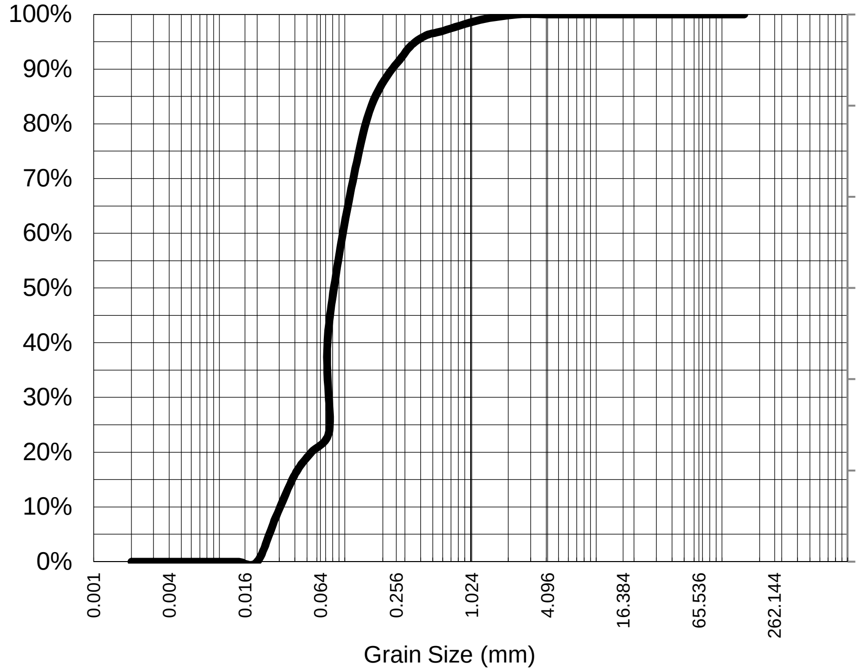
CLIENT: PAUL NICHOLS
DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd
DATE RECEIVED: 22-Mar-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA
REPORT NO: EP1902664-006 / PSD

PROJECT: 401012-02698 WEL SCABS
SAMPLE ID: M5CT

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	97%
0.425	96%
0.300	93%
0.150	81%
0.075	44%
Particle Size (microns)	
54	20%
40	16%
28	8%
20	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.087

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.68

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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fax 02 4968 0349
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ALS Environmental

Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

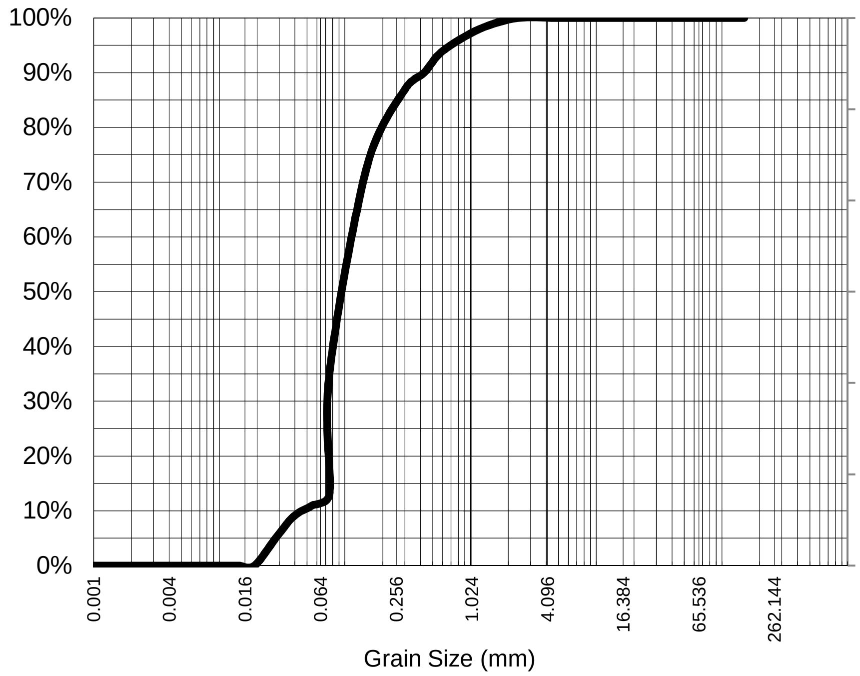
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-007 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M5CB

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	94%
0.425	90%
0.300	87%
0.150	73%
0.075	35%
Particle Size (microns)	
55	11%
39	9%
28	5%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.105

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.72

NATA Accreditation: 825 Site: Newcastle
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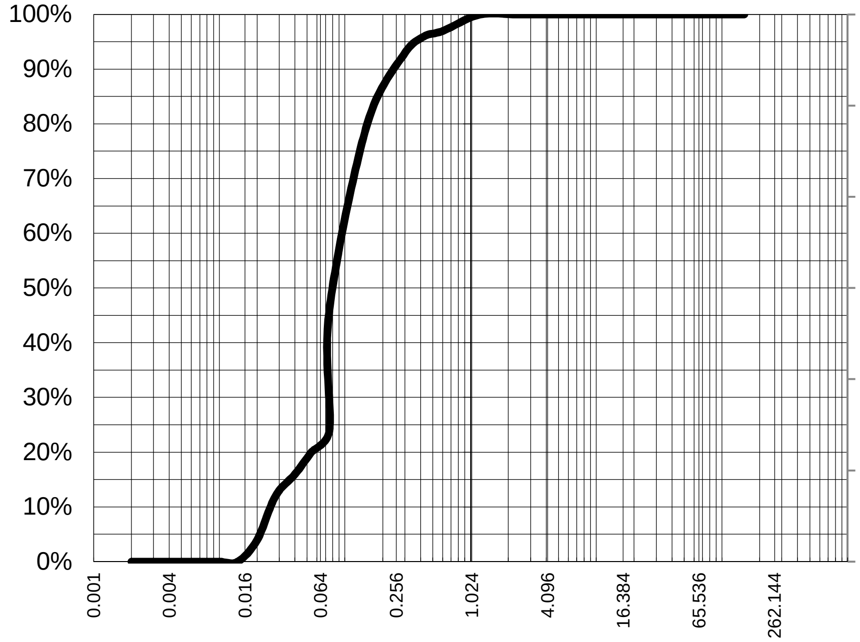
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-008 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M4T

Particle Size Distribution



Grain Size (mm)

Particle Size (mm)	% Passing
1.18	100%
0.600	97%
0.425	96%
0.300	93%
0.150	80%
0.075	46%
Particle Size (microns)	
54	20%
40	16%
28	12%
20	4%
14	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.084

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.68

NATA Accreditation: 825 Site: Newcastle
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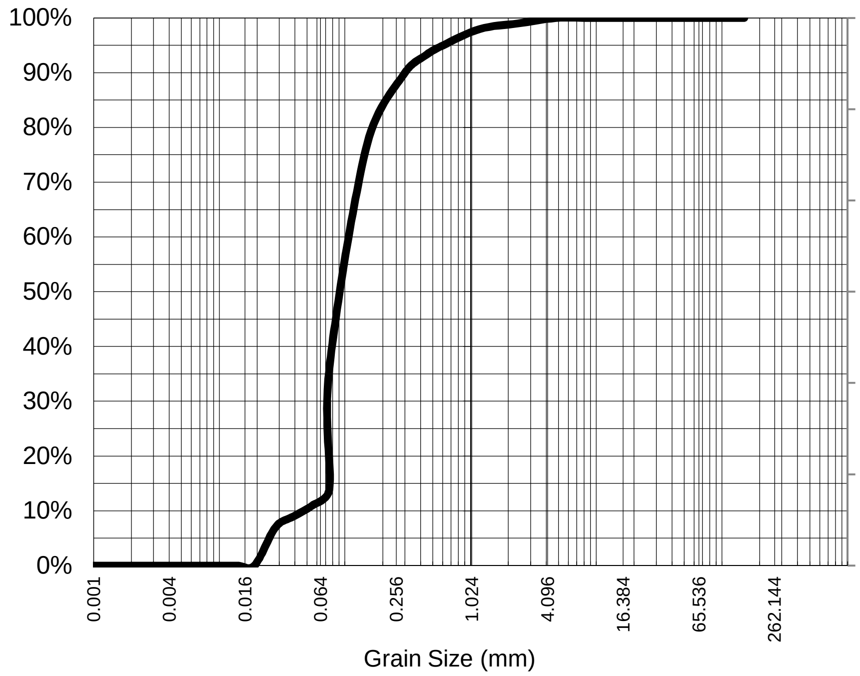
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-009 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M4B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	95%
0.425	93%
0.300	90%
0.150	77%
0.075	36%
Particle Size (microns)	
55	11%
39	9%
28	7%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.101

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.72

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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

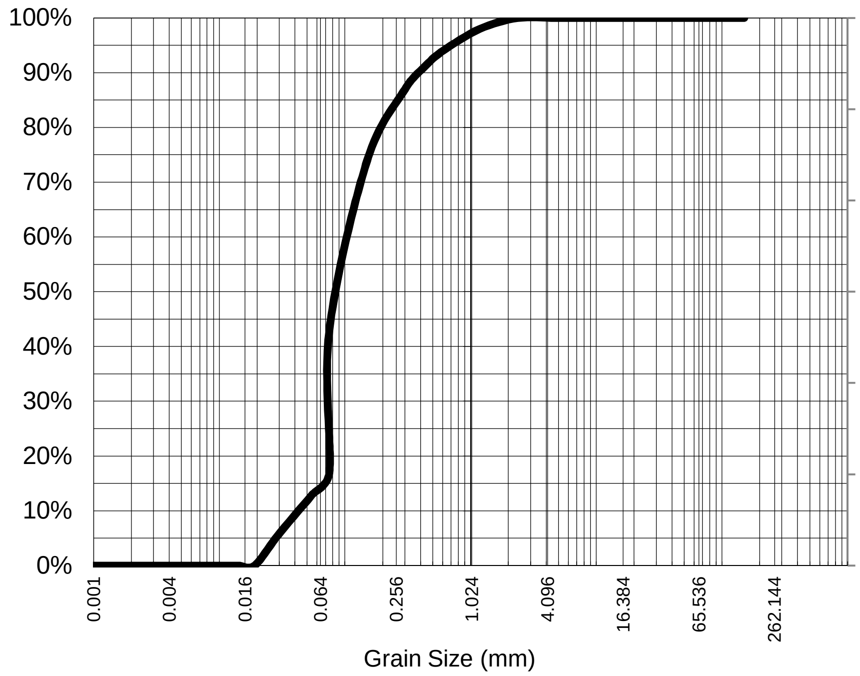
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-010 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M3T

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	94%
0.425	91%
0.300	87%
0.150	74%
0.075	43%
Particle Size (microns)	
55	13%
39	9%
28	5%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.092

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.73

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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

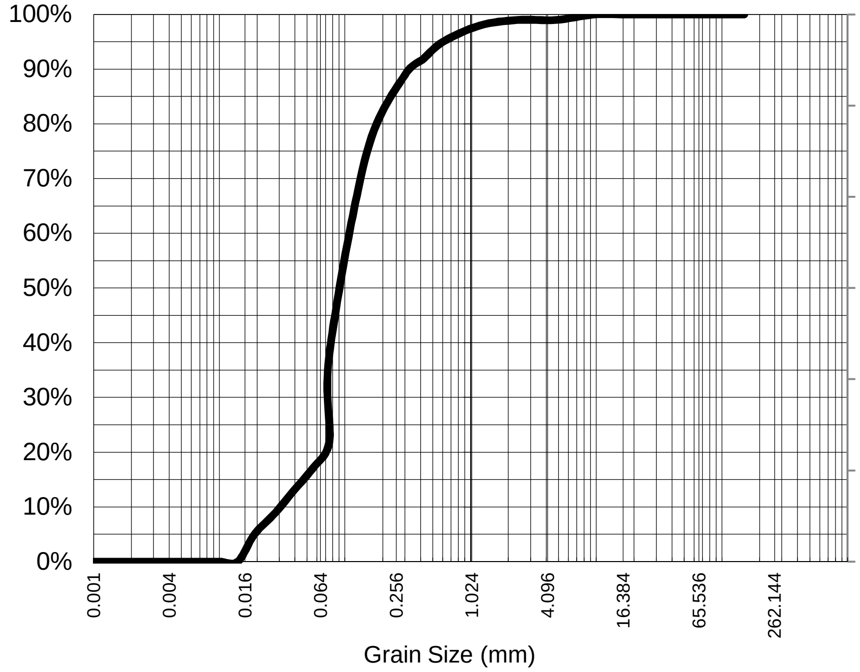
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-011 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M3B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	99%
1.18	98%
0.600	95%
0.425	92%
0.300	89%
0.150	75%
0.075	38%
Particle Size (microns)	
55	17%
39	13%
28	9%
19	5%
14	0%

Analysis Notes

Samples analysed as received.

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.099

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.72

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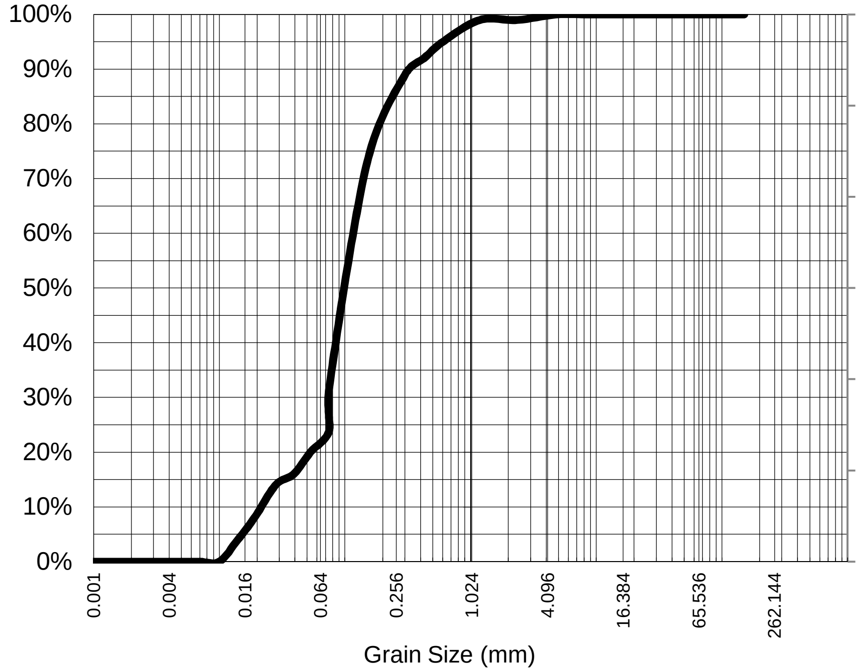
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-012 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M2T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	95%
0.425	92%
0.300	89%
0.150	73%
0.075	32%
Particle Size (microns)	
53	20%
39	16%
28	14%
19	8%
14	4%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.108

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.72

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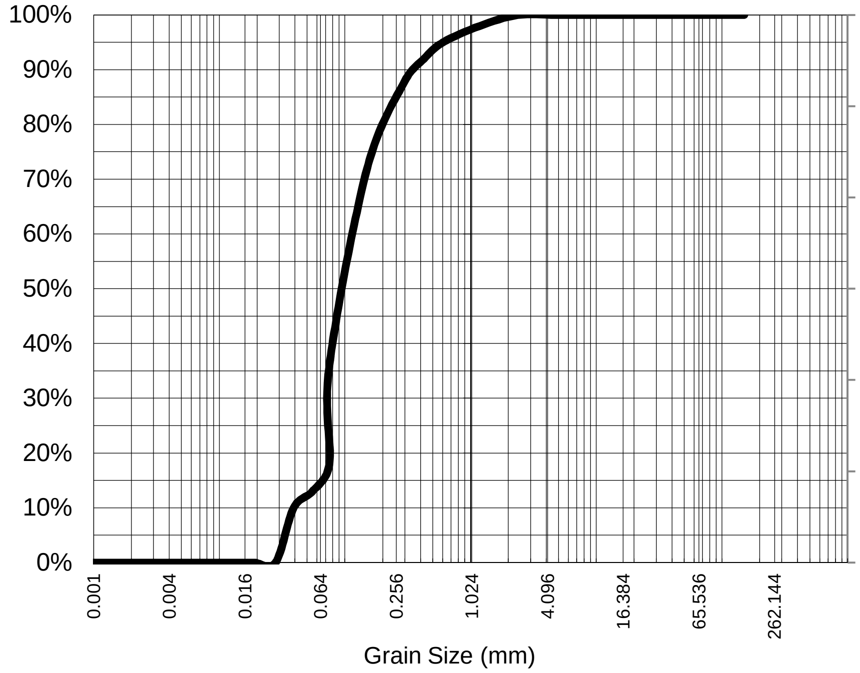
ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-013 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M2B

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	95%
0.425	92%
0.300	88%
0.150	72%
0.075	36%
Particle Size (microns)	
55	13%
39	10%
28	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.104

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.74

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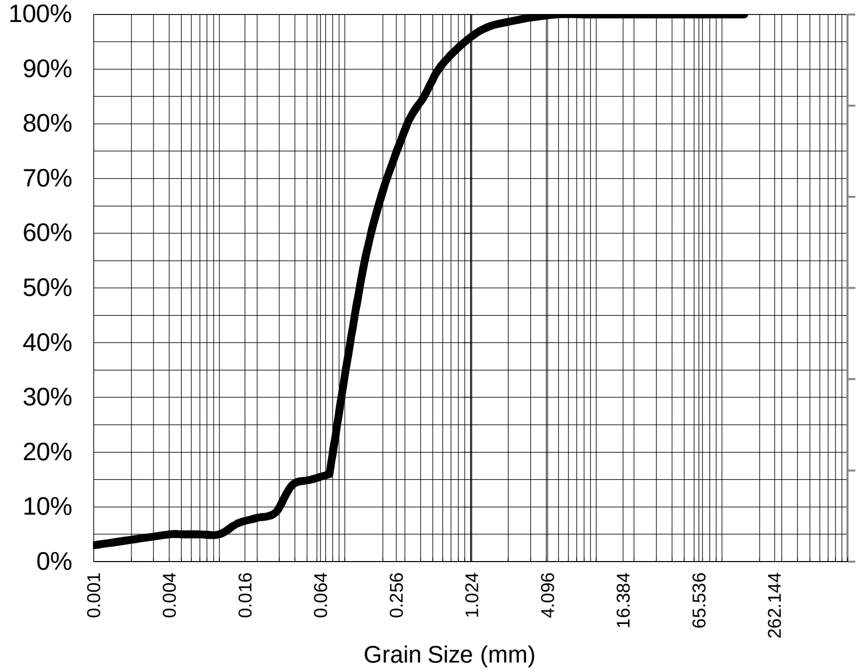
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-014 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M1T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	97%
0.600	91%
0.425	85%
0.300	79%
0.150	57%
0.075	16%
Particle Size (microns)	
54	15%
38	14%
28	9%
20	8%
14	7%
10	5%
7	5%
5	5%
1	3%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.137

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.66 (2.65)*

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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

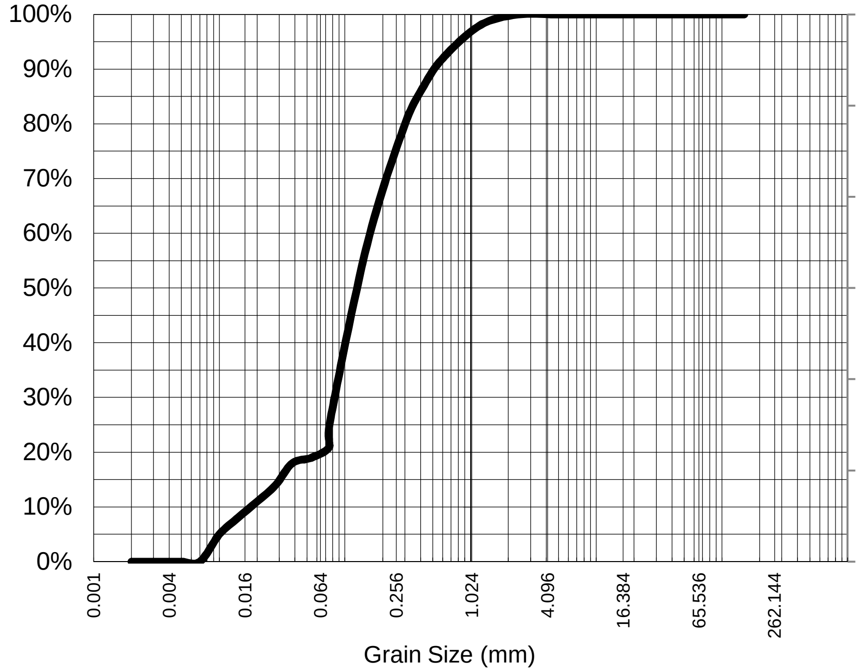
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-015 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M1B

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	92%
0.425	87%
0.300	80%
0.150	58%
0.075	25%
Particle Size (microns)	
54	19%
38	18%
28	14%
20	11%
14	8%
10	5%
7	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.132

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.7 (2.65)*

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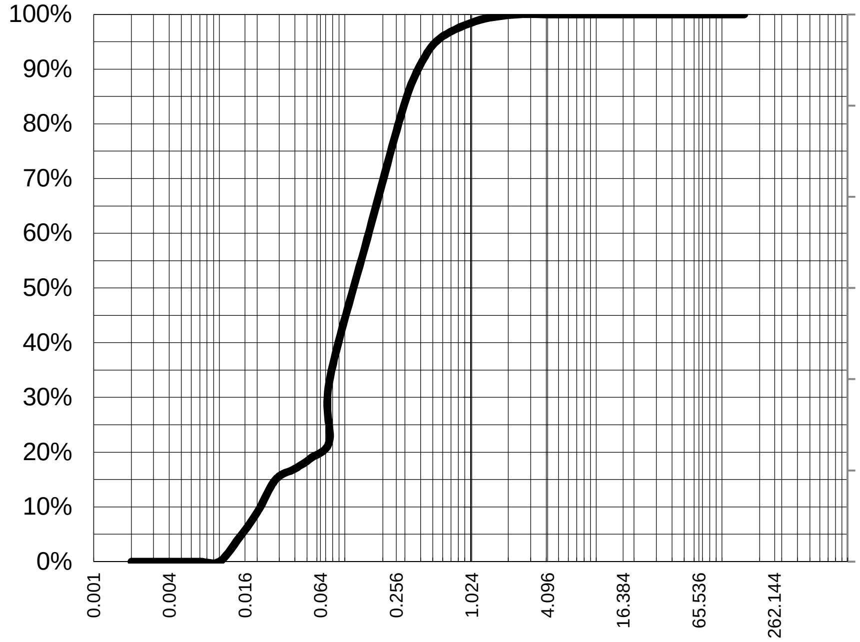
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-016 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M10T

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	96%
0.425	92%
0.300	84%
0.150	59%
0.075	33%
Particle Size (microns)	
54	19%
40	17%
28	15%
20	9%
14	4%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.124

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.69 (2.65)*

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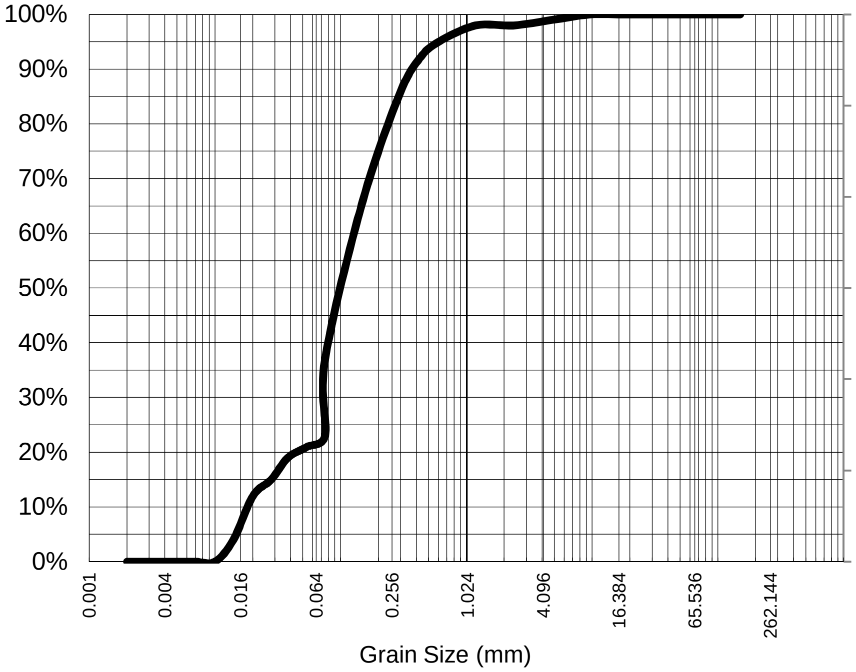
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-017 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M10B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	98%
0.600	95%
0.425	92%
0.300	86%
0.150	66%
0.075	37%
Particle Size (microns)	
54	21%
38	19%
28	15%
20	12%
14	4%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.109

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.7 (2.65)*

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DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

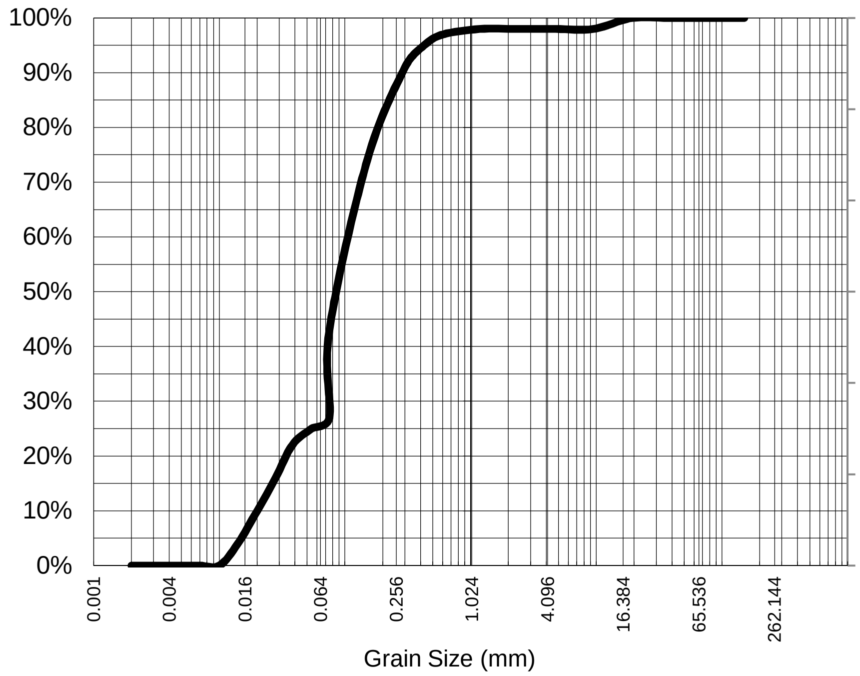
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-018 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M9T

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	98%
4.75	98%
2.36	98%
1.18	98%
0.600	97%
0.425	95%
0.300	91%
0.150	74%
0.075	43%
Particle Size (microns)	
54	25%
38	22%
28	16%
20	10%
14	4%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.092

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.67 (2.65)*

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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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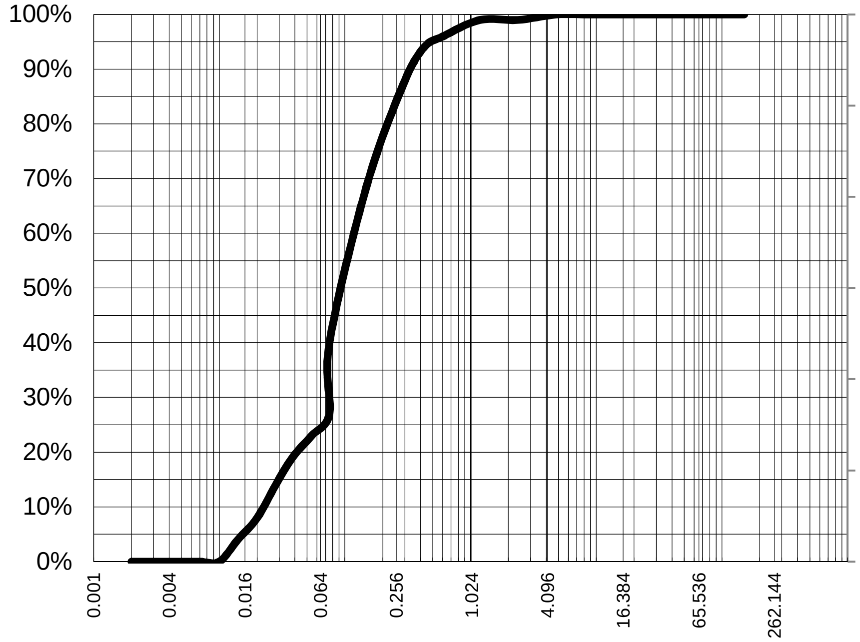
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-019 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M9B

Particle Size Distribution



Grain Size (mm)

Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	96%
0.425	94%
0.300	88%
0.150	69%
0.075	40%
Particle Size (microns)	
54	23%
38	19%
28	14%
20	8%
14	4%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.101

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.72 (2.65)*

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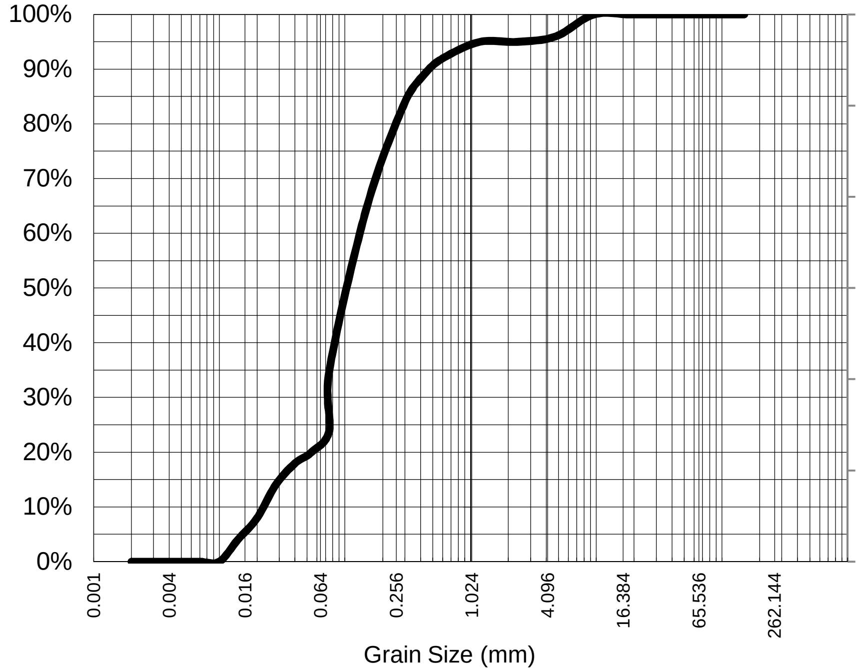
ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-020 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M8T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	96%
2.36	95%
1.18	95%
0.600	92%
0.425	89%
0.300	84%
0.150	65%
0.075	35%
Particle Size (microns)	
54	20%
40	18%
28	14%
20	8%
14	4%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.113

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.7 (2.65)*

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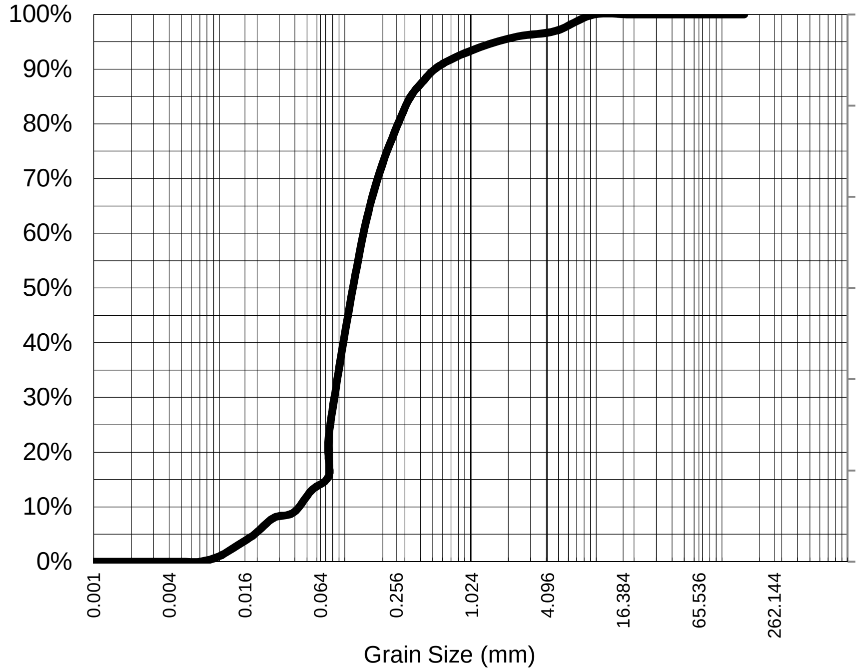
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-021 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M8B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	97%
2.36	96%
1.18	94%
0.600	91%
0.425	88%
0.300	83%
0.150	63%
0.075	24%
Particle Size (microns)	
54	13%
39	9%
27	8%
19	5%
14	3%
10	1%
7	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.125

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.71

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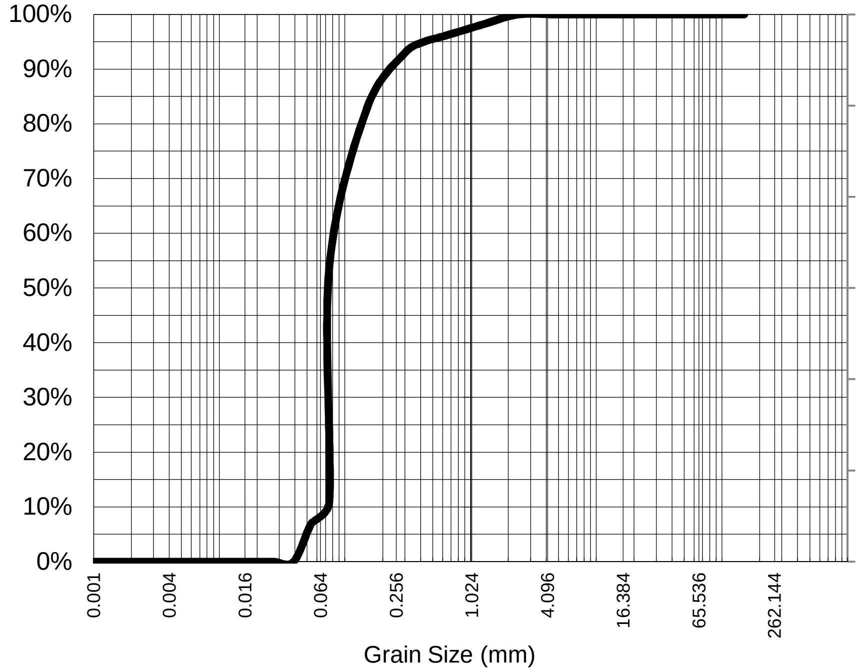
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-022 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M7T

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	96%
0.425	95%
0.300	93%
0.150	83%
0.075	54%
Particle Size (microns)	
54	7%
39	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:		**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.7

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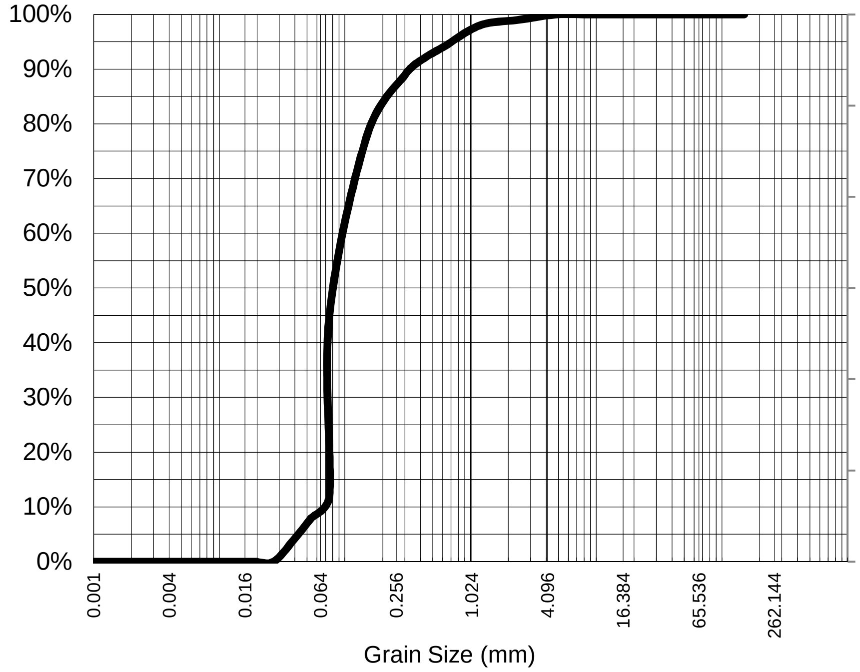
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-023 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M7B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	94%
0.425	92%
0.300	89%
0.150	78%
0.075	45%
Particle Size (microns)	
54	8%
39	4%
27	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.086

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.7

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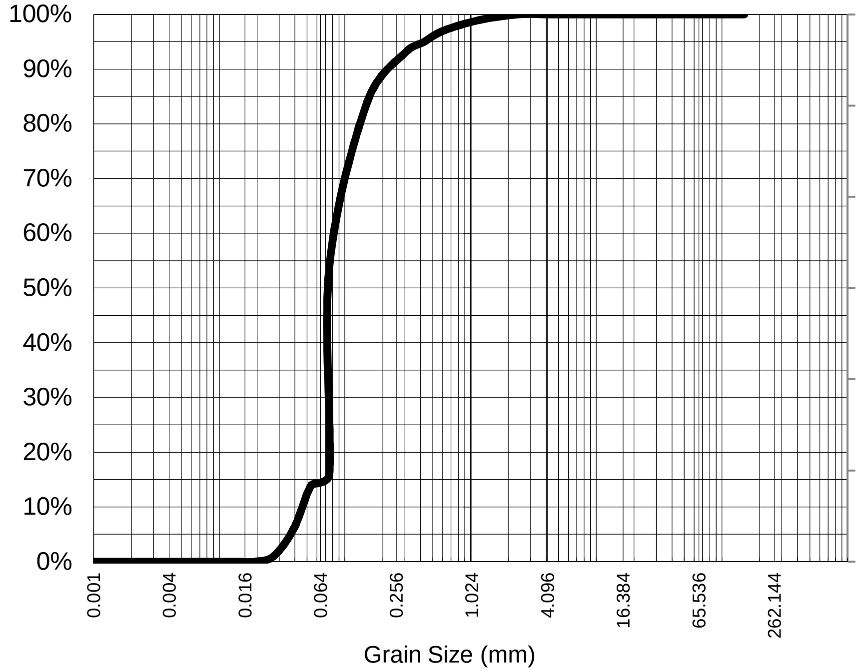
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-024 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M6T

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	97%
0.425	95%
0.300	93%
0.150	84%
0.075	54%
Particle Size (microns)	
54	14%
39	6%
27	1%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.71

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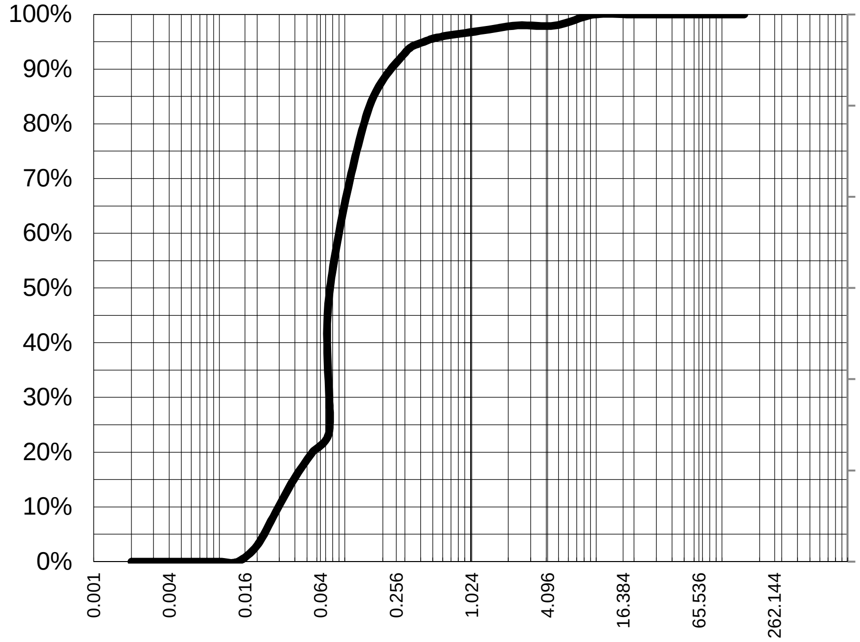
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-025 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M6B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	98%
1.18	97%
0.600	96%
0.425	95%
0.300	93%
0.150	82%
0.075	49%
Particle Size (microns)	
55	20%
39	15%
28	9%
20	3%
14	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.077

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.68

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ALS Environmental

Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

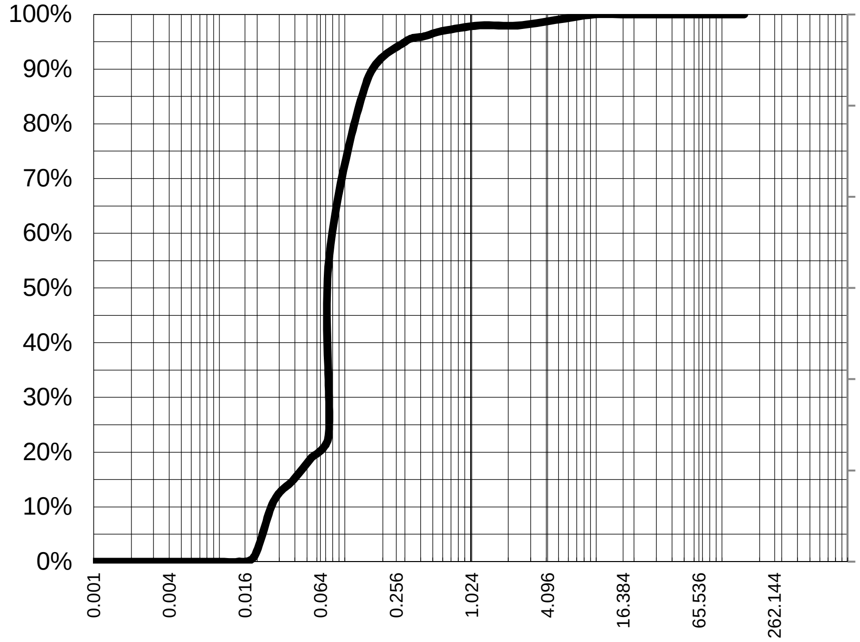
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-026 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M5AT

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	98%
0.600	97%
0.425	96%
0.300	95%
0.150	88%
0.075	56%
Particle Size (microns)	
54	19%
39	15%
27	11%
19	1%
14	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.7

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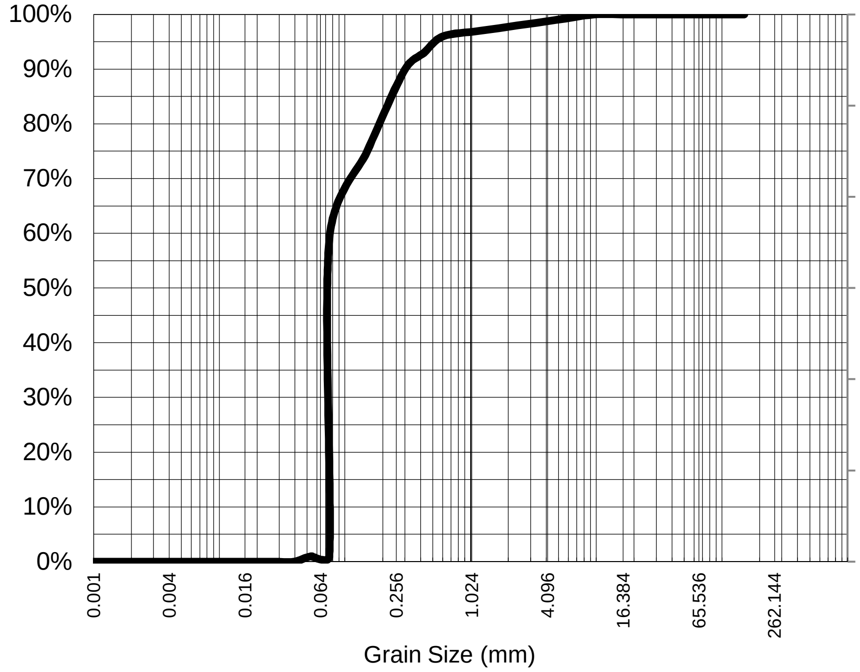
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-027 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	N16T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	97%
0.600	96%
0.425	93%
0.300	90%
0.150	75%
0.075	59%
Particle Size (microns)	
54	1%
39	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.71

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

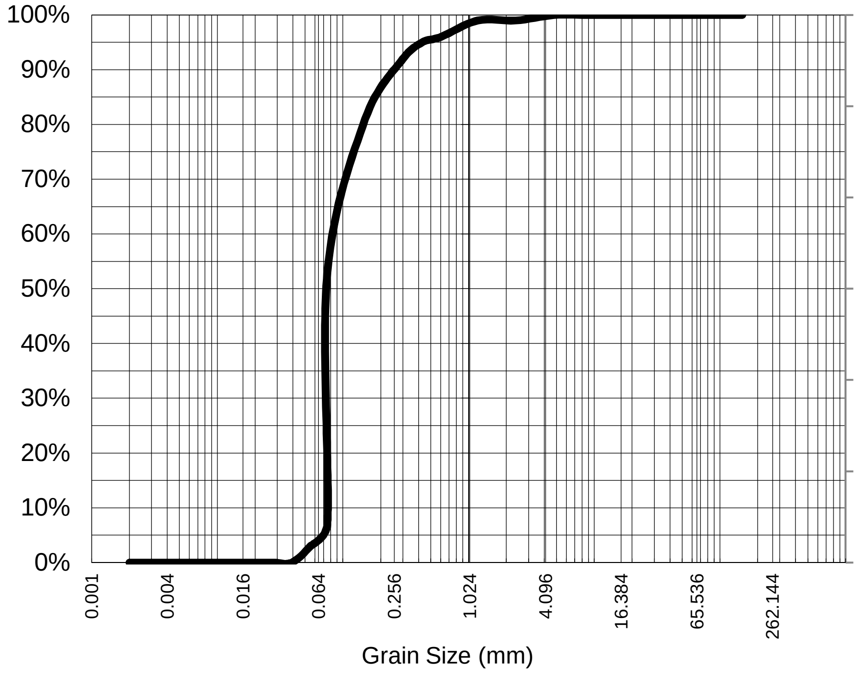
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-028 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M5AB

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	96%
0.425	95%
0.300	92%
0.150	81%
0.075	53%
Particle Size (microns)	
55	3%
39	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.66

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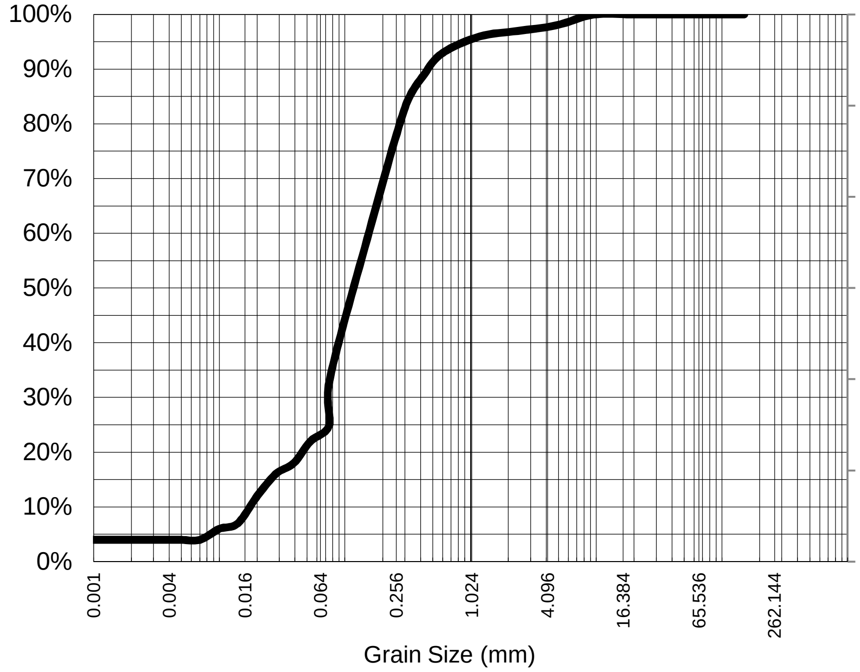
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-029 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	N17T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	97%
1.18	96%
0.600	93%
0.425	89%
0.300	83%
0.150	59%
0.075	33%
Particle Size (microns)	
53	22%
39	18%
28	16%
20	12%
14	7%
10	6%
7	4%
5	4%
1	4%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.124

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.69

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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-030 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: N18T

Particle Size Distribution

Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	94%
0.425	90%
0.300	82%
0.150	48%
0.075	11%
Particle Size (microns)	

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.159

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.69

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-031 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	N18B

Particle Size Distribution

Particle Size (mm)	% Passing
9.50	100%
4.75	97%
2.36	96%
1.18	93%
0.600	85%
0.425	77%
0.300	65%
0.150	33%
0.075	0%
Particle Size (microns)	

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.230

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	AS1289.3.6.3 states that hydrometer analysis is not applicable for samples containing <10% fines (<75um). Results should be assessed accordingly	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.69

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Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

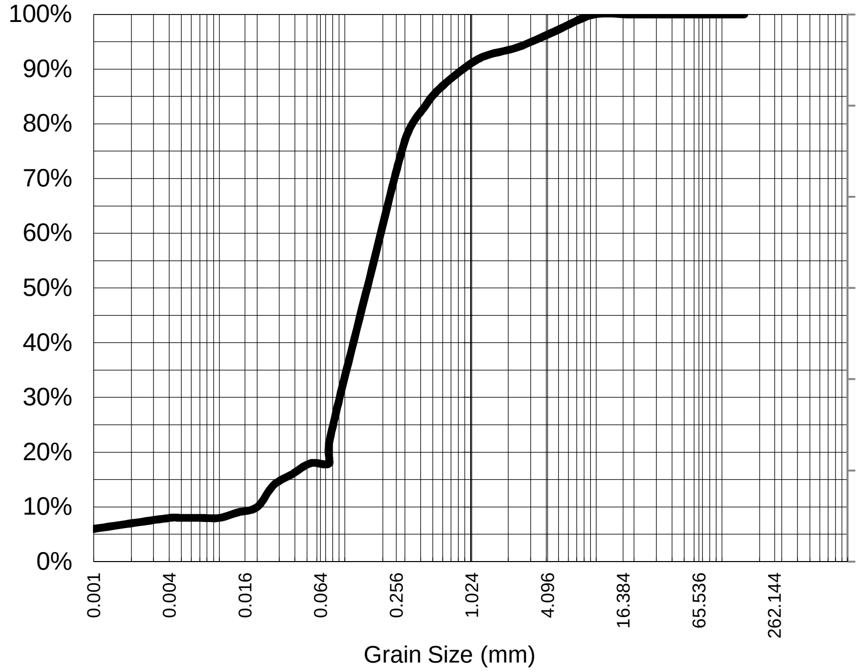
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-032 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: N19T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	97%
2.36	94%
1.18	92%
0.600	87%
0.425	83%
0.300	77%
0.150	50%
0.075	22%
Particle Size (microns)	
53	18%
38	16%
27	14%
20	10%
14	9%
10	8%
7	8%
5	8%
1	6%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.150

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.69

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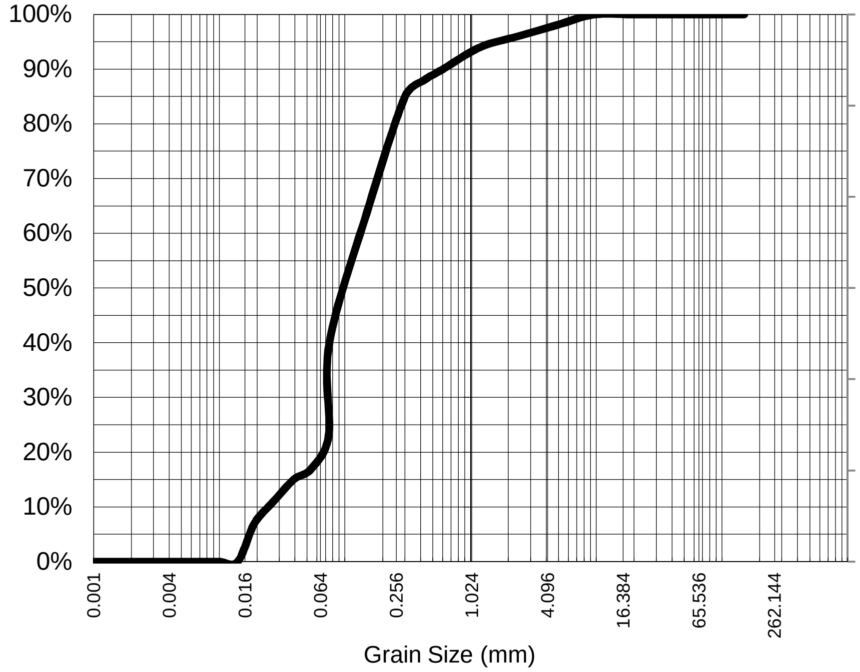
ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-033 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C1T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	96%
1.18	94%
0.600	90%
0.425	88%
0.300	85%
0.150	64%
0.075	40%
Particle Size (microns)	
54	17%
39	15%
27	11%
19	7%
14	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.106

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.71

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ALS Environmental

Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

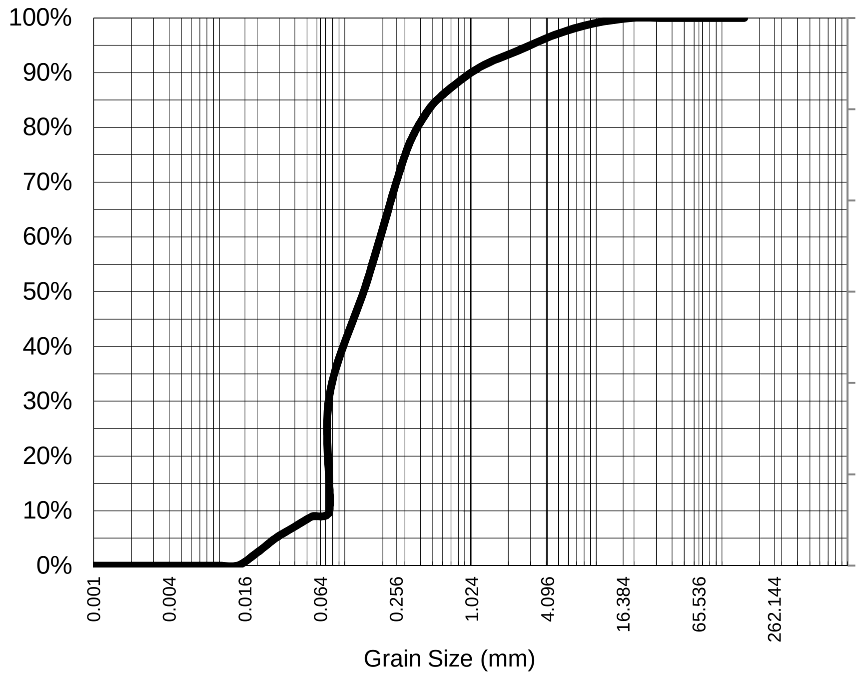
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-034 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C1B

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	99%
4.75	97%
2.36	94%
1.18	91%
0.600	86%
0.425	82%
0.300	75%
0.150	52%
0.075	31%
Particle Size (microns)	
55	9%
39	7%
28	5%
19	2%
14	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.143

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.7

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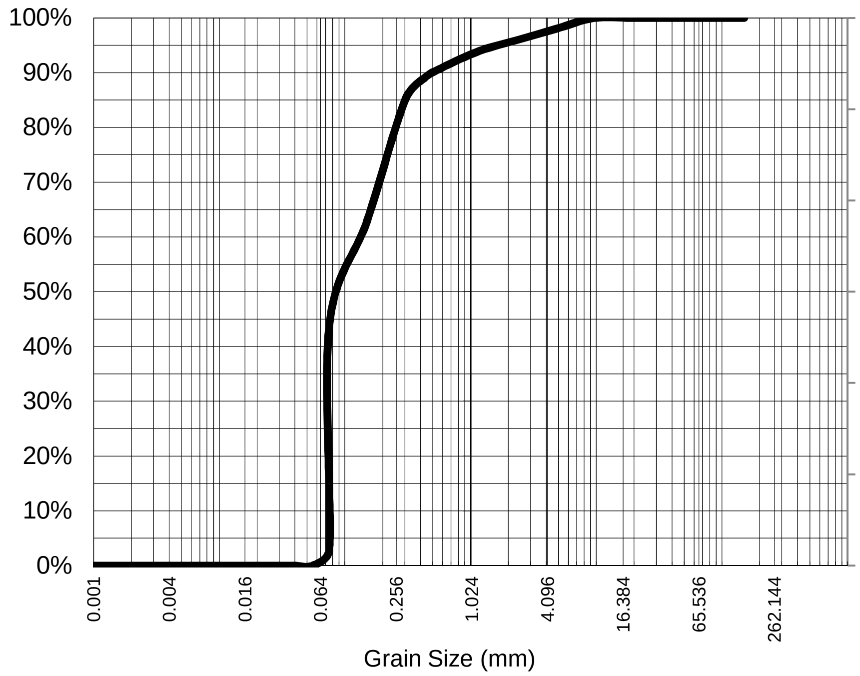
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-035 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2AT

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	96%
1.18	94%
0.600	91%
0.425	89%
0.300	85%
0.150	63%
0.075	44%
Particle Size (microns)	

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.099

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.72

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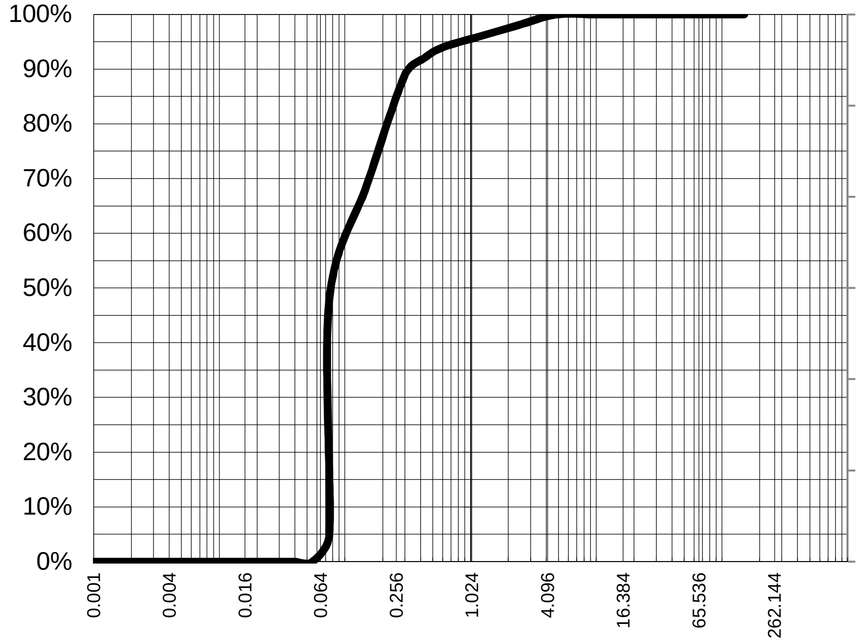
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-036 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2AB

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	98%
1.18	96%
0.600	94%
0.425	92%
0.300	89%
0.150	69%
0.075	48%
Particle Size (microns)	

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.082

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.72

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ALS Environmental
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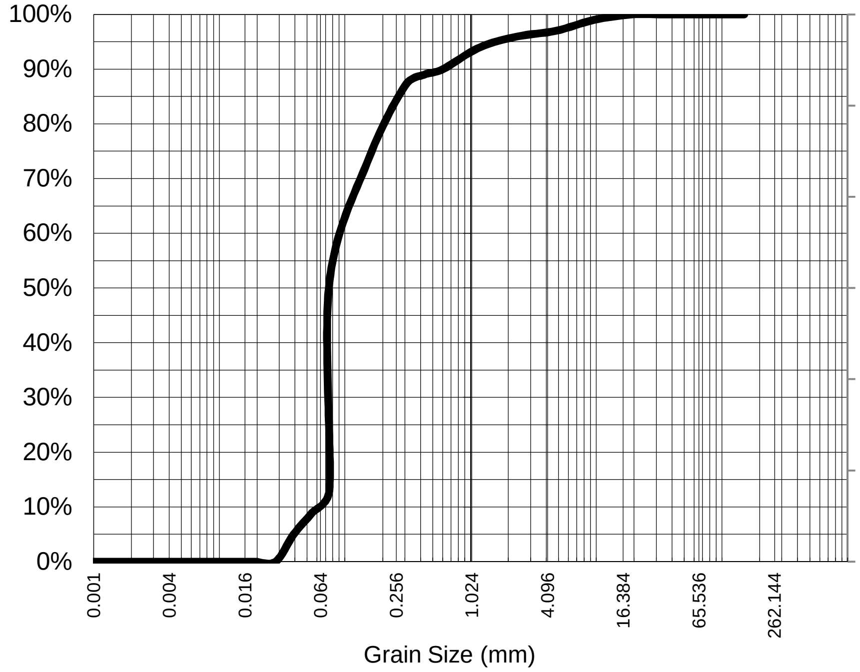
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-037 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2BT

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	99%
4.75	97%
2.36	96%
1.18	94%
0.600	90%
0.425	89%
0.300	87%
0.150	73%
0.075	51%
Particle Size (microns)	
55	9%
39	5%
28	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.7

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

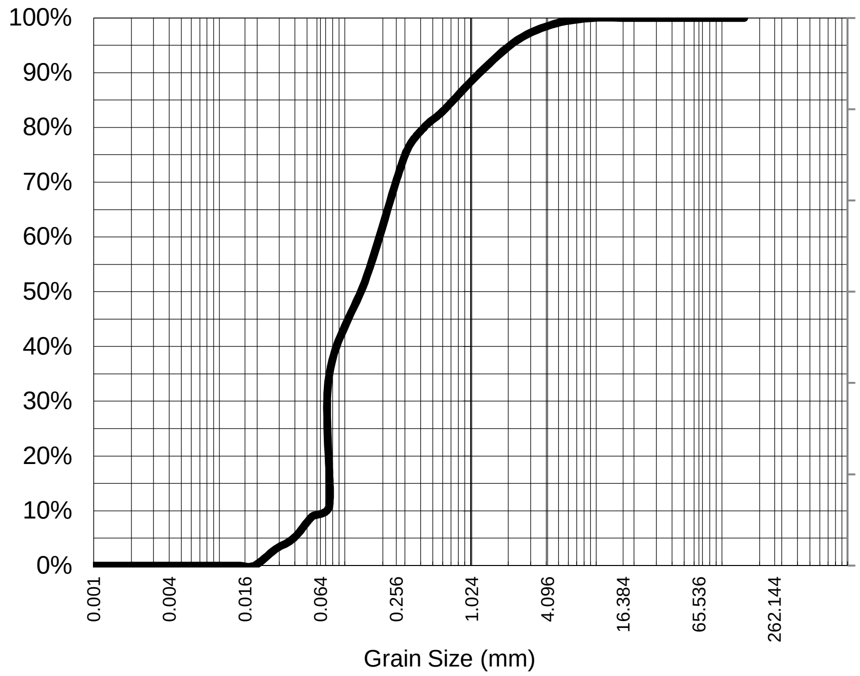
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-038 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C2BB

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	96%
1.18	90%
0.600	83%
0.425	80%
0.300	75%
0.150	53%
0.075	35%
Particle Size (microns)	
55	9%
39	5%
28	3%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.138

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.71

NATA Accreditation: 825 Site: Newcastle

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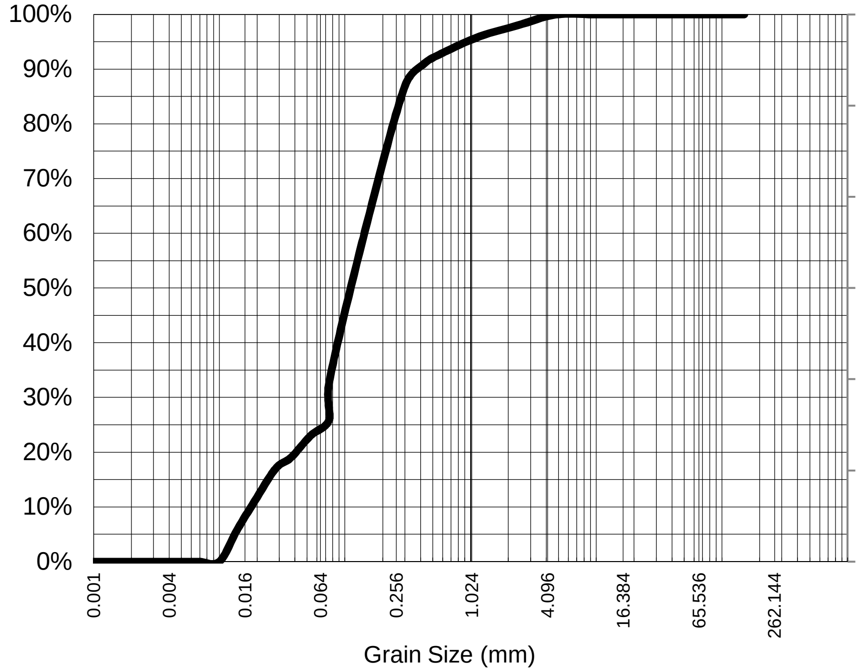
ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-039 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2CT

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	98%
1.18	96%
0.600	93%
0.425	91%
0.300	87%
0.150	62%
0.075	33%
Particle Size (microns)	
53	23%
37	19%
28	17%
19	11%
14	6%
10	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.119

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.73

NATA Accreditation: 825 Site: Newcastle
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ALS Environmental

Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

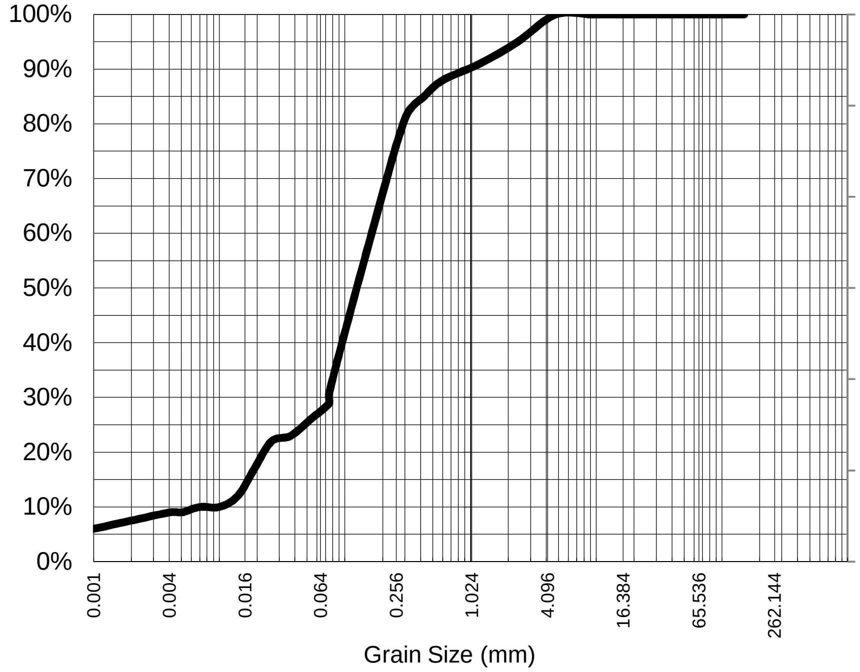
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-040 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C2CB

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	95%
1.18	91%
0.600	88%
0.425	85%
0.300	81%
0.150	57%
0.075	31%
Particle Size (microns)	
53	26%
37	23%
26	22%
19	17%
14	12%
10	10%
7	10%
5	9%
1	6%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.130

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.74

NATA Accreditation: 825 Site: Newcastle
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Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

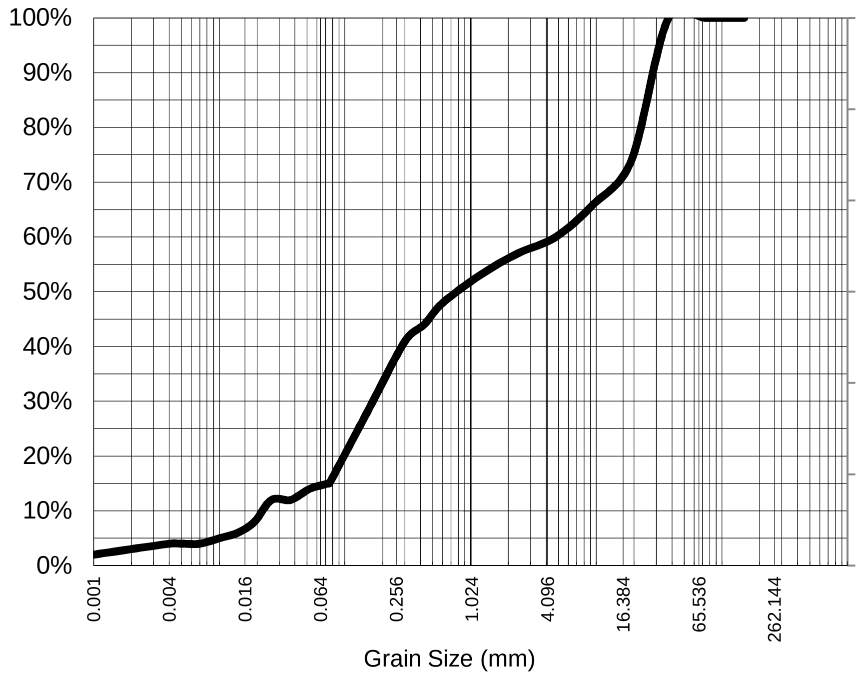
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-041 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C3T

Particle Size Distribution



Particle Size (mm)	% Passing
37.5	100%
19.0	74%
9.50	66%
4.75	60%
2.36	57%
1.18	53%
0.600	48%
0.425	44%
0.300	41%
0.150	28%
0.075	15%
Particle Size (microns)	
52	14%
37	12%
26	12%
19	8%
14	6%
10	5%
7	4%
5	4%
1	2%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.832

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.75

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 22-Mar-2019

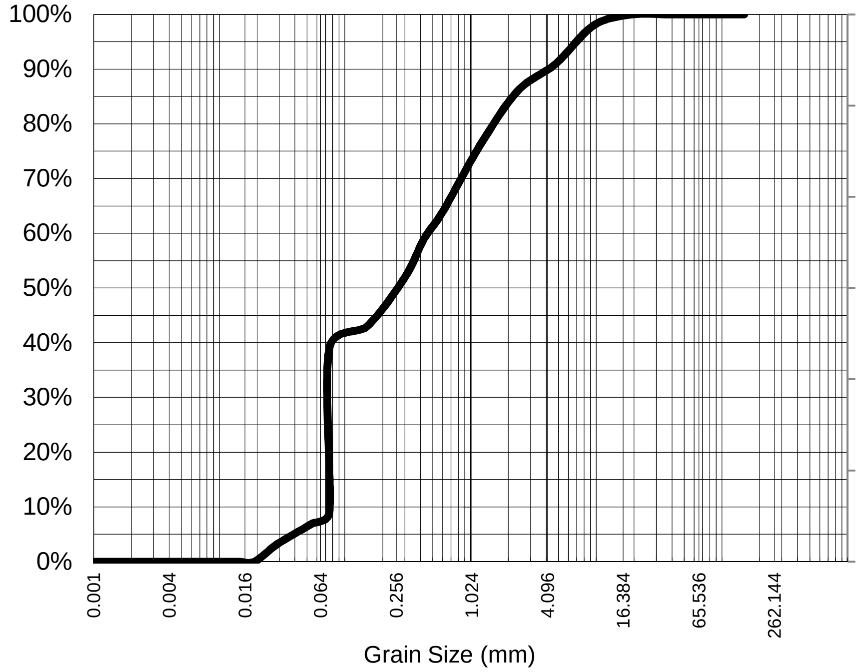
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902664-042 / PSD

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C4T

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	98%
4.75	91%
2.36	86%
1.18	76%
0.600	64%
0.425	59%
0.300	52%
0.150	43%
0.075	39%
Particle Size (microns)	
55	7%
39	5%
28	3%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.267

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments: Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids

Analysed: 9-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINES, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.72

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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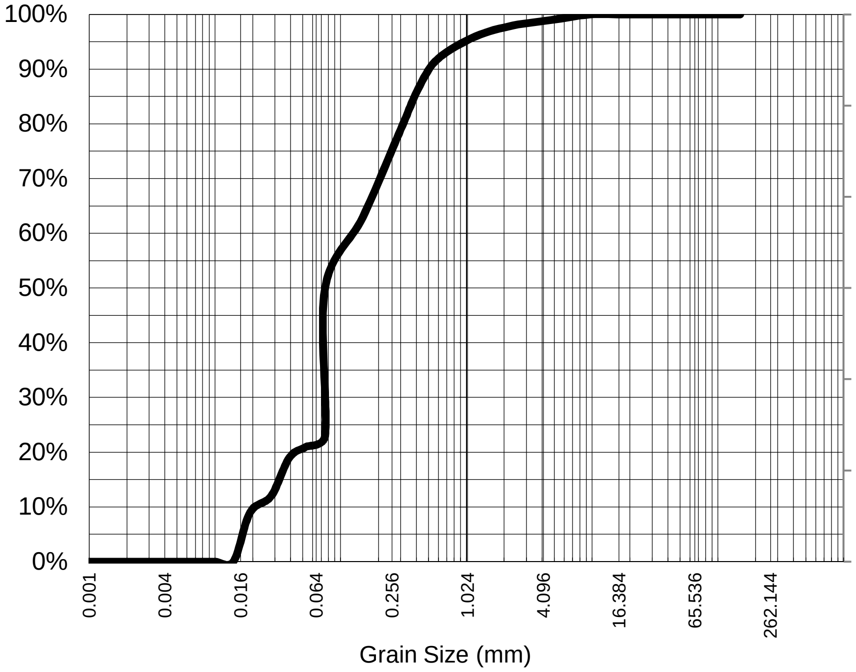
ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-043 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C5T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	96%
0.600	92%
0.425	87%
0.300	79%
0.150	63%
0.075	50%
Particle Size (microns)	
53	21%
39	19%
28	12%
19	9%
14	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.075

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.72

NATA Accreditation: 825 Site: Newcastle
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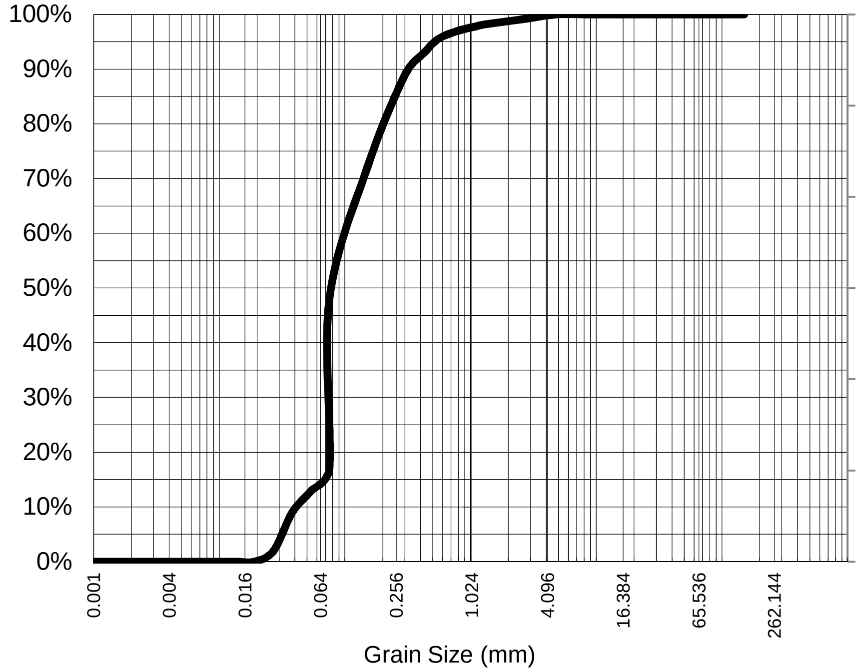
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-044 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M8T DUP

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	96%
0.425	93%
0.300	89%
0.150	72%
0.075	48%
Particle Size (microns)	
54	13%
38	9%
27	2%
19	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.081

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm) 2.75

NATA Accreditation: 825 Site: Newcastle
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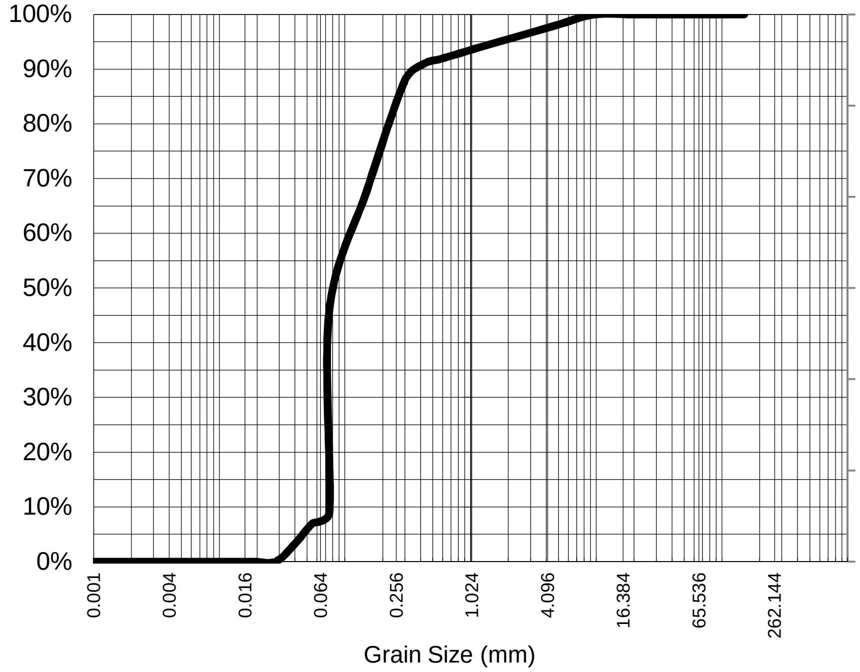
ALS Environmental

Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	22-Mar-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902664-045 / PSD
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2AT DUP

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	96%
1.18	94%
0.600	92%
0.425	91%
0.300	88%
0.150	68%
0.075	46%
Particle Size (microns)	
55	7%
39	3%
28	0%

Analysis Notes

Samples analysed as received.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Median Particle Size (mm)*	0.089

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:	Analysis results have been corrected for salinity and should be scrutinised accordingly. Mass percentages are reported relative to total insoluble solids	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Limit of Reporting:**	1%
Sample Description:	FINES, SAND, SHELL	**Dispersion Method**	Shaker
Test Method:	AS1289.3.6.2/AS1289.3.6.3		

Soil Particle Density (<2.36mm)   2.72

NATA Accreditation: 825   Site: Newcastle
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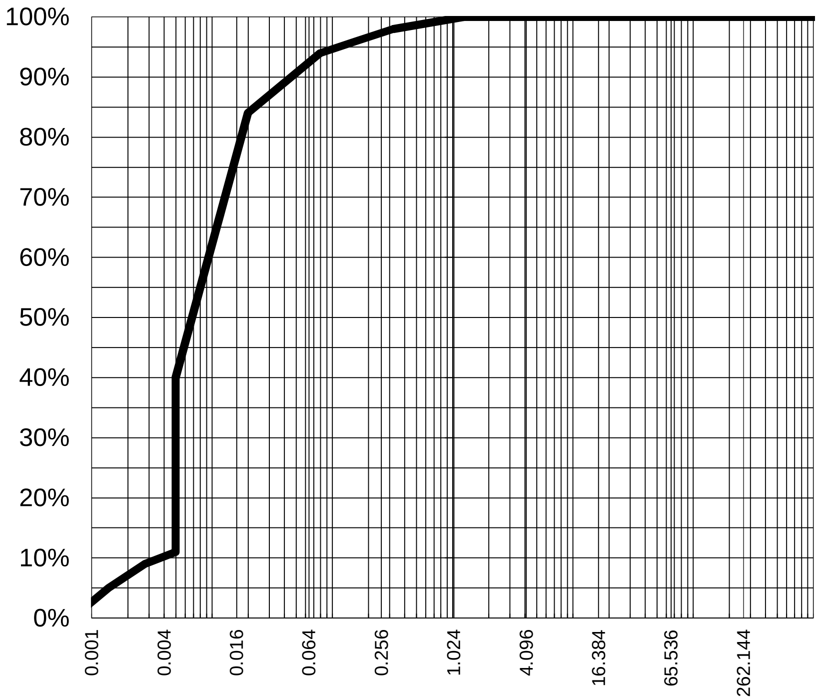
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-004 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M5BT



Samples analysed as received. **Settling Velocity (m/s)**

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
1.18	100%	1.2	1.4E-02
0.600	98%	0.32	5.2E-02
0.425	96%	0.16	1.0E-01
0.300	94%	0.080	2.1E-01
0.150	84%	0.020	8.4E-01
0.075	40%	0.005	3.4E+00
µm			
56	9%	2.8E-03	6.028
40	5%	1.4E-03	12.056
28	0%	6.9E-04	24.112
20	0%	3.5E-04	48.224
10	0%	9.2E-05	180.84
5	0%	2.3E-05	723.35
2	0%	2.0E-06	8165.20

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.78
Time for 90% to Settle 100cm	4.52
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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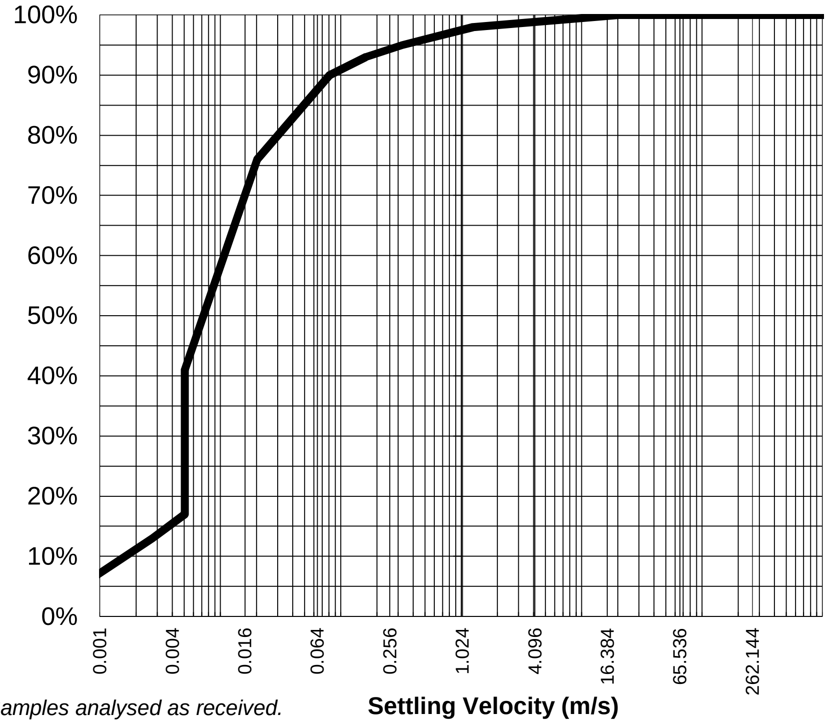
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-005 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M5BB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	20	8.2E-04
2.36	99%	5.0	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	95%	0.32	5.1E-02
0.425	93%	0.16	1.0E-01
0.300	90%	0.081	2.1E-01
0.150	76%	0.020	8.2E-01
0.075	41%	0.005	3.3E+00
µm			
55	13%	2.7E-03	6.102
39	9%	1.4E-03	12.204
28	5%	6.8E-04	24.407
19	0%	3.4E-04	48.815
10	0%	9.1E-05	183.06
5	0%	2.3E-05	732.22
1	0%	2.0E-06	8260.49

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.66
Time for 90% to Settle 100cm	10.68
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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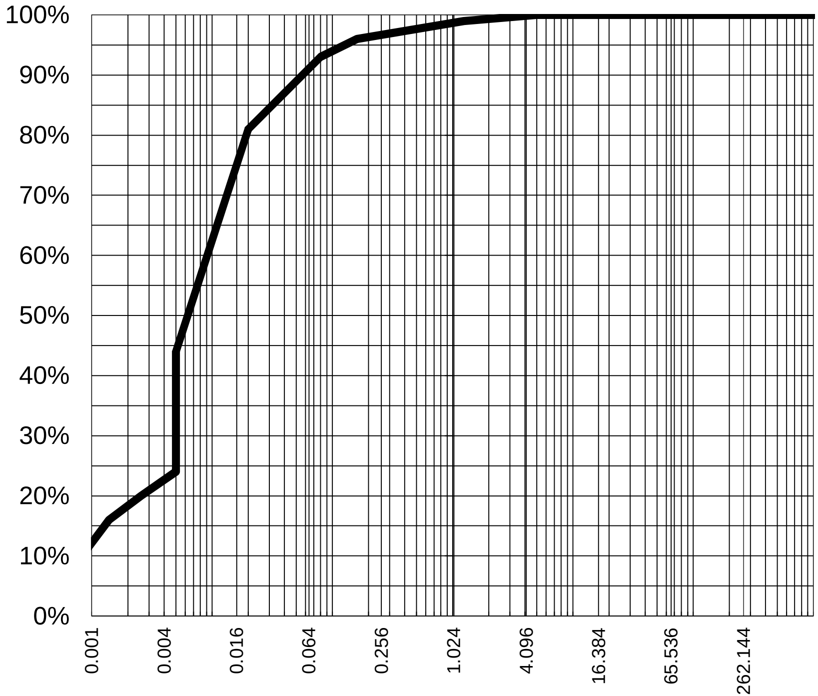
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-006 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M5CT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.0	3.4E-03
1.18	99%	1.2	1.3E-02
0.600	97%	0.32	5.2E-02
0.425	96%	0.16	1.0E-01
0.300	93%	0.080	2.1E-01
0.150	81%	0.020	8.3E-01
0.075	44%	0.005	3.3E+00
µm			
54	20%	2.6E-03	6.492
40	16%	1.4E-03	11.983
28	8%	7.0E-04	23.966
20	0%	3.5E-04	47.932
10	0%	9.3E-05	179.75
5	0%	2.3E-05	718.98
2	0%	2.1E-06	8115.86

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.93
Time for 90% to Settle 100cm	20.97
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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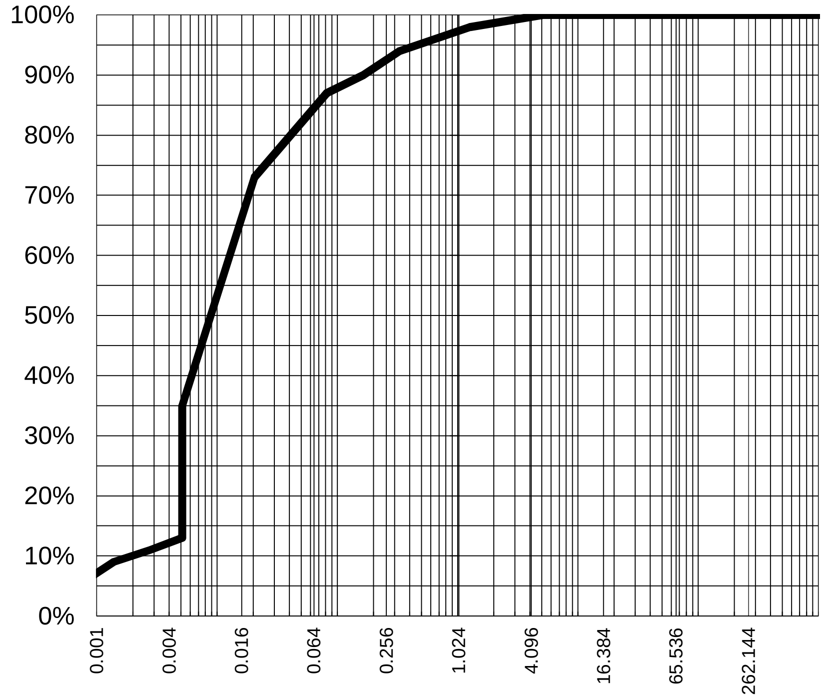
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-007 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M5CB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.1	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	94%	0.33	5.1E-02
0.425	90%	0.16	1.0E-01
0.300	87%	0.082	2.0E-01
0.150	73%	0.020	8.1E-01
0.075	35%	0.005	3.3E+00
µm			
55	11%	2.8E-03	6.030
39	9%	1.4E-03	12.060
28	5%	6.9E-04	24.119
19	0%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Time for 50% to Settle 100cm	2.29
Time for 90% to Settle 100cm	9.05
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

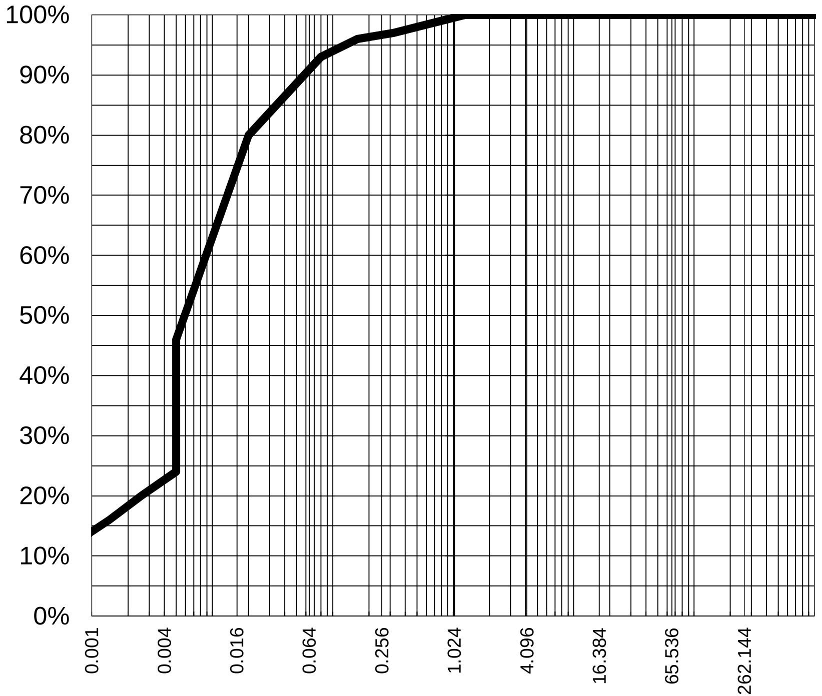
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-008 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M4T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
1.18	100%	1.2	1.3E-02
0.600	97%	0.32	5.2E-02
0.425	96%	0.16	1.0E-01
0.300	93%	0.080	2.1E-01
0.150	80%	0.020	8.3E-01
0.075	46%	0.005	3.3E+00
µm			
54	20%	2.6E-03	6.492
40	16%	1.4E-03	11.983
28	12%	7.0E-04	23.966
20	4%	3.5E-04	47.932
10	0%	9.3E-05	179.75
5	0%	2.3E-05	718.98
2	0%	2.1E-06	8115.86

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.04
Time for 90% to Settle 100cm	29.96
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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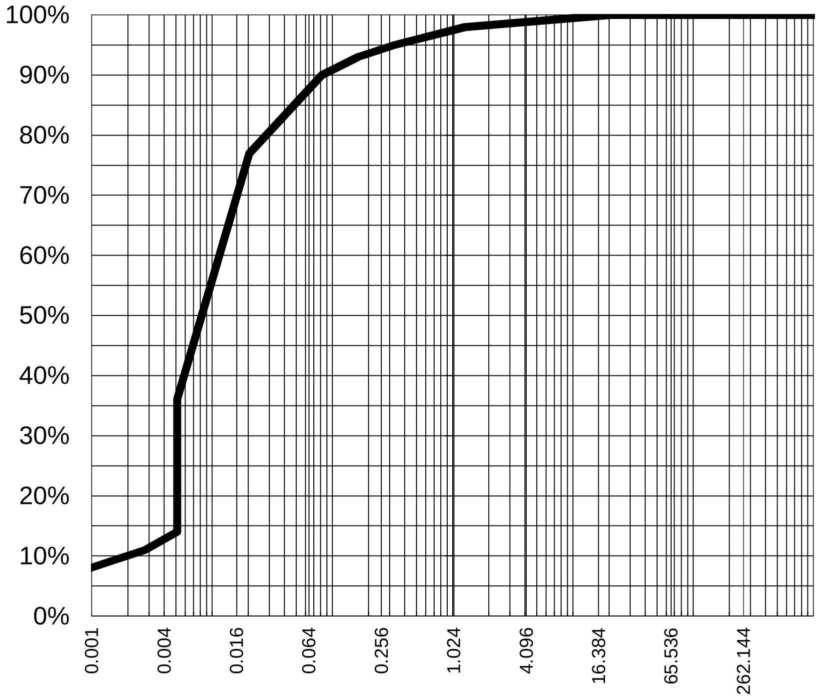
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-009 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M4B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.1E-04
2.36	99%	5.1	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	95%	0.33	5.1E-02
0.425	93%	0.16	1.0E-01
0.300	90%	0.082	2.0E-01
0.150	77%	0.020	8.1E-01
0.075	36%	0.005	3.3E+00
µm			
55	11%	2.8E-03	6.030
39	9%	1.4E-03	12.060
28	7%	6.9E-04	24.119
19	0%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Time for 50% to Settle 100cm	2.42
Time for 90% to Settle 100cm	9.05
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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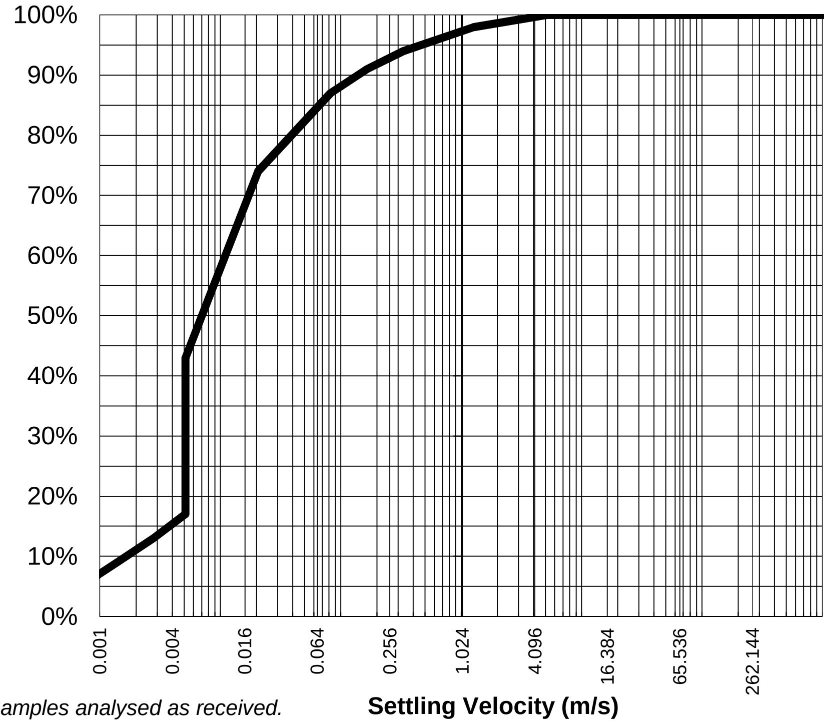
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-010 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M3T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.1	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	94%	0.33	5.1E-02
0.425	91%	0.17	1.0E-01
0.300	87%	0.082	2.0E-01
0.150	74%	0.021	8.1E-01
0.075	43%	0.005	3.2E+00
µm			
55	13%	2.8E-03	5.994
39	9%	1.4E-03	11.989
28	5%	7.0E-04	23.978
19	0%	3.5E-04	47.956
10	0%	9.3E-05	179.83
5	0%	2.3E-05	719.34
1	0%	2.1E-06	8115.14

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.69
Time for 90% to Settle 100cm	10.49
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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ALS Environmental

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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

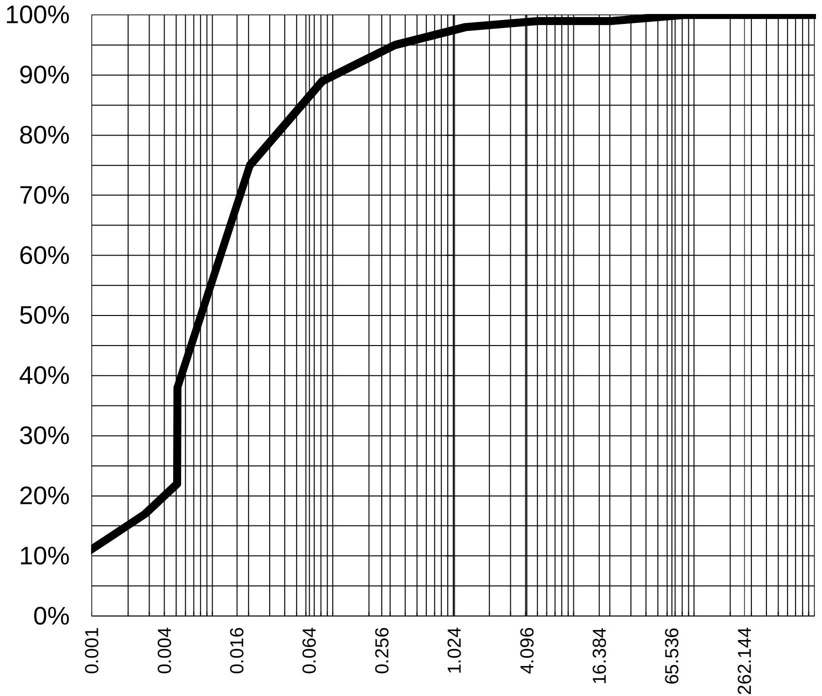
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-011 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M3B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	99%	21	8.1E-04
2.36	99%	5.1	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	95%	0.33	5.1E-02
0.425	92%	0.16	1.0E-01
0.300	89%	0.082	2.0E-01
0.150	75%	0.020	8.1E-01
0.075	38%	0.005	3.3E+00
µm			
55	17%	2.8E-03	6.030
39	13%	1.4E-03	12.060
28	9%	6.9E-04	24.119
19	5%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Time for 50% to Settle 100cm	2.46
Time for 90% to Settle 100cm	21.10
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
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pH 02 4014 2500
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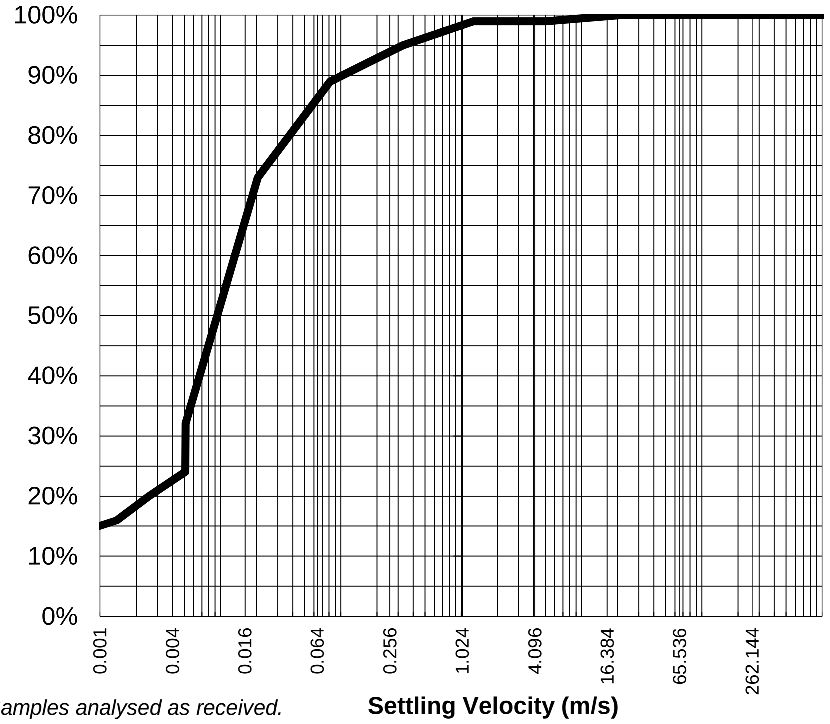
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-012 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M2T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.1E-04
2.36	99%	5.1	3.3E-03
1.18	99%	1.3	1.3E-02
0.600	95%	0.33	5.1E-02
0.425	92%	0.16	1.0E-01
0.300	89%	0.082	2.0E-01
0.150	73%	0.020	8.1E-01
0.075	32%	0.005	3.3E+00
µm			
53	20%	2.6E-03	6.534
39	16%	1.4E-03	12.060
28	14%	6.9E-04	24.119
19	8%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Time for 50% to Settle 100cm	2.18
Time for 90% to Settle 100cm	40.20
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
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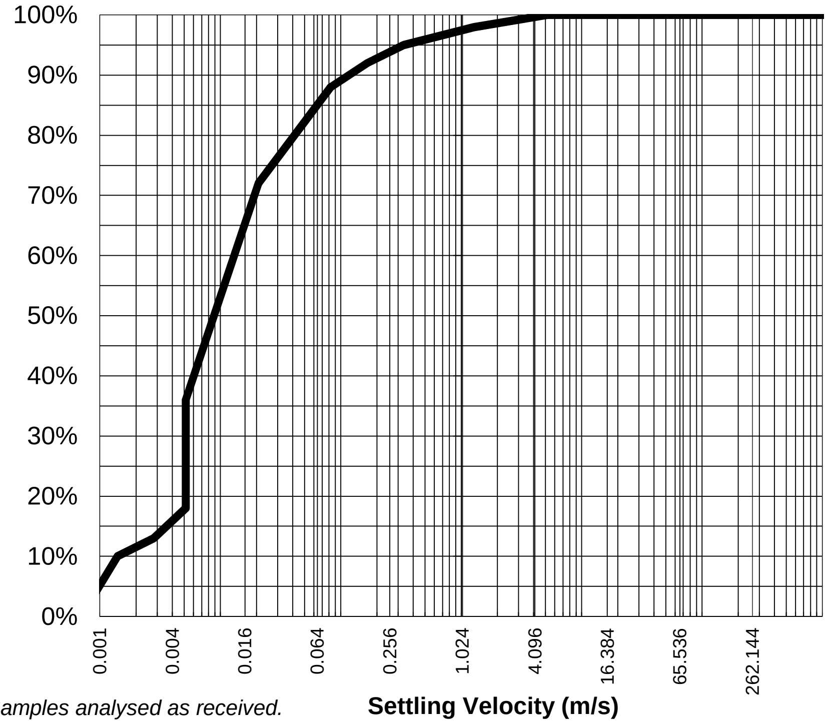
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-013 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M2B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.1	3.2E-03
1.18	98%	1.3	1.3E-02
0.600	95%	0.33	5.0E-02
0.425	92%	0.17	1.0E-01
0.300	88%	0.083	2.0E-01
0.150	72%	0.021	8.0E-01
0.075	36%	0.005	3.2E+00
µm			
55	13%	2.8E-03	5.960
39	10%	1.4E-03	11.919
28	0%	7.0E-04	23.838
19	0%	3.5E-04	47.676
10	0%	9.3E-05	178.79
5	0%	2.3E-05	715.14
1	0%	2.1E-06	8067.82

Time for 50% to Settle 100cm	2.28
Time for 90% to Settle 100cm	11.92
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

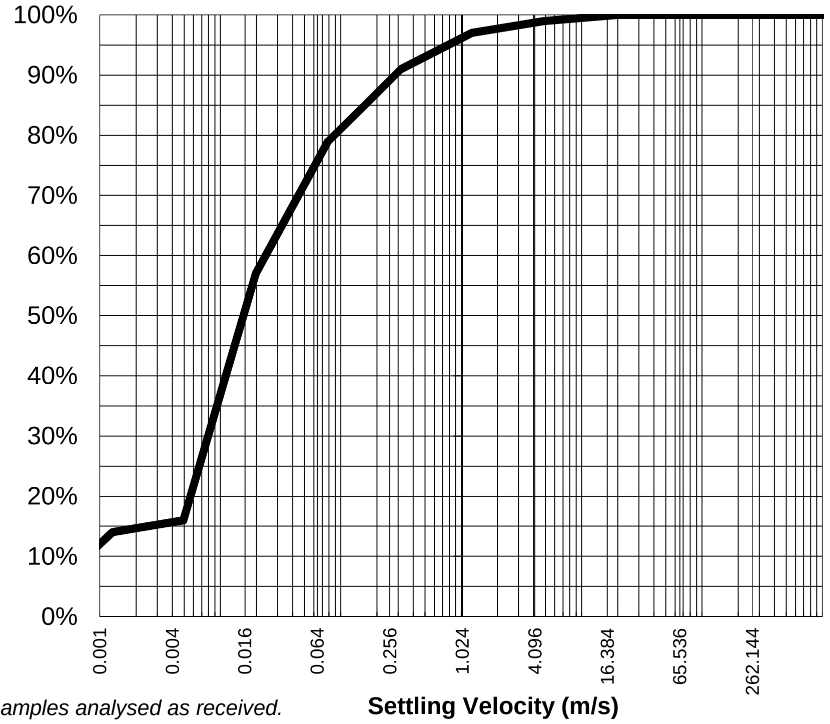
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-014 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M1T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	20	8.4E-04
2.36	99%	4.9	3.4E-03
1.18	97%	1.2	1.4E-02
0.600	91%	0.32	5.3E-02
0.425	85%	0.16	1.1E-01
0.300	79%	0.079	2.1E-01
0.150	57%	0.020	8.4E-01
0.075	16%	0.005	3.4E+00
µm			
54	15%	2.5E-03	6.571
38	14%	1.3E-03	13.143
28	9%	6.9E-04	24.259
20	8%	3.4E-04	48.519
10	5%	9.2E-05	181.94
5	5%	2.3E-05	727.78
1	3%	1.9E-06	8839.19

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	1.28
Time for 90% to Settle 100cm	22.04
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

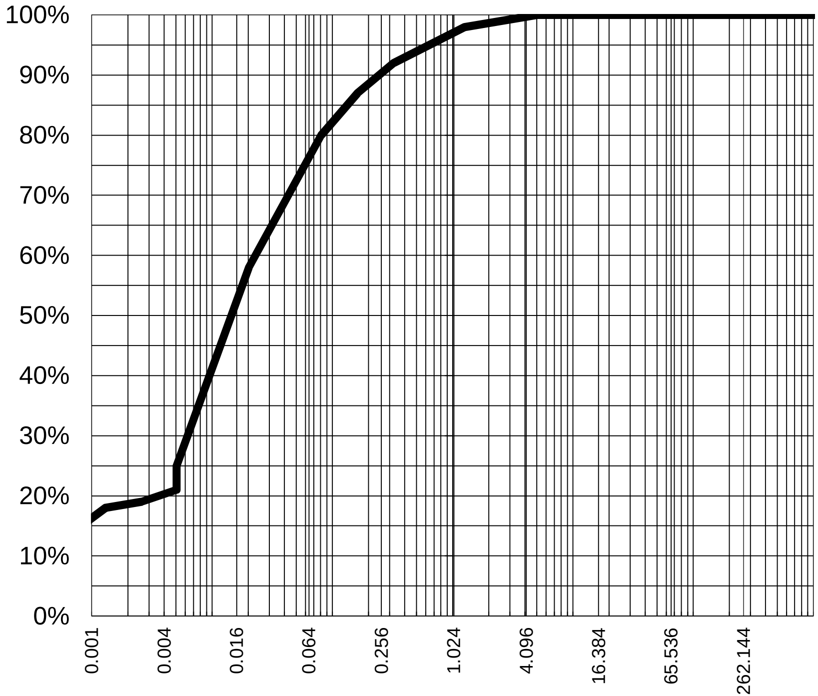
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-015 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M1B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.0	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	92%	0.32	5.1E-02
0.425	87%	0.16	1.0E-01
0.300	80%	0.081	2.1E-01
0.150	58%	0.020	8.2E-01
0.075	25%	0.005	3.3E+00
µm			
54	19%	2.6E-03	6.415
38	18%	1.3E-03	12.829
28	14%	7.0E-04	23.680
20	11%	3.5E-04	47.360
10	5%	9.4E-05	177.60
5	0%	2.3E-05	710.40
2	0%	2.1E-06	8018.96

Time for 50% to Settle 100cm	1.42
Time for 90% to Settle 100cm	61.17
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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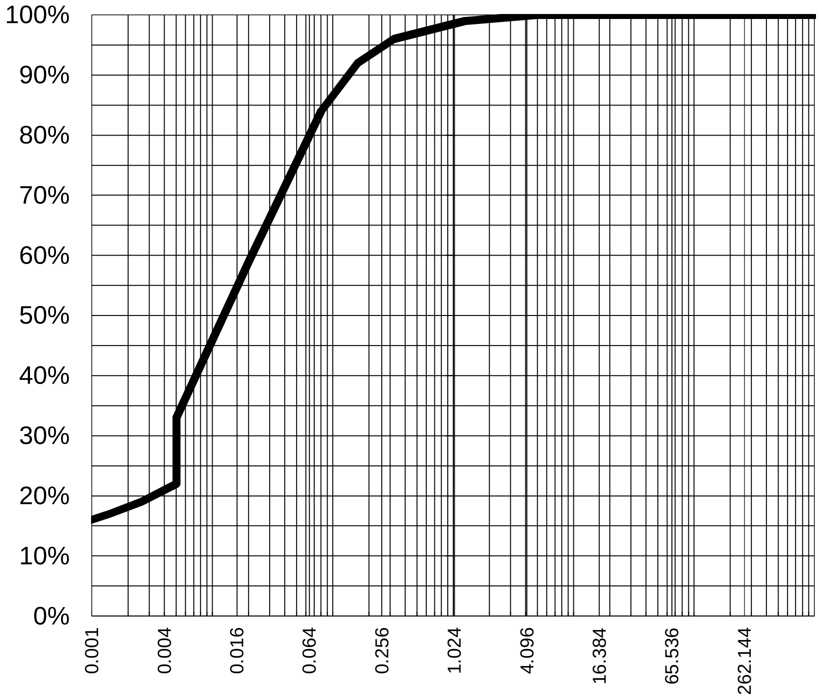
Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-016 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M10T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.0	3.3E-03
1.18	99%	1.2	1.3E-02
0.600	96%	0.32	5.2E-02
0.425	92%	0.16	1.0E-01
0.300	84%	0.080	2.1E-01
0.150	59%	0.020	8.3E-01
0.075	33%	0.005	3.3E+00
µm			
54	19%	2.6E-03	6.453
40	17%	1.4E-03	11.911
28	15%	7.0E-04	23.822
20	9%	3.5E-04	47.644
10	0%	9.3E-05	178.67
5	0%	2.3E-05	714.66
2	0%	2.1E-06	8067.12

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	1.69
Time for 90% to Settle 100cm	43.67
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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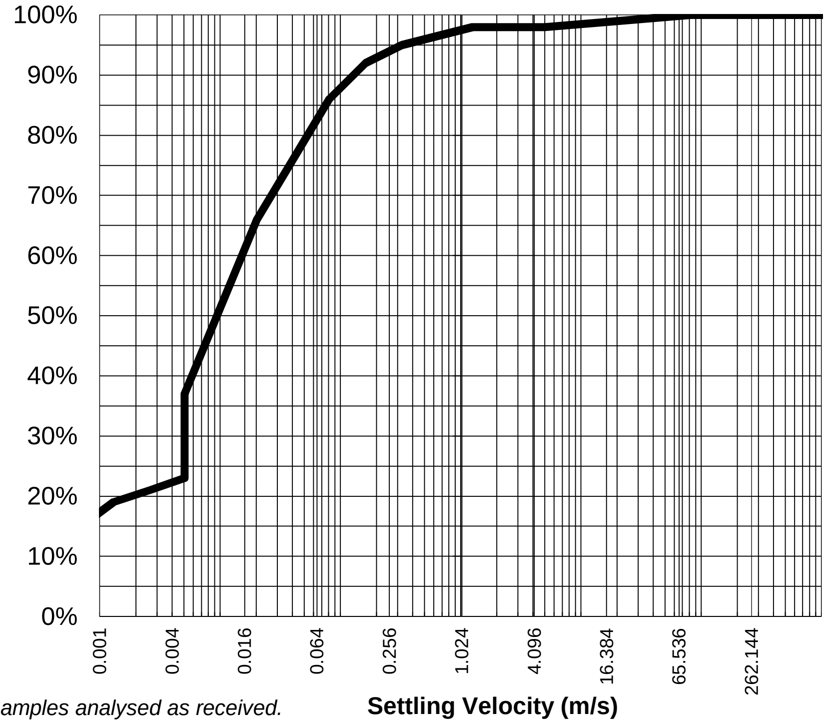
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-017 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M10B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	81	2.1E-04
4.75	99%	20	8.2E-04
2.36	98%	5.0	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	95%	0.32	5.1E-02
0.425	92%	0.16	1.0E-01
0.300	86%	0.081	2.1E-01
0.150	66%	0.020	8.2E-01
0.075	37%	0.005	3.3E+00
µm			
54	21%	2.6E-03	6.415
38	19%	1.3E-03	12.829
28	15%	7.0E-04	23.680
20	12%	3.5E-04	47.360
10	0%	9.4E-05	177.60
5	0%	2.3E-05	710.40
2	0%	2.1E-06	8018.96

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.19
Time for 90% to Settle 100cm	57.72
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
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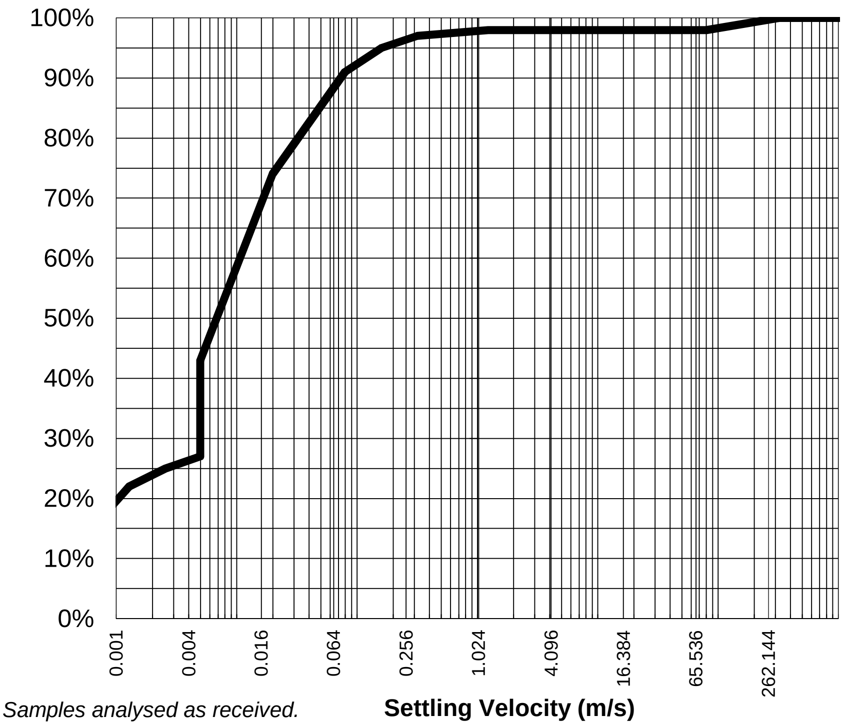
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-018 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M9T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
19.0	100%	319	5.2E-05
9.50	98%	80	2.1E-04
4.75	98%	20	8.4E-04
2.36	98%	4.9	3.4E-03
1.18	98%	1.2	1.4E-02
0.600	97%	0.32	5.2E-02
0.425	95%	0.16	1.0E-01
0.300	91%	0.080	2.1E-01
0.150	74%	0.020	8.4E-01
0.075	43%	0.005	3.4E+00
µm			
54	25%	2.6E-03	6.532
38	22%	1.3E-03	13.063
28	16%	6.9E-04	24.112
20	10%	3.5E-04	48.224
10	0%	9.2E-05	180.84
5	0%	2.3E-05	723.35
2	0%	2.0E-06	8165.20

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.79
Time for 90% to Settle 100cm	48.23
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
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Certificate of Analysis

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

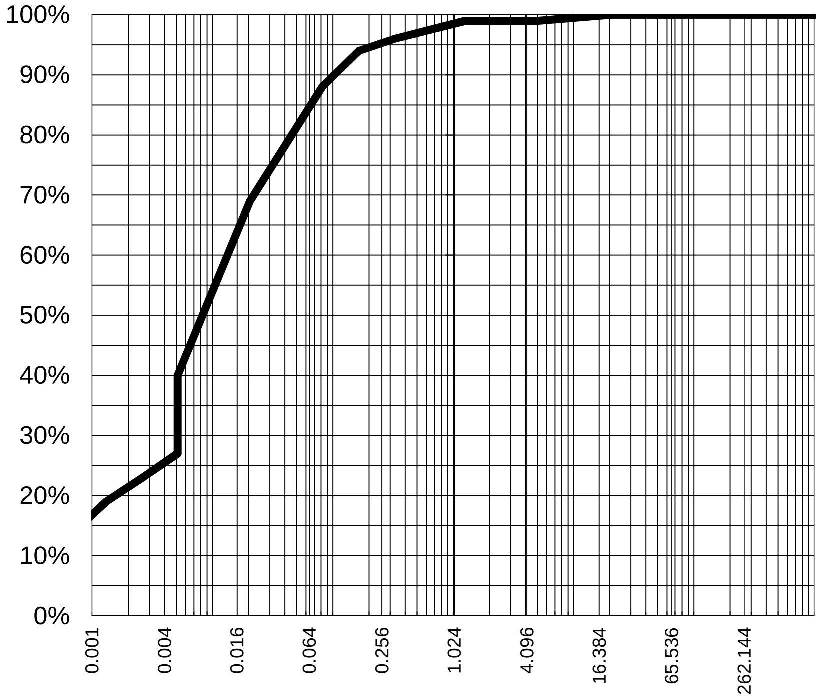
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-019 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M9B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.1E-04
2.36	99%	5.1	3.3E-03
1.18	99%	1.3	1.3E-02
0.600	96%	0.33	5.1E-02
0.425	94%	0.16	1.0E-01
0.300	88%	0.082	2.0E-01
0.150	69%	0.020	8.1E-01
0.075	40%	0.005	3.3E+00
µm			
54	23%	2.6E-03	6.339
38	19%	1.3E-03	12.678
28	14%	7.1E-04	23.401
20	8%	3.6E-04	46.801
10	0%	9.5E-05	175.50
5	0%	2.4E-05	702.02
2	0%	2.1E-06	7924.34

Time for 50% to Settle 100cm	2.41
Time for 90% to Settle 100cm	39.00
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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Authorised Signatory

Certificate of Analysis

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

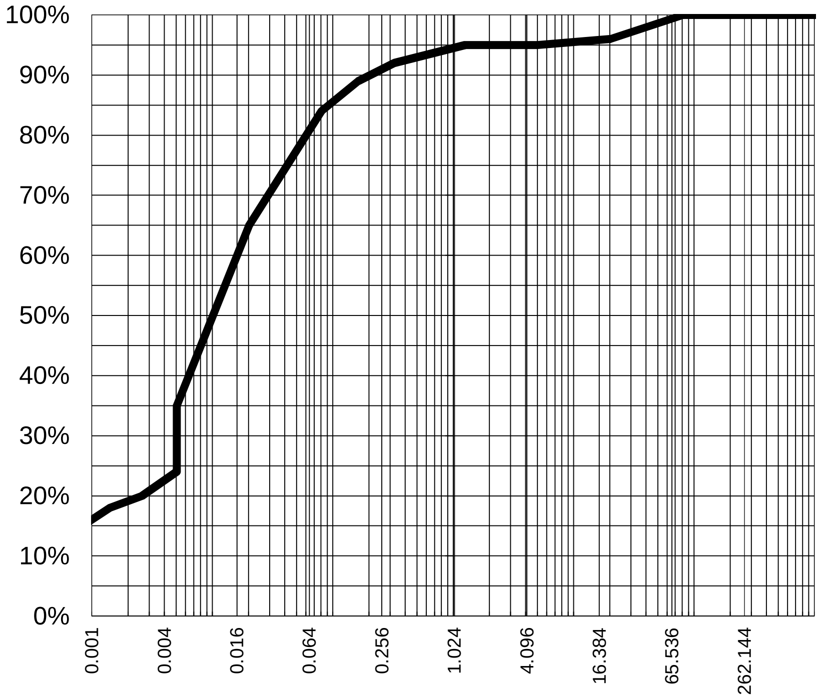
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-020 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M8T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	81	2.1E-04
4.75	96%	20	8.2E-04
2.36	95%	5.0	3.3E-03
1.18	95%	1.3	1.3E-02
0.600	92%	0.32	5.1E-02
0.425	89%	0.16	1.0E-01
0.300	84%	0.081	2.1E-01
0.150	65%	0.020	8.2E-01
0.075	35%	0.005	3.3E+00
µm			
54	20%	2.6E-03	6.415
40	18%	1.4E-03	11.840
28	14%	7.0E-04	23.680
20	8%	3.5E-04	47.360
10	0%	9.4E-05	177.60
5	0%	2.3E-05	710.40
2	0%	2.1E-06	8018.96

Time for 50% to Settle 100cm	2.06
Time for 90% to Settle 100cm	39.47
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

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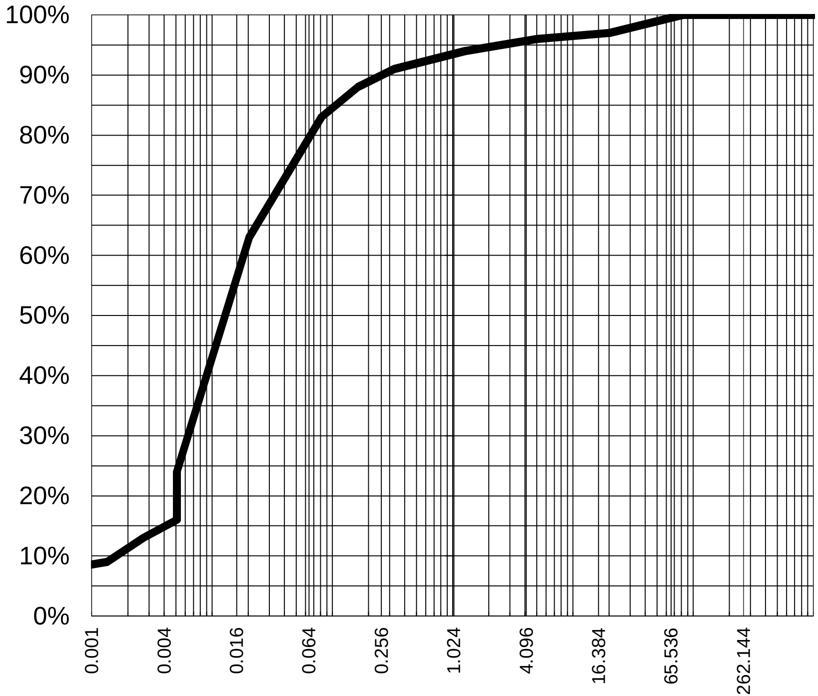
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-021 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M8B



Samples analysed as received.

Settling Velocity (m/s)

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	97%	20	8.2E-04
2.36	96%	5.0	3.3E-03
1.18	94%	1.3	1.3E-02
0.600	91%	0.33	5.1E-02
0.425	88%	0.16	1.0E-01
0.300	83%	0.081	2.0E-01
0.150	63%	0.020	8.2E-01
0.075	24%	0.005	3.3E+00
µm			
54	13%	2.7E-03	6.207
39	9%	1.3E-03	12.413
27	8%	6.7E-04	24.827
19	5%	3.4E-04	49.654
10	1%	9.0E-05	186.20
5	0%	2.3E-05	727.88
1	0%	2.0E-06	8211.46

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	1.64
Time for 90% to Settle 100cm	10.86
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

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pH 02 4014 2500
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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

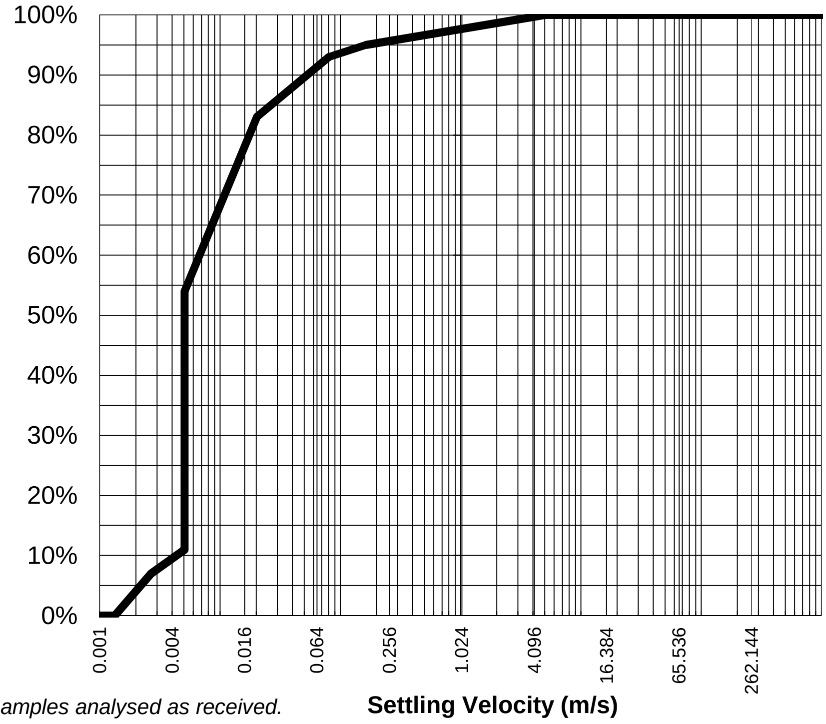
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-022 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M7T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.0	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	96%	0.32	5.1E-02
0.425	95%	0.16	1.0E-01
0.300	93%	0.081	2.1E-01
0.150	83%	0.020	8.2E-01
0.075	54%	0.005	3.3E+00
µm			
54	7%	2.7E-03	6.244
39	0%	1.3E-03	12.488
27	0%	6.7E-04	24.975
19	0%	3.3E-04	49.950
10	0%	8.9E-05	187.31
5	0%	2.3E-05	732.22
1	0%	2.0E-06	8260.49

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.28
Time for 90% to Settle 100cm	3.90
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

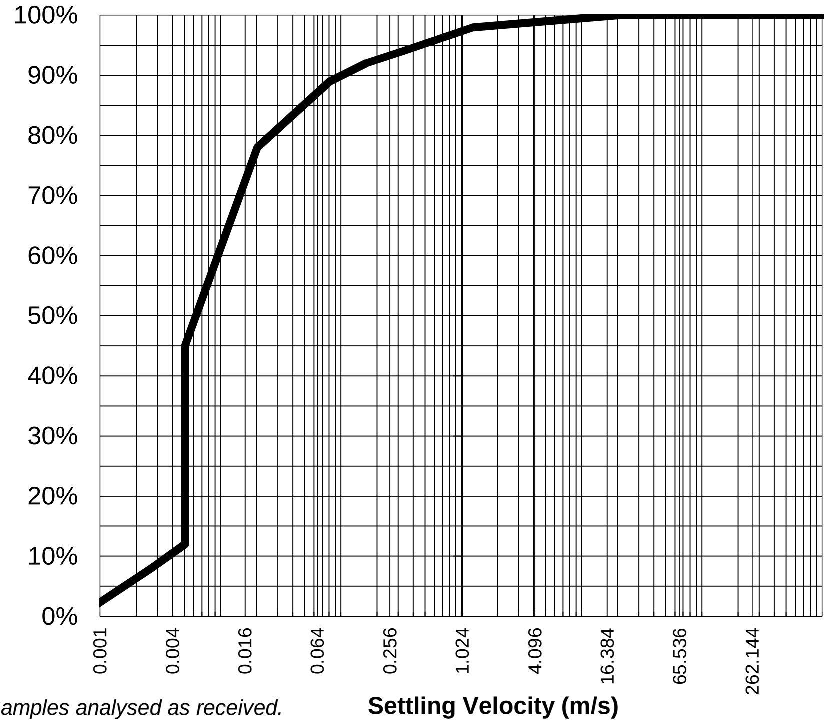
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-023 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M7B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	20	8.2E-04
2.36	99%	5.0	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	94%	0.32	5.1E-02
0.425	92%	0.16	1.0E-01
0.300	89%	0.081	2.1E-01
0.150	78%	0.020	8.2E-01
0.075	45%	0.005	3.3E+00
µm			
54	8%	2.7E-03	6.244
39	4%	1.3E-03	12.488
27	0%	6.7E-04	24.975
19	0%	3.3E-04	49.950
10	0%	8.9E-05	187.31
5	0%	2.3E-05	732.22
1	0%	2.0E-06	8260.49

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.92
Time for 90% to Settle 100cm	4.68
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
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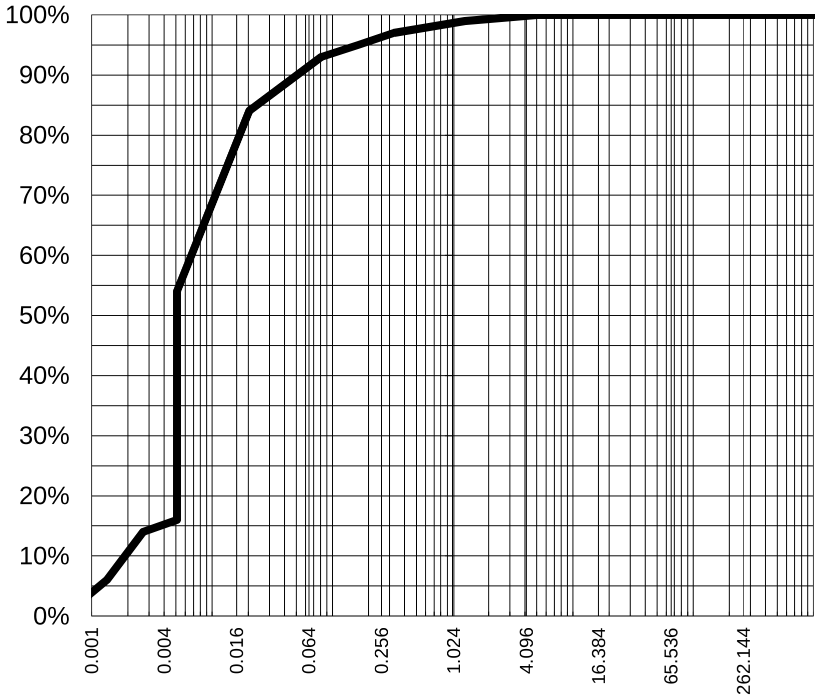
WA, AUSTRALIA

REPORT NUMBER: EP1902664-024 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M6T



Samples analysed as received. **Settling Velocity (m/s)**

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.0	3.3E-03
1.18	99%	1.3	1.3E-02
0.600	97%	0.33	5.1E-02
0.425	95%	0.16	1.0E-01
0.300	93%	0.081	2.0E-01
0.150	84%	0.020	8.2E-01
0.075	54%	0.005	3.3E+00
µm			
54	14%	2.7E-03	6.207
39	6%	1.3E-03	12.413
27	1%	6.7E-04	24.827
19	0%	3.4E-04	49.654
10	0%	9.0E-05	186.20
5	0%	2.3E-05	727.88
1	0%	2.0E-06	8211.46

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.26
Time for 90% to Settle 100cm	9.31
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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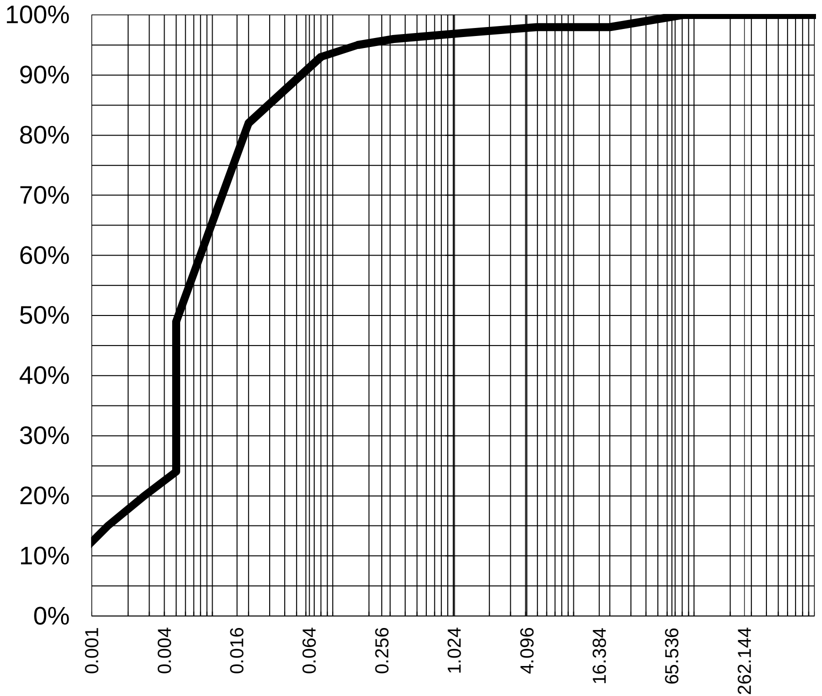
Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-025 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M6B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	80	2.1E-04
4.75	98%	20	8.3E-04
2.36	98%	5.0	3.4E-03
1.18	97%	1.2	1.3E-02
0.600	96%	0.32	5.2E-02
0.425	95%	0.16	1.0E-01
0.300	93%	0.080	2.1E-01
0.150	82%	0.020	8.3E-01
0.075	49%	0.005	3.3E+00
µm			
55	20%	2.7E-03	6.138
39	15%	1.4E-03	12.276
28	9%	6.8E-04	24.552
20	3%	3.4E-04	49.105
10	0%	9.1E-05	184.14
5	0%	2.3E-05	718.98
2	0%	2.1E-06	8115.86

Time for 50% to Settle 100cm	3.26
Time for 90% to Settle 100cm	22.51
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

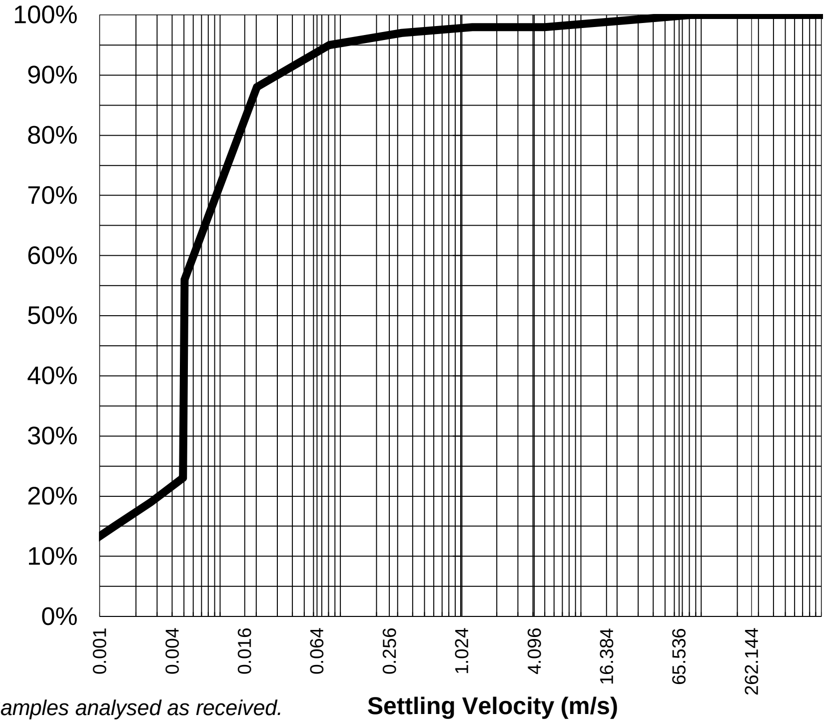
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-026 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M5AT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	81	2.1E-04
4.75	99%	20	8.2E-04
2.36	98%	5.0	3.3E-03
1.18	98%	1.3	1.3E-02
0.600	97%	0.32	5.1E-02
0.425	96%	0.16	1.0E-01
0.300	95%	0.081	2.1E-01
0.150	88%	0.020	8.2E-01
0.075	56%	0.005	3.3E+00
µm			
54	19%	2.7E-03	6.244
39	15%	1.3E-03	12.488
27	11%	6.7E-04	24.975
19	1%	3.3E-04	49.950
10	0%	8.9E-05	187.31
5	0%	2.3E-05	732.22
1	0%	2.0E-06	8260.49

Time for 50% to Settle 100cm	3.31
Time for 90% to Settle 100cm	27.47
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

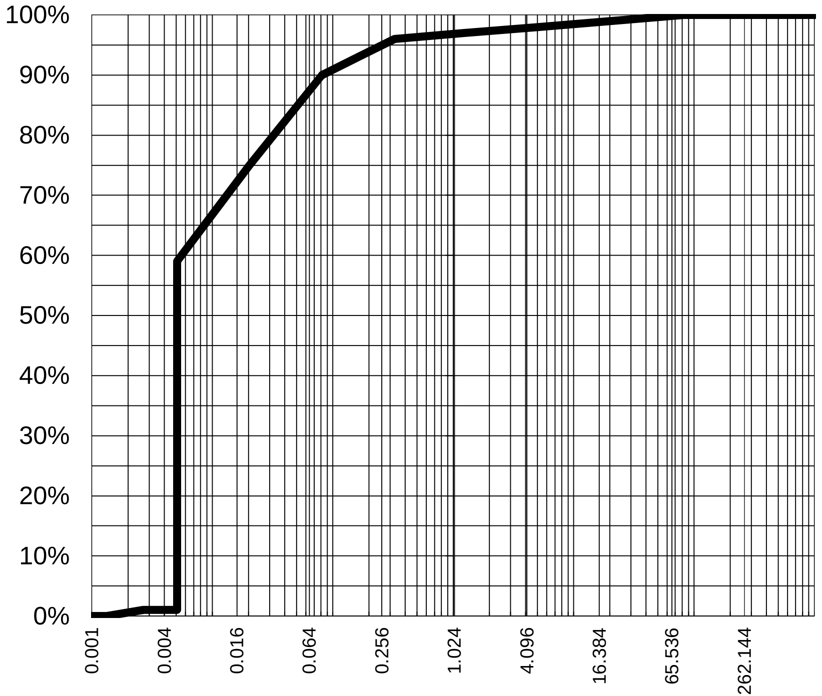
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-027 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: N16T



Samples analysed as received.

Particle Size **mm**	Percent Passing **%**	Settling Velocity **m/s**	Time to Settle 100cm **min**
9.50	100%	82	2.0E-04
4.75	99%	20	8.2E-04
2.36	98%	5.0	3.3E-03
1.18	97%	1.3	1.3E-02
0.600	96%	0.33	5.1E-02
0.425	93%	0.16	1.0E-01
0.300	90%	0.081	2.0E-01
0.150	75%	0.020	8.2E-01
0.075	59%	0.005	3.3E+00
µm			
54	1%	2.7E-03	6.207
39	0%	1.3E-03	12.413
27	0%	6.7E-04	24.827
19	0%	3.4E-04	49.654
10	0%	9.0E-05	186.20
5	0%	2.3E-05	727.88
1	0%	1.9E-06	8734.51

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.25
Time for 90% to Settle 100cm	3.13
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.01

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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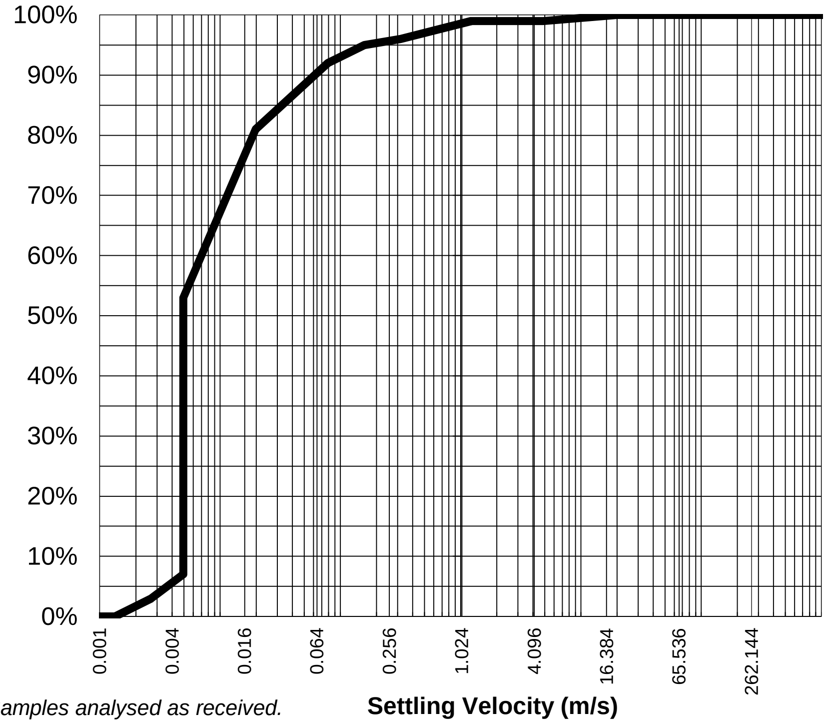
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-028 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	M5AB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	20	8.4E-04
2.36	99%	4.9	3.4E-03
1.18	99%	1.2	1.4E-02
0.600	96%	0.32	5.3E-02
0.425	95%	0.16	1.1E-01
0.300	92%	0.079	2.1E-01
0.150	81%	0.020	8.4E-01
0.075	53%	0.005	3.4E+00
µm			
55	3%	2.7E-03	6.213
39	0%	1.3E-03	12.426
28	0%	6.7E-04	24.853
20	0%	3.4E-04	49.705
10	0%	8.9E-05	186.40
5	0%	2.3E-05	727.78
2	0%	2.0E-06	8215.14

Time for 50% to Settle 100cm	3.36
Time for 90% to Settle 100cm	3.12
Settling Rate at 50% settled (m/s)	0.00
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

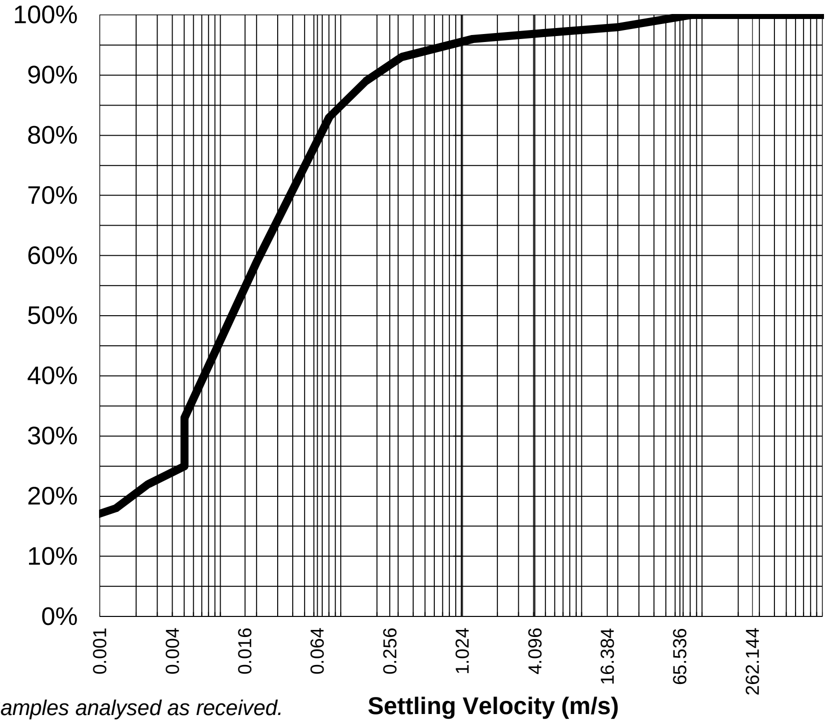
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-029 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: N17T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	81	2.1E-04
4.75	98%	20	8.3E-04
2.36	97%	5.0	3.3E-03
1.18	96%	1.2	1.3E-02
0.600	93%	0.32	5.2E-02
0.425	89%	0.16	1.0E-01
0.300	83%	0.080	2.1E-01
0.150	59%	0.020	8.3E-01
0.075	33%	0.005	3.3E+00
µm			
53	22%	2.5E-03	6.611
39	18%	1.4E-03	12.202
28	16%	6.8E-04	24.405
20	12%	3.4E-04	48.810
10	6%	9.3E-05	178.67
5	4%	2.3E-05	714.66
1	4%	1.9E-06	8679.93

Time for 50% to Settle 100cm	1.69
Time for 90% to Settle 100cm	65.89
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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Certificate of Analysis

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

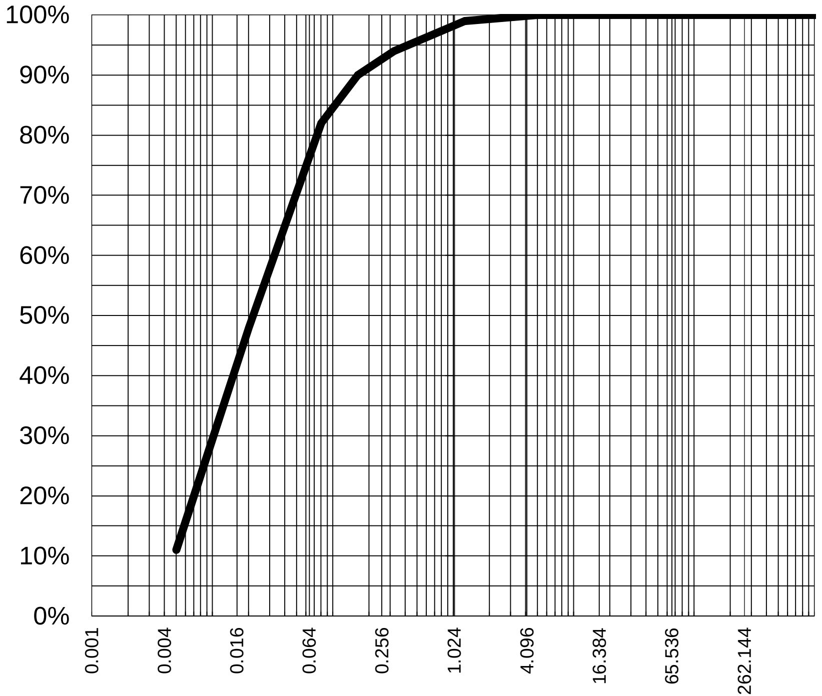
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-030 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: N18T



Samples analysed as received. **Settling Velocity (m/s)**

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	5.0	3.3E-03
1.18	99%	1.2	1.3E-02
0.600	94%	0.32	5.2E-02
0.425	90%	0.16	1.0E-01
0.300	82%	0.080	2.1E-01
0.150	48%	0.020	8.3E-01
0.075	11%	0.005	3.3E+00
µm			

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	>3.3E+0
Time for 90% to Settle 100cm	>3.3E+0
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	<5.0E-3

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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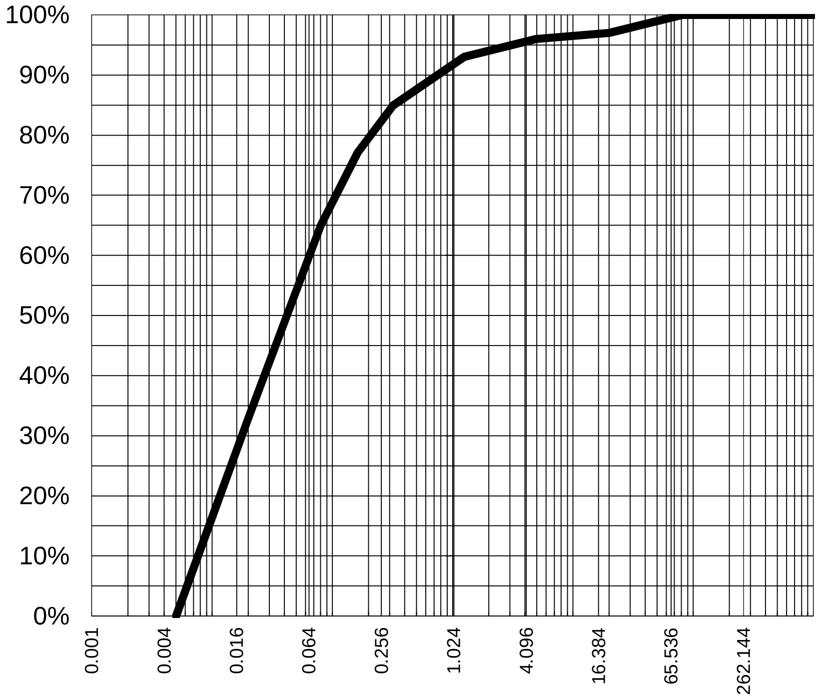
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-031 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	N18B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	81	2.1E-04
4.75	97%	20	8.3E-04
2.36	96%	5.0	3.3E-03
1.18	93%	1.2	1.3E-02
0.600	85%	0.32	5.2E-02
0.425	77%	0.16	1.0E-01
0.300	65%	0.080	2.1E-01
0.150	33%	0.020	8.3E-01
0.075	0%	0.005	3.3E+00
µm			

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	>3.3E+0
Time for 90% to Settle 100cm	>3.3E+0
Settling Rate at 50% settled (m/s)	0.05
Settling Rate at 90% settled (m/s)	0.01

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

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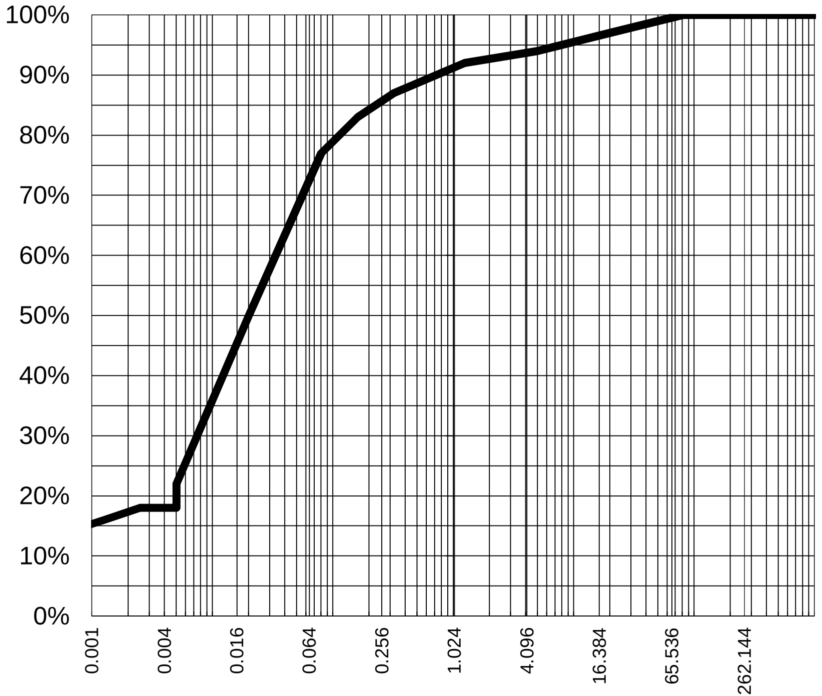
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-032 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	N19T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	81	2.1E-04
4.75	97%	20	8.3E-04
2.36	94%	5.0	3.3E-03
1.18	92%	1.2	1.3E-02
0.600	87%	0.32	5.2E-02
0.425	83%	0.16	1.0E-01
0.300	77%	0.080	2.1E-01
0.150	50%	0.020	8.3E-01
0.075	22%	0.005	3.3E+00
µm			
53	18%	2.5E-03	6.611
38	16%	1.3E-03	13.222
27	14%	6.3E-04	26.444
20	10%	3.4E-04	48.810
10	8%	9.3E-05	178.67
5	8%	2.3E-05	714.66
1	6%	1.9E-06	8679.93

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	0.83
Time for 90% to Settle 100cm	48.81
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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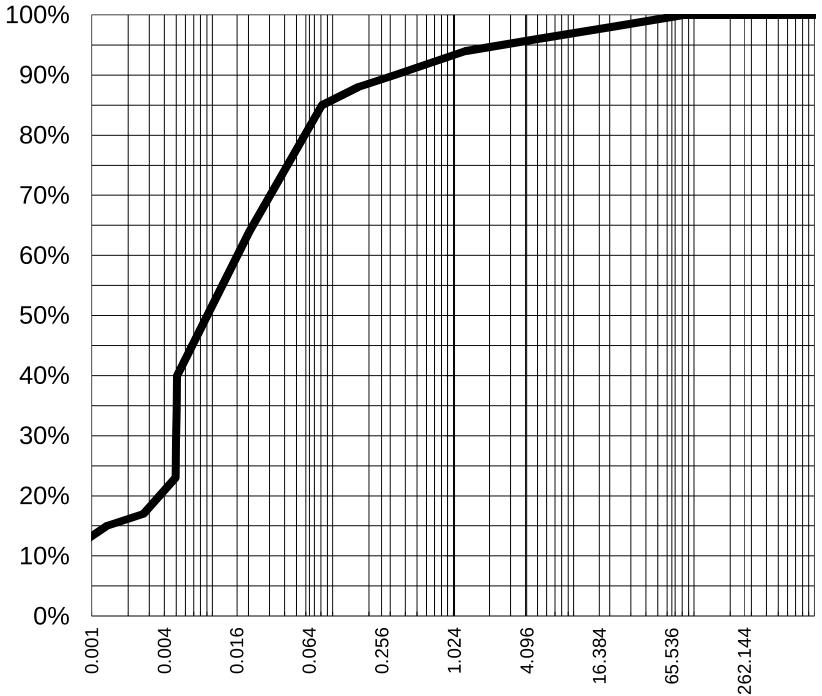
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-033 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C1T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	98%	20	8.2E-04
2.36	96%	5.0	3.3E-03
1.18	94%	1.3	1.3E-02
0.600	90%	0.33	5.1E-02
0.425	88%	0.16	1.0E-01
0.300	85%	0.081	2.0E-01
0.150	64%	0.020	8.2E-01
0.075	40%	0.005	3.3E+00
µm			
54	17%	2.7E-03	6.207
39	15%	1.3E-03	12.413
27	11%	6.7E-04	24.827
19	7%	3.4E-04	49.654
10	0%	9.2E-05	181.97
5	0%	2.3E-05	727.88
1	0%	2.0E-06	8211.46

Time for 50% to Settle 100cm	2.25
Time for 90% to Settle 100cm	31.03
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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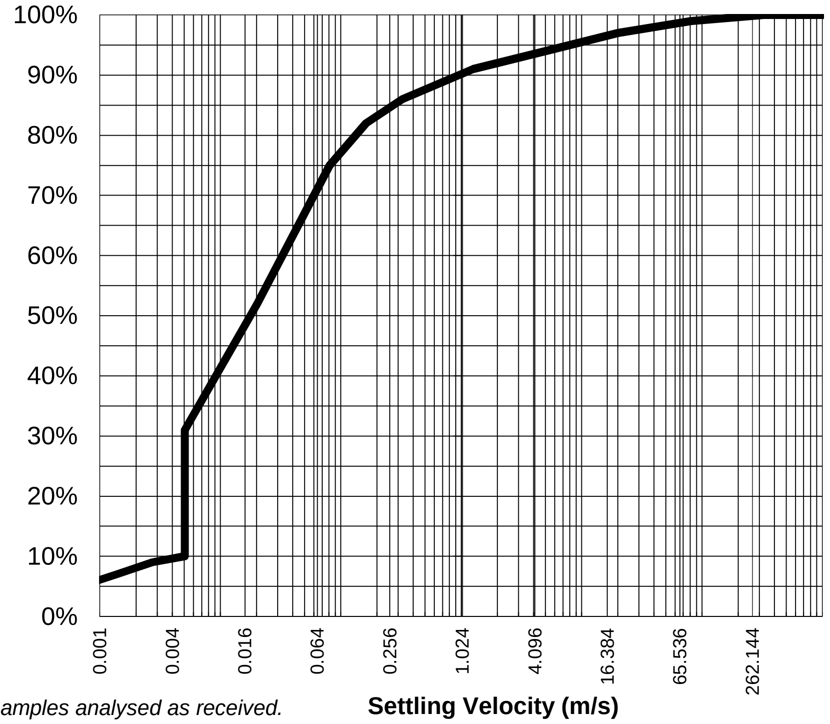
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-034 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C1B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
19.0	100%	325	5.1E-05
9.50	99%	81	2.1E-04
4.75	97%	20	8.2E-04
2.36	94%	5.0	3.3E-03
1.18	91%	1.3	1.3E-02
0.600	86%	0.32	5.1E-02
0.425	82%	0.16	1.0E-01
0.300	75%	0.081	2.1E-01
0.150	52%	0.020	8.2E-01
0.075	31%	0.005	3.3E+00
μm			
55	9%	2.7E-03	6.102
39	7%	1.4E-03	12.204
28	5%	6.8E-04	24.407
19	2%	3.4E-04	48.815
10	0%	9.1E-05	183.06
5	0%	2.3E-05	732.22
1	0%	2.0E-06	8260.49

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	1.06
Time for 90% to Settle 100cm	3.12
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.01

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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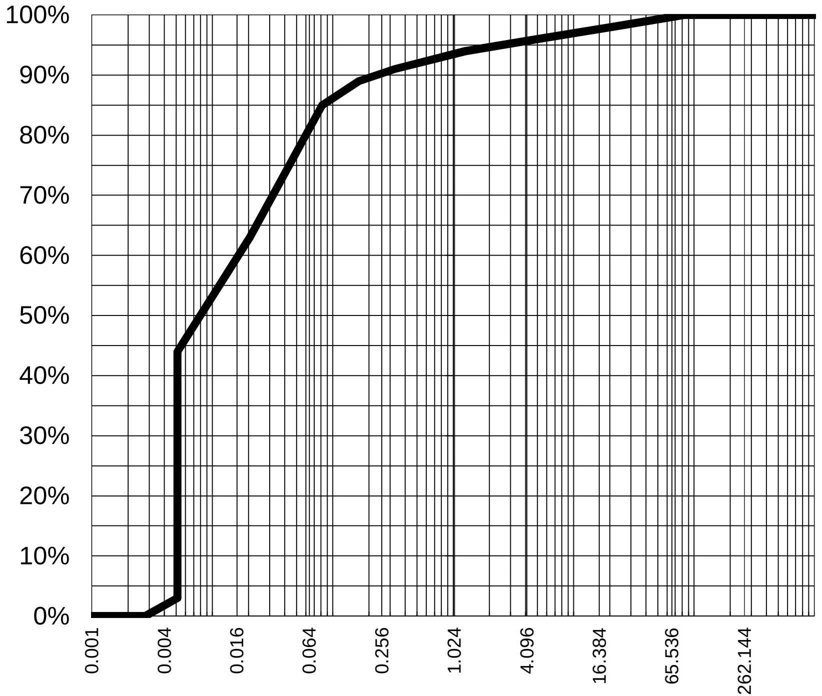
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-035 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2AT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	98%	21	8.1E-04
2.36	96%	5.1	3.3E-03
1.18	94%	1.3	1.3E-02
0.600	91%	0.33	5.1E-02
0.425	89%	0.16	1.0E-01
0.300	85%	0.082	2.0E-01
0.150	63%	0.020	8.1E-01
0.075	44%	0.005	3.3E+00
µm			
55	0%	2.8E-03	6.030
39	0%	1.4E-03	12.060
28	0%	6.9E-04	24.119
19	0%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.48
Time for 90% to Settle 100cm	3.06
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.01

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

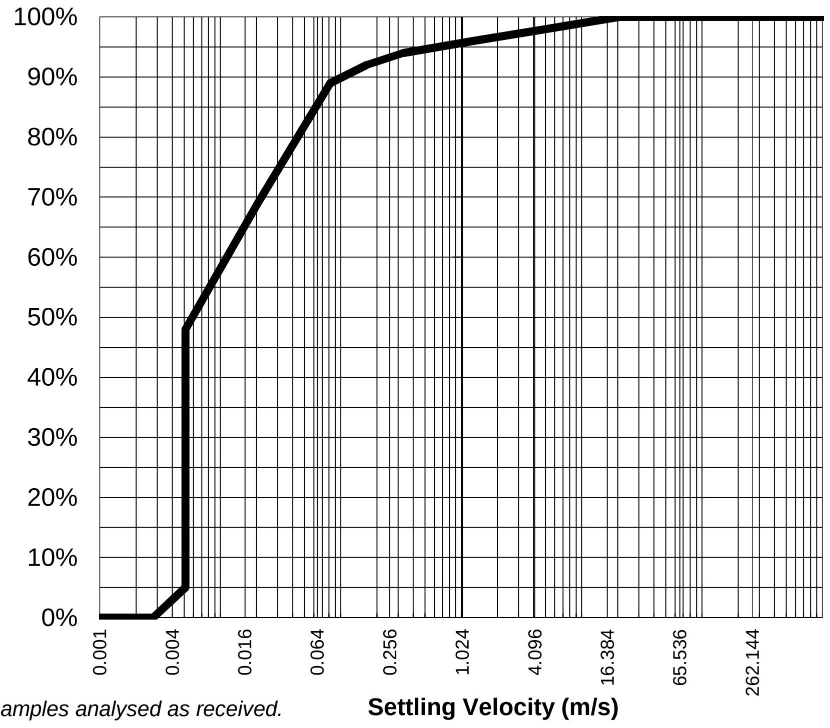
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-036 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C2AB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.1E-04
2.36	98%	5.1	3.3E-03
1.18	96%	1.3	1.3E-02
0.600	94%	0.33	5.1E-02
0.425	92%	0.16	1.0E-01
0.300	89%	0.082	2.0E-01
0.150	69%	0.020	8.1E-01
0.075	48%	0.005	3.3E+00
µm			
55	0%	2.8E-03	6.030
39	0%	1.4E-03	12.060
28	0%	6.9E-04	24.119
19	0%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.02
Time for 90% to Settle 100cm	3.04
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.01

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

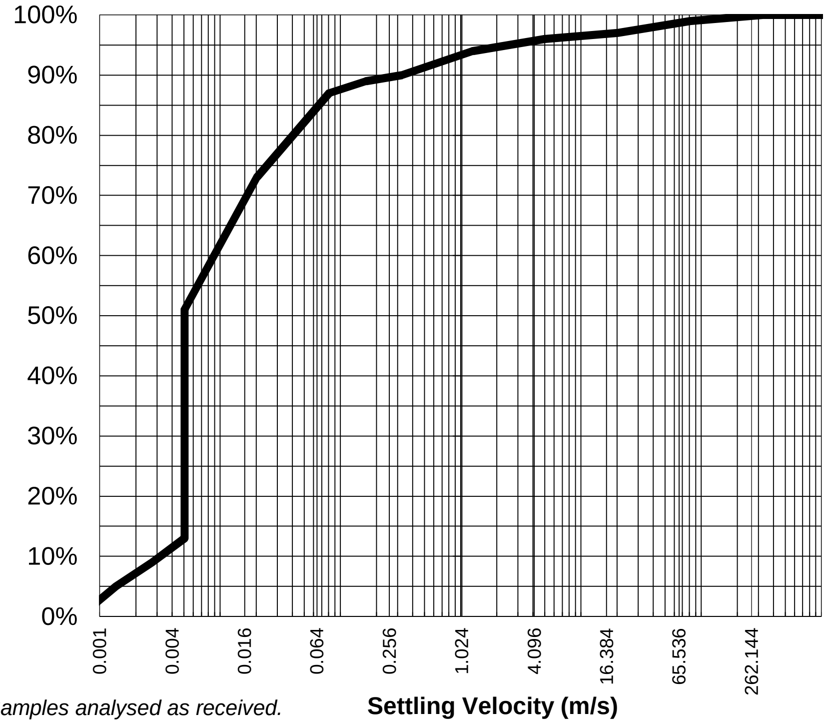
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-037 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C2BT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
19.0	100%	325	5.1E-05
9.50	99%	81	2.1E-04
4.75	97%	20	8.2E-04
2.36	96%	5.0	3.3E-03
1.18	94%	1.3	1.3E-02
0.600	90%	0.32	5.1E-02
0.425	89%	0.16	1.0E-01
0.300	87%	0.081	2.1E-01
0.150	73%	0.020	8.2E-01
0.075	51%	0.005	3.3E+00
µm			
55	9%	2.7E-03	6.102
39	5%	1.4E-03	12.204
28	0%	6.8E-04	24.407
19	0%	3.4E-04	48.815
10	0%	9.1E-05	183.06
5	0%	2.3E-05	732.22
1	0%	2.0E-06	8260.49

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.29
Time for 90% to Settle 100cm	5.34
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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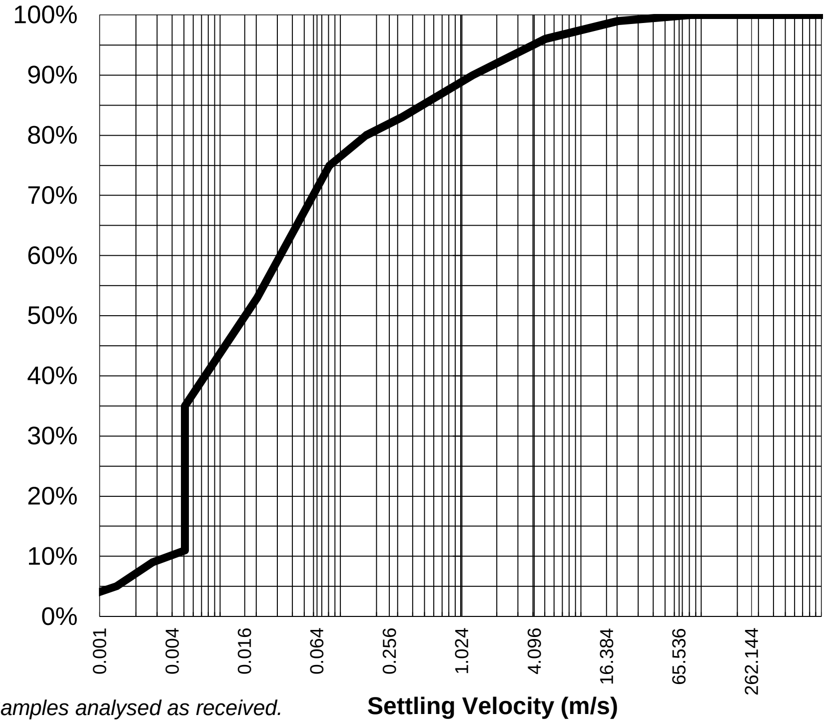
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-038 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2BB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	99%	20	8.2E-04
2.36	96%	5.0	3.3E-03
1.18	90%	1.3	1.3E-02
0.600	83%	0.33	5.1E-02
0.425	80%	0.16	1.0E-01
0.300	75%	0.081	2.0E-01
0.150	53%	0.020	8.2E-01
0.075	35%	0.005	3.3E+00
µm			
55	9%	2.7E-03	6.066
39	5%	1.4E-03	12.131
28	3%	6.9E-04	24.263
19	0%	3.4E-04	48.525
10	0%	9.2E-05	181.97
5	0%	2.3E-05	727.88
1	0%	2.0E-06	8211.46

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	1.23
Time for 90% to Settle 100cm	4.55
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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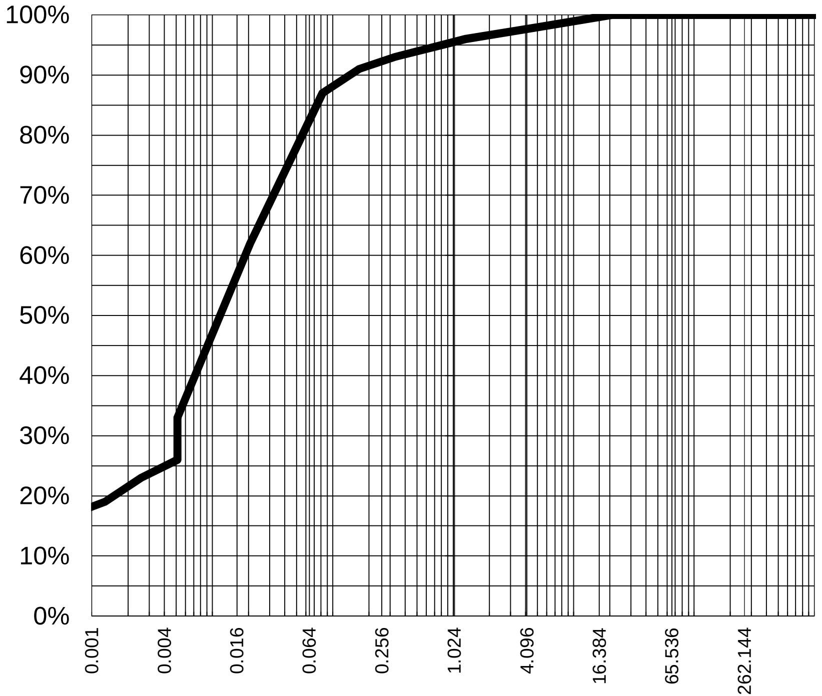
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-039 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2CT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.1E-04
2.36	98%	5.1	3.3E-03
1.18	96%	1.3	1.3E-02
0.600	93%	0.33	5.1E-02
0.425	91%	0.17	1.0E-01
0.300	87%	0.082	2.0E-01
0.150	62%	0.021	8.1E-01
0.075	33%	0.005	3.2E+00
µm			
53	23%	2.6E-03	6.495
37	19%	1.3E-03	12.991
28	17%	7.0E-04	23.978
19	11%	3.5E-04	47.956
10	0%	9.3E-05	179.83
5	0%	2.3E-05	719.34
1	0%	2.1E-06	8115.14

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	1.81
Time for 90% to Settle 100cm	56.35
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINES, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	9-Apr-19
Loss on Pretreatment	NA	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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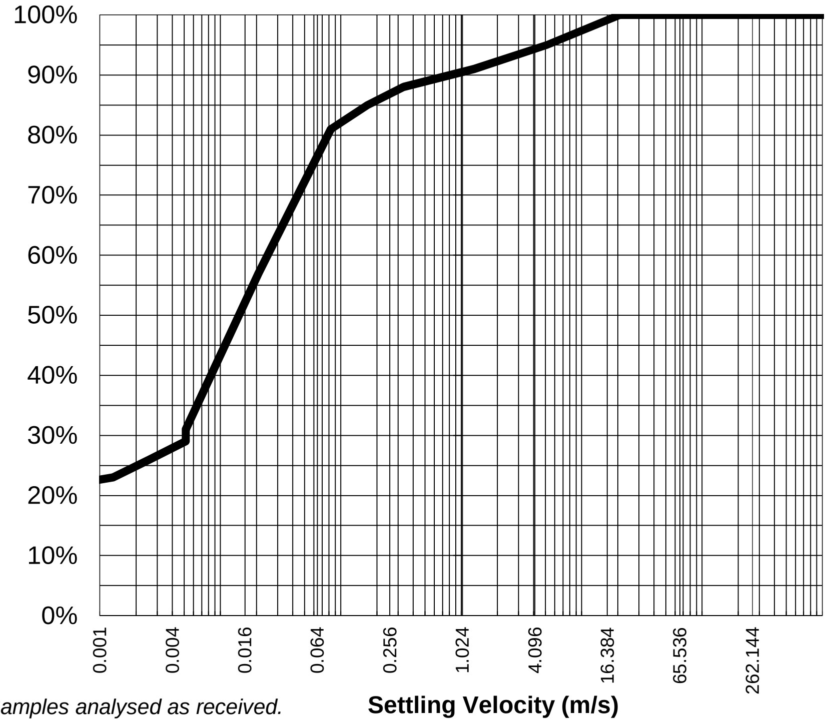
CLIENT:	Paul Nichols	**DATE REPORTED:**	30-Apr-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902664-040 / SR
PROJECT:	401012-02698 WEL SCABS	**SAMPLE ID:**	C2CB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.0E-04
2.36	95%	5.1	3.2E-03
1.18	91%	1.3	1.3E-02
0.600	88%	0.33	5.0E-02
0.425	85%	0.17	1.0E-01
0.300	81%	0.083	2.0E-01
0.150	57%	0.021	8.0E-01
0.075	31%	0.005	3.2E+00
µm			
53	26%	2.6E-03	6.457
37	23%	1.3E-03	12.915
26	22%	6.5E-04	25.830
19	17%	3.2E-04	51.659
10	10%	9.3E-05	178.79
5	9%	2.3E-05	715.14
1	6%	1.9E-06	8680.68

Time for 50% to Settle 100cm	1.45
Time for 90% to Settle 100cm	357.57
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Loss on Pretreatment NA

Limit of Reporting: 1%

Analysed: 9-Apr-19

Dispersion Method Shaker

Hydrometer Type ASTM E100

Peter Keyte
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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

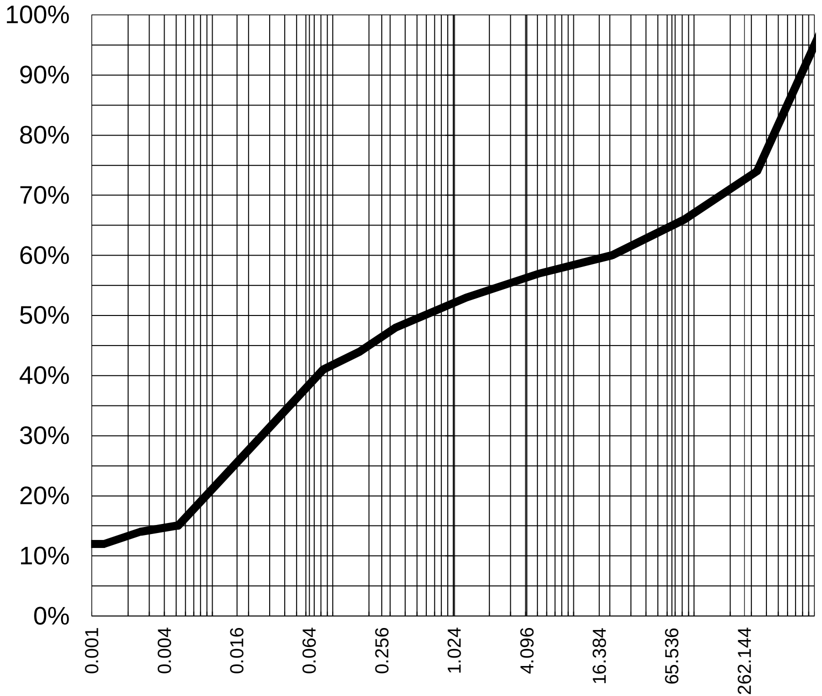
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-041 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C3T



Samples analysed as received.

Settling Velocity (m/s)

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
37.5	100%	1303	1.3E-05
19.0	74%	334	5.0E-05
9.50	66%	84	2.0E-04
4.75	60%	21	8.0E-04
2.36	57%	5.2	3.2E-03
1.18	53%	1.3	1.3E-02
0.600	48%	0.33	5.0E-02
0.425	44%	0.17	1.0E-01
0.300	41%	0.083	2.0E-01
0.150	28%	0.021	8.0E-01
0.075	15%	0.005	3.2E+00
µm			
52	14%	2.5E-03	6.610
37	12%	1.3E-03	13.220
26	12%	6.3E-04	26.440
19	8%	3.4E-04	48.803
10	5%	9.1E-05	183.01
5	4%	2.3E-05	732.05
1	2%	1.9E-06	8887.36

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	0.04
Time for 90% to Settle 100cm	37.62
Settling Rate at 50% settled (m/s)	0.72
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
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pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

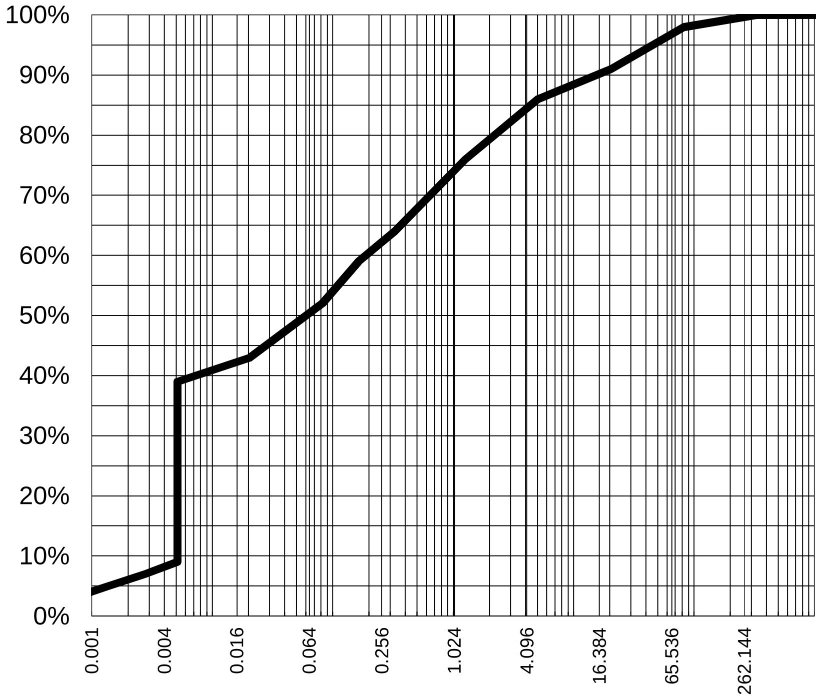
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-042 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C4T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
19.0	100%	329	5.1E-05
9.50	98%	82	2.0E-04
4.75	91%	21	8.1E-04
2.36	86%	5.1	3.3E-03
1.18	76%	1.3	1.3E-02
0.600	64%	0.33	5.1E-02
0.425	59%	0.16	1.0E-01
0.300	52%	0.082	2.0E-01
0.150	43%	0.020	8.1E-01
0.075	39%	0.005	3.3E+00
µm			
55	7%	2.8E-03	6.030
39	5%	1.4E-03	12.060
28	3%	6.9E-04	24.119
19	0%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	0.34
Time for 90% to Settle 100cm	3.02
Settling Rate at 50% settled (m/s)	0.07
Settling Rate at 90% settled (m/s)	0.01

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

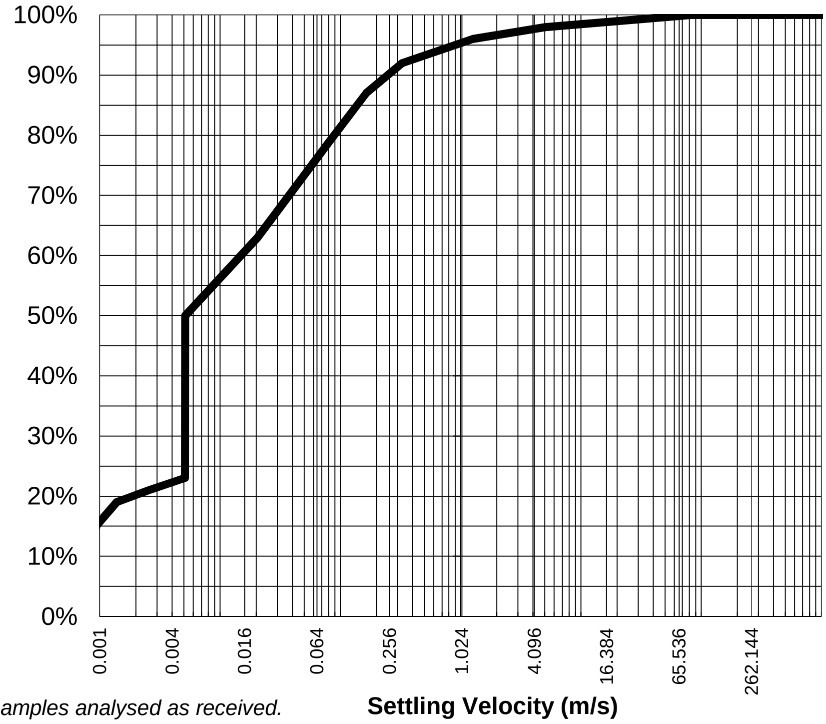
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-043 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C5T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	99%	21	8.1E-04
2.36	98%	5.1	3.3E-03
1.18	96%	1.3	1.3E-02
0.600	92%	0.33	5.1E-02
0.425	87%	0.16	1.0E-01
0.300	79%	0.082	2.0E-01
0.150	63%	0.020	8.1E-01
0.075	50%	0.005	3.3E+00
µm			
53	21%	2.6E-03	6.534
39	19%	1.4E-03	12.060
28	12%	6.9E-04	24.119
19	9%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Time for 50% to Settle 100cm	3.25
Time for 90% to Settle 100cm	40.20
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

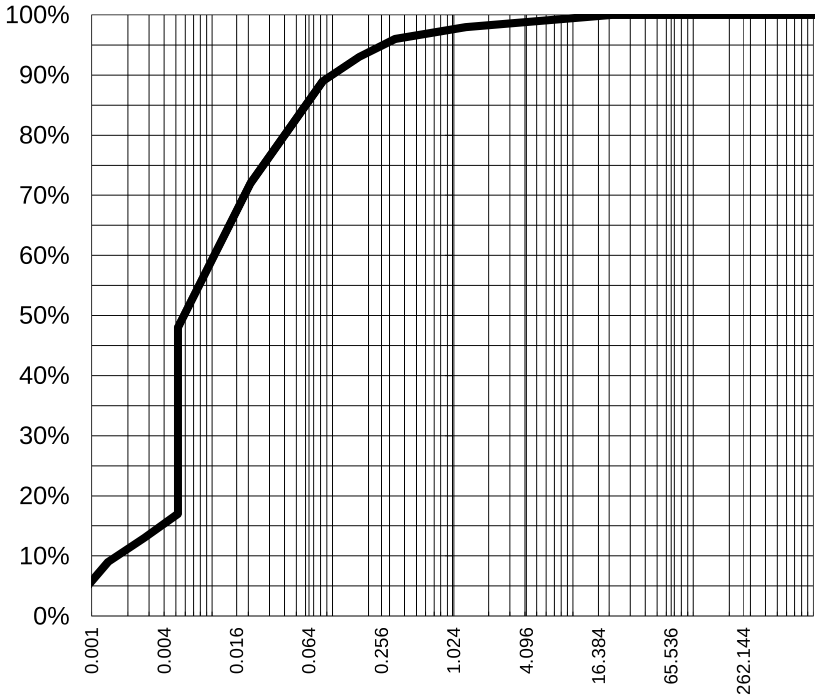
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-044 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: M8T DUP



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	21	8.0E-04
2.36	99%	5.2	3.2E-03
1.18	98%	1.3	1.3E-02
0.600	96%	0.33	5.0E-02
0.425	93%	0.17	1.0E-01
0.300	89%	0.083	2.0E-01
0.150	72%	0.021	8.0E-01
0.075	48%	0.005	3.2E+00
µm			
54	13%	2.7E-03	6.100
38	9%	1.4E-03	12.201
27	2%	6.8E-04	24.402
19	0%	3.4E-04	48.803
10	0%	9.1E-05	183.01
5	0%	2.3E-05	732.05
1	0%	2.0E-06	8259.91

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	3.00
Time for 90% to Settle 100cm	10.68
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 30-Apr-2019

COMPANY: WorleyParsons Services Pty Ltd

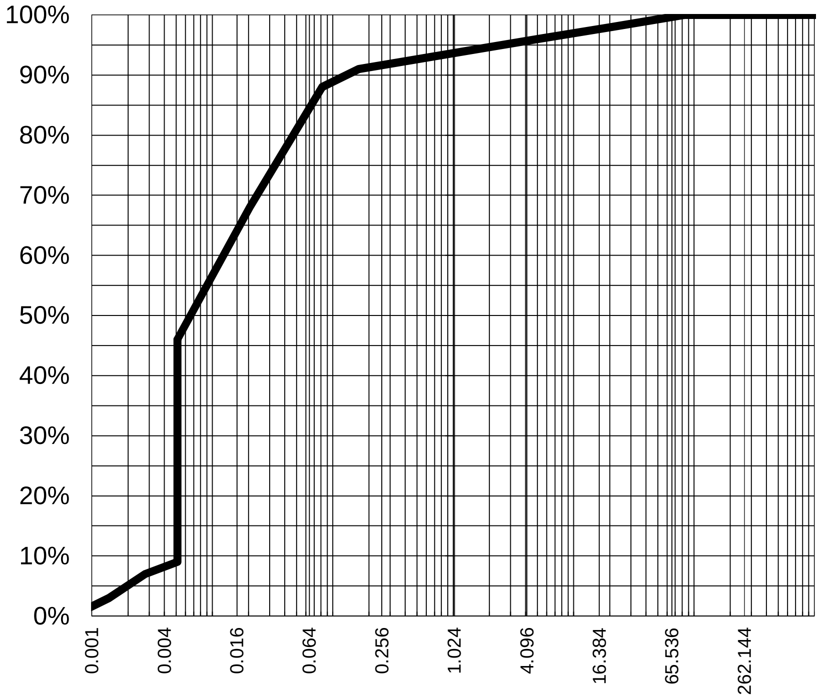
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902664-045 / SR

PROJECT: 401012-02698 WEL SCABS

SAMPLE ID: C2AT DUP



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	82	2.0E-04
4.75	98%	21	8.1E-04
2.36	96%	5.1	3.3E-03
1.18	94%	1.3	1.3E-02
0.600	92%	0.33	5.1E-02
0.425	91%	0.16	1.0E-01
0.300	88%	0.082	2.0E-01
0.150	68%	0.020	8.1E-01
0.075	46%	0.005	3.3E+00
µm			
55	7%	2.8E-03	6.030
39	3%	1.4E-03	12.060
28	0%	6.9E-04	24.119
19	0%	3.5E-04	48.239
10	0%	9.2E-05	180.90
5	0%	2.3E-05	723.58
1	0%	2.0E-06	8163.02

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity. Consequently, NATA accreditation does not apply to clay and silt results

Time for 50% to Settle 100cm	2.81
Time for 90% to Settle 100cm	3.02
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.01

Sample Description: FINES, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 9-Apr-19

Loss on Pretreatment NA

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order : **EP1902982**
Client : **WorleyParsons Services Pty Ltd**
Contact : MR PAUL NICHOLS
Address : LEVEL 4, 600 MURRAY STREET
WEST PERTH WA, AUSTRALIA 6005
Telephone : +61 08 9278 8111
Project : WEL SCABS
Order number : 401012-02698
C-O-C number : ----
Sampler : ASHLEY LEMMON
Site : ----
Quote number : EP/114/19 V3
No. of samples received : 47
No. of samples analysed : 47

Page : 1 of 22
Laboratory : Environmental Division Perth
Contact : Marnie Thomsett
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : 08 9406 1311
Date Samples Received : 01-Apr-2019 12:19
Date Analysis Commenced : 02-Apr-2019
Issue Date : 02-May-2019 13:11

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA
Indra Astuty	Instrument Chemist	Perth Inorganics, Wangara, WA
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Peter Keyte	Newcastle Manager	Newcastle - Inorganics, Mayfield West, NSW
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- TOC and Organotin analysis conducted by ALS Brisbane, NATA Site No. 818.
- PSD analysis conducted by ALS Newcastle, NATA accreditation no. 825, site no 1656.
- EP090S Organotin (soluable): High LCS recovery deemed acceptable as all associated analyte results are less than LOR.
- EA150H: Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for salinity differences. Mass percentages are reported relative to total insoluble solids. Consequently, NATA accreditation does not apply and results should be scrutinised accordingly.
- EP005 (Organic Carbon): Result for sample EP1902982-009 "R5" and 010 "R6" were confirmed by re-analysis.
- EG020T: Positive metals for sample #8, 9 and 10 confirmed by re-preparation and re-analysis.

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**N11B**	**R5T**	**R5B**	**R6T**	**R6B**
			Client sampling date / time	29-Mar-2019 13:20	29-Mar-2019 14:20	29-Mar-2019 14:20	29-Mar-2019 15:00	29-Mar-2019 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-001**	**EP1902982-002**	**EP1902982-003**	**EP1902982-004**	**EP1902982-005**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**35.7**	**32.1**	**31.7**	**32.7**	**31.2**
EA150: Particle Sizing								
+75µm	----	1	%	**76**	**75**	**75**	**55**	**59**
+150µm	----	1	%	**37**	**36**	**41**	**18**	**29**
+300µm	----	1	%	**16**	**15**	**20**	**8**	**15**
+425µm	----	1	%	**10**	**10**	**14**	**5**	**11**
+600µm	----	1	%	**6**	**6**	**10**	**2**	**8**
+1180µm	----	1	%	**3**	**2**	**5**	<1	**4**
+2.36mm	----	1	%	**1**	**1**	**2**	<1	**3**
+4.75mm	----	1	%	<1	<1	<1	<1	**1**
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**15**	**17**	**14**	**30**	**24**
Sand (0.06-2.00 mm)	----	1	%	**83**	**81**	**83**	**70**	**72**
Gravel (>2mm)	----	1	%	**2**	**2**	**3**	<1	**4**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.60**	**2.59**	**2.62**	**2.63**	**2.58**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4170**	**4670**	**4120**	**7260**	**5260**
Iron	7439-89-6	50	mg/kg	**11300**	**12200**	**11300**	**15400**	**12300**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**12.0**	**12.4**	**11.9**	**10.4**	**10.4**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	**0.1**	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**28.5**	**29.9**	**26.9**	**44.1**	**34.3**
Copper	7440-50-8	1.0	mg/kg	**3.2**	**3.6**	**3.0**	**7.0**	**4.2**
Lead	7439-92-1	1.0	mg/kg	**3.1**	**3.5**	**3.2**	**4.2**	**3.2**
Nickel	7440-02-0	1.0	mg/kg	**10.1**	**10.3**	**9.5**	**16.5**	**12.6**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**N11B**	**R5T**	**R5B**	**R6T**	**R6B**
			Client sampling date / time	29-Mar-2019 13:20	29-Mar-2019 14:20	29-Mar-2019 14:20	29-Mar-2019 15:00	29-Mar-2019 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-001**	**EP1902982-002**	**EP1902982-003**	**EP1902982-004**	**EP1902982-005**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.5**	**9.9**	**8.3**	**16.0**	**10.1**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.18**	**0.19**	**0.19**	**0.24**	**0.17**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**96.6**	**98.8**	**112**	**148**	**92.0**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL**)

			Client sample ID	**N12T**	**N12B**	**R1T**	**R1B**	**N20T**
			Client sampling date / time	29-Mar-2019 15:45	29-Mar-2019 15:45	30-Mar-2019 11:35	30-Mar-2019 11:35	30-Mar-2019 13:20
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-006**	**EP1902982-007**	**EP1902982-011**	**EP1902982-012**	**EP1902982-013**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**34.1**	**31.8**	**32.7**	**30.6**	**35.3**
EA150: Particle Sizing								
+75µm	----	1	%	**57**	**61**	**75**	**74**	**67**
+150µm	----	1	%	**22**	**30**	**51**	**50**	**37**
+300µm	----	1	%	**9**	**14**	**19**	**18**	**13**
+425µm	----	1	%	**5**	**9**	**9**	**9**	**6**
+600µm	----	1	%	**3**	**6**	**5**	**6**	**3**
+1180µm	----	1	%	**1**	**2**	**2**	**3**	**1**
+2.36mm	----	1	%	**1**	<1	**2**	**2**	<1
+4.75mm	----	1	%	<1	<1	**1**	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**15**	**20**	**7**	**13**	**23**
Sand (0.06-2.00 mm)	----	1	%	**84**	**79**	**91**	**85**	**76**
Gravel (>2mm)	----	1	%	**1**	**1**	**2**	**2**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.61**	**2.57**	**2.63**	**2.61**	**2.60**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**6660**	**5020**	**4330**	**3730**	**4020**
Iron	7439-89-6	50	mg/kg	**14600**	**11700**	**12100**	**10000**	**9250**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**10.9**	**9.96**	**16.0**	**13.2**	**9.48**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**41.8**	**32.3**	**30.3**	**25.7**	**24.9**
Copper	7440-50-8	1.0	mg/kg	**5.9**	**3.8**	**3.3**	**2.7**	**3.6**
Lead	7439-92-1	1.0	mg/kg	**4.1**	**3.1**	**3.4**	**2.9**	**2.9**
Nickel	7440-02-0	1.0	mg/kg	**15.2**	**11.6**	**9.7**	**8.3**	**9.1**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**N12T**	**N12B**	**R1T**	**R1B**	**N20T**
			Client sampling date / time	29-Mar-2019 15:45	29-Mar-2019 15:45	30-Mar-2019 11:35	30-Mar-2019 11:35	30-Mar-2019 13:20
Compound	CAS Number	LOR	Unit	**EP1902982-006**	**EP1902982-007**	**EP1902982-011**	**EP1902982-012**	**EP1902982-013**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**14.6**	**9.2**	**9.0**	**7.0**	**9.7**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.20**	**0.16**	**0.15**	**0.12**	**0.09**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	μgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	μgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	μgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**107**	**95.4**	**93.2**	**88.8**	**102**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL**)

			Client sample ID	**N22T**	**N8T**	**N8B**	**N9T**	**N9B**
			Client sampling date / time	30-Mar-2019 15:15	29-Mar-2019 10:05	29-Mar-2019 10:05	29-Mar-2019 11:15	29-Mar-2019 11:15
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-014**	**EP1902982-015**	**EP1902982-016**	**EP1902982-017**	**EP1902982-018**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**33.8**	**33.6**	**29.9**	**35.7**	**32.9**
EA150: Particle Sizing								
+75µm	----	1	%	**83**	**59**	**71**	**56**	**75**
+150µm	----	1	%	**66**	**24**	**40**	**22**	**43**
+300µm	----	1	%	**37**	**8**	**20**	**7**	**21**
+425µm	----	1	%	**16**	**5**	**14**	**4**	**15**
+600µm	----	1	%	**6**	**2**	**9**	**2**	**10**
+1180µm	----	1	%	**2**	<1	**4**	<1	**6**
+2.36mm	----	1	%	<1	<1	**2**	<1	**2**
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	**8**	**6**	<1
Silt (2-60 µm)	----	1	%	**10**	**33**	**18**	**10**	**9**
Sand (0.06-2.00 mm)	----	1	%	**89**	**67**	**72**	**84**	**88**
Gravel (>2mm)	----	1	%	**1**	<1	**2**	<1	**3**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.63**	**2.63**	**2.62**	**2.59**	**2.61**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**2000**	**6840**	**4430**	**6370**	**4440**
Iron	7439-89-6	50	mg/kg	**8200**	**15500**	**12400**	**15100**	**12200**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**9.30**	**11.5**	**12.1**	**13.0**	**11.8**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**21.0**	**38.8**	**28.2**	**35.5**	**28.5**
Copper	7440-50-8	1.0	mg/kg	**2.6**	**6.2**	**3.2**	**6.0**	**3.2**
Lead	7439-92-1	1.0	mg/kg	**2.4**	**4.3**	**3.2**	**4.4**	**3.2**
Nickel	7440-02-0	1.0	mg/kg	**6.9**	**14.8**	**10.2**	**13.4**	**10.0**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			*Client sample ID*	**N22T**	**N8T**	**N8B**	**N9T**	**N9B**
			Client sampling date / time	30-Mar-2019 15:15	29-Mar-2019 10:05	29-Mar-2019 10:05	29-Mar-2019 11:15	29-Mar-2019 11:15
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-014**	**EP1902982-015**	**EP1902982-016**	**EP1902982-017**	**EP1902982-018**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.8**	**16.1**	**8.2**	**13.8**	**8.6**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.08**	**0.24**	**0.13**	**0.17**	**0.12**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**97.9**	**85.8**	**91.6**	**90.6**	**68.2**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL**)

			Client sample ID	**N10T**	**N10B**	**N11T**	**N11T DUP**	**N13T**
			Client sampling date / time	29-Mar-2019 11:55	29-Mar-2019 11:55	29-Mar-2019 13:20	29-Mar-2019 13:20	30-Mar-2019 08:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-019**	**EP1902982-020**	**EP1902982-021**	**EP1902982-022**	**EP1902982-023**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**34.3**	**30.5**	**35.9**	**37.7**	**34.1**
EA150: Particle Sizing								
+75µm	----	1	%	**62**	**77**	**63**	**67**	**56**
+150µm	----	1	%	**25**	**44**	**30**	**29**	**24**
+300µm	----	1	%	**9**	**21**	**11**	**11**	**10**
+425µm	----	1	%	**6**	**15**	**8**	**7**	**7**
+600µm	----	1	%	**4**	**11**	**5**	**4**	**5**
+1180µm	----	1	%	**1**	**6**	**2**	**1**	**3**
+2.36mm	----	1	%	<1	**3**	**2**	<1	**2**
+4.75mm	----	1	%	<1	**1**	**1**	<1	**2**
+9.5mm	----	1	%	<1	<1	<1	<1	**2**
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	<1
Silt (2-60 µm)	----	1	%	**8**	**14**	**7**	**27**	**31**
Sand (0.06-2.00 mm)	----	1	%	**91**	**82**	**91**	**72**	**67**
Gravel (>2mm)	----	1	%	**1**	**4**	**2**	**1**	**2**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.61**	**2.62**	**2.60**	**2.61**	**2.62**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**6100**	**4670**	**6210**	**5820**	**7110**
Iron	7439-89-6	50	mg/kg	**14900**	**12500**	**15400**	**14400**	**15100**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**12.5**	**12.1**	**12.9**	**12.4**	**10.1**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**34.7**	**28.8**	**34.9**	**32.5**	**40.4**
Copper	7440-50-8	1.0	mg/kg	**5.1**	**3.4**	**5.2**	**4.8**	**6.2**
Lead	7439-92-1	1.0	mg/kg	**4.2**	**3.3**	**4.3**	**4.2**	**4.1**
Nickel	7440-02-0	1.0	mg/kg	**12.8**	**10.3**	**12.9**	**12.0**	**15.3**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			*Client sample ID*	**N10T**	**N10B**	**N11T**	**N11T DUP**	**N13T**
			Client sampling date / time	29-Mar-2019 11:55	29-Mar-2019 11:55	29-Mar-2019 13:20	29-Mar-2019 13:20	30-Mar-2019 08:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-019**	**EP1902982-020**	**EP1902982-021**	**EP1902982-022**	**EP1902982-023**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**14.0**	**8.6**	**14.1**	**12.7**	**14.8**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.11**	**0.09**	**0.12**	**0.14**	**0.24**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**73.3**	**76.6**	**69.6**	**84.0**	**88.2**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**N13B**	**N14AT**	**N14AB**	**N14BT**	**N14BB**
			Client sampling date / time	30-Mar-2019 08:00	30-Mar-2019 08:35	30-Mar-2019 08:35	30-Mar-2019 09:10	30-Mar-2019 09:10
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-024**	**EP1902982-025**	**EP1902982-026**	**EP1902982-027**	**EP1902982-028**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**33.0**	**36.6**	**30.7**	**34.9**	**32.9**
EA150: Particle Sizing								
+75µm	----	1	%	**68**	**61**	**74**	**62**	**67**
+150µm	----	1	%	**32**	**27**	**37**	**27**	**35**
+300µm	----	1	%	**15**	**10**	**18**	**10**	**17**
+425µm	----	1	%	**9**	**6**	**12**	**6**	**11**
+600µm	----	1	%	**6**	**3**	**9**	**4**	**8**
+1180µm	----	1	%	**2**	<1	**4**	**1**	**3**
+2.36mm	----	1	%	<1	<1	**3**	<1	**2**
+4.75mm	----	1	%	<1	<1	**2**	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	**8**	<1	<1
Silt (2-60 µm)	----	1	%	**19**	**17**	**12**	**20**	**4**
Sand (0.06-2.00 mm)	----	1	%	**80**	**82**	**77**	**79**	**94**
Gravel (>2mm)	----	1	%	**1**	**1**	**3**	**1**	**2**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.62**	**2.59**	**2.60**	**2.60**	**2.56**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**5020**	**6280**	**4700**	**5800**	**4430**
Iron	7439-89-6	50	mg/kg	**11300**	**13700**	**10700**	**12900**	**10500**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**9.38**	**10.2**	**9.88**	**9.82**	**9.62**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	**0.1**	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**30.1**	**36.4**	**28.6**	**34.7**	**28.3**
Copper	7440-50-8	1.0	mg/kg	**3.9**	**5.1**	**3.6**	**5.0**	**3.5**
Lead	7439-92-1	1.0	mg/kg	**3.1**	**3.9**	**3.1**	**3.8**	**2.9**
Nickel	7440-02-0	1.0	mg/kg	**11.0**	**13.5**	**10.4**	**13.1**	**10.2**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			*Client sample ID*	**N13B**	**N14AT**	**N14AB**	**N14BT**	**N14BB**
			Client sampling date / time	30-Mar-2019 08:00	30-Mar-2019 08:35	30-Mar-2019 08:35	30-Mar-2019 09:10	30-Mar-2019 09:10
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-024**	**EP1902982-025**	**EP1902982-026**	**EP1902982-027**	**EP1902982-028**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**9.1**	**12.9**	**8.3**	**12.2**	**8.2**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.12**	**0.16**	**0.16**	**0.17**	**0.15**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**85.7**	**79.2**	**86.4**	**78.4**	**60.1**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**N14CT**	**N14CB**	**N15T**	**N15B**	**R2T**
			Client sampling date / time	30-Mar-2019 09:40	30-Mar-2019 09:40	30-Mar-2019 10:25	30-Mar-2019 10:25	30-Mar-2019 11:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-029**	**EP1902982-030**	**EP1902982-031**	**EP1902982-032**	**EP1902982-033**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**34.5**	**34.2**	**32.3**	**32.1**	**34.1**
EA150: Particle Sizing								
+75µm	----	1	%	**64**	**68**	**74**	**74**	**74**
+150µm	----	1	%	**28**	**34**	**35**	**38**	**40**
+300µm	----	1	%	**12**	**16**	**12**	**16**	**13**
+425µm	----	1	%	**7**	**11**	**7**	**10**	**7**
+600µm	----	1	%	**4**	**8**	**4**	**6**	**4**
+1180µm	----	1	%	**1**	**4**	**2**	**2**	**2**
+2.36mm	----	1	%	<1	**2**	**1**	**1**	**1**
+4.75mm	----	1	%	<1	**1**	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	<1	<1	<1	<1	**6**
Silt (2-60 µm)	----	1	%	**11**	**17**	**12**	**11**	**11**
Sand (0.06-2.00 mm)	----	1	%	**88**	**80**	**87**	**88**	**82**
Gravel (>2mm)	----	1	%	**1**	**3**	**1**	**1**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.61**	**2.60**	**2.64**	**2.59**	**2.56**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**5860**	**4710**	**4530**	**4270**	**4280**
Iron	7439-89-6	50	mg/kg	**13100**	**11000**	**10800**	**10400**	**10900**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**9.56**	**9.30**	**10.1**	**10.1**	**11.6**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**34.6**	**29.4**	**28.1**	**26.8**	**26.7**
Copper	7440-50-8	1.0	mg/kg	**5.0**	**3.7**	**3.7**	**3.2**	**3.2**
Lead	7439-92-1	1.0	mg/kg	**3.6**	**3.1**	**3.4**	**3.0**	**3.4**
Nickel	7440-02-0	1.0	mg/kg	**13.0**	**10.7**	**10.0**	**9.7**	**9.3**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			*Client sample ID*	**N14CT**	**N14CB**	**N15T**	**N15B**	**R2T**
			Client sampling date / time	30-Mar-2019 09:40	30-Mar-2019 09:40	30-Mar-2019 10:25	30-Mar-2019 10:25	30-Mar-2019 11:00
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-029**	**EP1902982-030**	**EP1902982-031**	**EP1902982-032**	**EP1902982-033**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**12.1**	**8.7**	**9.6**	**7.8**	**8.9**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.15**	**0.17**	**0.16**	**0.15**	**0.12**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**77.2**	**115**	**93.4**	**70.1**	**80.0**

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**R2B**	**N22BT**	**N22CT**	**R4T**	**R4B**
			Client sampling date / time	30-Mar-2019 11:00	31-Mar-2019 08:30	31-Mar-2019 09:00	31-Mar-2019 10:55	31-Mar-2019 10:55
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-034**	**EP1902982-035**	**EP1902982-036**	**EP1902982-037**	**EP1902982-038**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**33.8**	**36.0**	**32.5**	**32.6**	**31.7**
EA150: Particle Sizing								
+75µm	----	1	%	**75**	**72**	**85**	**58**	**67**
+150µm	----	1	%	**41**	**55**	**66**	**22**	**30**
+300µm	----	1	%	**17**	**30**	**35**	**10**	**14**
+425µm	----	1	%	**10**	**13**	**15**	**6**	**9**
+600µm	----	1	%	**7**	**5**	**5**	**4**	**6**
+1180µm	----	1	%	**3**	**1**	**1**	**2**	**2**
+2.36mm	----	1	%	**1**	<1	<1	**1**	<1
+4.75mm	----	1	%	<1	<1	<1	**1**	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**13**	**16**	**12**	**8**	**8**
Silt (2-60 µm)	----	1	%	**6**	**7**	**2**	**22**	**15**
Sand (0.06-2.00 mm)	----	1	%	**79**	**77**	**85**	**69**	**76**
Gravel (>2mm)	----	1	%	**2**	<1	**1**	**1**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.63**	**2.64**	**2.60**	**2.57**	**2.58**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**3970**	**4090**	**2810**	**4880**	**4300**
Iron	7439-89-6	50	mg/kg	**9730**	**10200**	**9250**	**12700**	**10400**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**10.1**	**10.5**	**12.0**	**14.0**	**8.99**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**24.9**	**25.5**	**19.9**	**47.8**	**27.3**
Copper	7440-50-8	1.0	mg/kg	**2.9**	**3.4**	**2.2**	**6.7**	**3.3**
Lead	7439-92-1	1.0	mg/kg	**2.9**	**2.7**	**2.5**	**5.7**	**2.9**
Nickel	7440-02-0	1.0	mg/kg	**9.0**	**8.7**	**6.0**	**16.5**	**9.8**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL**)			*Client sample ID*	**R2B**	**N22BT**	**N22CT**	**R4T**	**R4B**
			Client sampling date / time	30-Mar-2019 11:00	31-Mar-2019 08:30	31-Mar-2019 09:00	31-Mar-2019 10:55	31-Mar-2019 10:55
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-034**	**EP1902982-035**	**EP1902982-036**	**EP1902982-037**	**EP1902982-038**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**6.9**	**9.1**	**7.0**	**15.4**	**8.0**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.11**	**0.14**	**0.10**	**0.18**	**0.15**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**90.6**	**97.6**	**87.2**	**78.8**	**77.2**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL)**

			Client sample ID	**R7AT**	**R7AB**	**R7BT**	**R7BB**	**R7CT**
			Client sampling date / time	31-Mar-2019 11:35	31-Mar-2019 11:35	31-Mar-2019 12:05	31-Mar-2019 12:05	31-Mar-2019 12:40
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-039**	**EP1902982-040**	**EP1902982-041**	**EP1902982-042**	**EP1902982-043**
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**35.2**	**30.8**	**34.5**	**32.0**	**34.4**
EA150: Particle Sizing								
+75µm	----	1	%	**48**	**65**	**52**	**65**	**60**
+150µm	----	1	%	**16**	**33**	**20**	**32**	**25**
+300µm	----	1	%	**6**	**17**	**9**	**16**	**12**
+425µm	----	1	%	**4**	**13**	**6**	**11**	**8**
+600µm	----	1	%	**2**	**9**	**3**	**8**	**6**
+1180µm	----	1	%	<1	**4**	<1	**3**	**2**
+2.36mm	----	1	%	<1	**3**	<1	**2**	**1**
+4.75mm	----	1	%	<1	**2**	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**8**	**8**	**8**	**9**	**8**
Silt (2-60 µm)	----	1	%	**25**	**18**	**20**	**13**	**19**
Sand (0.06-2.00 mm)	----	1	%	**67**	**71**	**72**	**76**	**72**
Gravel (>2mm)	----	1	%	<1	**3**	<1	**2**	**1**
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.59**	**2.60**	**2.62**	**2.63**	**2.46**
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**6030**	**4720**	**6890**	**5090**	**6310**
Iron	7439-89-6	50	mg/kg	**13200**	**11100**	**15100**	**11800**	**13900**
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg	**9.00**	**9.15**	**10.2**	**9.36**	**9.67**
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg	**35.1**	**28.6**	**40.3**	**31.4**	**36.0**
Copper	7440-50-8	1.0	mg/kg	**5.4**	**3.5**	**6.0**	**3.8**	**5.0**
Lead	7439-92-1	1.0	mg/kg	**4.0**	**2.9**	**4.2**	**3.1**	**3.6**
Nickel	7440-02-0	1.0	mg/kg	**13.4**	**11.0**	**15.2**	**11.4**	**13.6**
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL)**

			Client sample ID	**R7AT**	**R7AB**	**R7BT**	**R7BB**	**R7CT**
			Client sampling date / time	31-Mar-2019 11:35	31-Mar-2019 11:35	31-Mar-2019 12:05	31-Mar-2019 12:05	31-Mar-2019 12:40
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-039**	**EP1902982-040**	**EP1902982-041**	**EP1902982-042**	**EP1902982-043**
				Result	Result	Result	Result	Result
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**12.6**	**8.6**	**14.1**	**9.0**	**11.9**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.15**	**0.18**	**0.21**	**0.16**	**0.21**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	<1
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	<1
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**64.8**	**80.6**	**76.6**	**73.8**	**83.2**

Analytical Results

Sub-Matrix: **SEDIMENT**
(Matrix: **SOIL)**

			Client sample ID	**R7CB**	**R3T**	**R3B**	**R4T DUP**	**----**
			Client sampling date / time	31-Mar-2019 12:40	31-Mar-2019 13:05	31-Mar-2019 13:05	31-Mar-2019 10:55	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-044**	**EP1902982-045**	**EP1902982-046**	**EP1902982-047**	--------
				Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**31.7**	**35.0**	**31.4**	**32.0**	----
EA150: Particle Sizing								
+75µm	----	1	%	**66**	**74**	**76**	**65**	----
+150µm	----	1	%	**33**	**38**	**44**	**23**	----
+300µm	----	1	%	**18**	**17**	**21**	**9**	----
+425µm	----	1	%	**14**	**12**	**15**	**6**	----
+600µm	----	1	%	**11**	**8**	**11**	**3**	----
+1180µm	----	1	%	**6**	**3**	**5**	<1	----
+2.36mm	----	1	%	**4**	**2**	**2**	<1	----
+4.75mm	----	1	%	**1**	<1	<1	<1	----
+9.5mm	----	1	%	<1	<1	<1	<1	----
+19.0mm	----	1	%	<1	<1	<1	<1	----
+37.5mm	----	1	%	<1	<1	<1	<1	----
+75.0mm	----	1	%	<1	<1	<1	<1	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	**7**	**7**	**12**	**13**	----
Silt (2-60 µm)	----	1	%	**14**	**11**	**7**	**10**	----
Sand (0.06-2.00 mm)	----	1	%	**74**	**80**	**78**	**77**	----
Gravel (>2mm)	----	1	%	**5**	**2**	**3**	<1	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	**2.63**	**2.64**	**2.62**	**2.60**	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**4880**	**4700**	**4060**	**6320**	----
Iron	7439-89-6	50	mg/kg	**11600**	**12400**	**11000**	**16400**	----
EG020-SD: Total Metals in Sediments by ICPMS								
Antimony	7440-36-0	0.50	mg/kg	<0.50	<0.50	<0.50	<0.50	----
Arsenic	7440-38-2	1.00	mg/kg	**9.59**	**11.5**	**10.8**	**14.3**	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	1.0	mg/kg	**29.5**	**27.6**	**24.8**	**60.5**	----
Copper	7440-50-8	1.0	mg/kg	**3.7**	**3.6**	**3.0**	**8.0**	----
Lead	7439-92-1	1.0	mg/kg	**3.2**	**3.5**	**3.0**	**5.9**	----
Nickel	7440-02-0	1.0	mg/kg	**11.1**	**10.0**	**9.0**	**17.5**	----
Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----

Analytical Results

Sub-Matrix: **SEDIMENT** (Matrix: **SOIL)**			Client sample ID	**R7CB**	**R3T**	**R3B**	**R4T DUP**	**----**
			Client sampling date / time	31-Mar-2019 12:40	31-Mar-2019 13:05	31-Mar-2019 13:05	31-Mar-2019 10:55	----
Compound	CAS Number	LOR	Unit	**EP1902982-044**	**EP1902982-045**	**EP1902982-046**	**EP1902982-047**	**--------**
				Result	Result	Result	Result	----
EG020-SD: Total Metals in Sediments by ICPMS - Continued								
Zinc	7440-66-6	1.0	mg/kg	**8.4**	**9.6**	**7.5**	**16.5**	**----**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	<0.01	<0.01	**----**
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.14**	**0.18**	**0.11**	**0.21**	**----**
EP090: Organotin Compounds								
Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	<1	<1	**----**
Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	<1	<1	**----**
Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	<0.5	<0.5	**----**
Supplementary Information								
ø **Supplementary Report**	----	-	-	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**EP1902982_SR**	**----**
EP090S: Organotin Surrogate								
Tripropyltin	----	0.5	%	**79.0**	**79.0**	**92.0**	**69.6**	**----**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**R4**	**R5**	**R6**	**----**	**----**
			Client sampling date / time	29-Mar-2019 16:30	30-Mar-2019 00:00	31-Mar-2019 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EP1902982-008**	**EP1902982-009**	**EP1902982-010**	**--------**	**--------**
				Result	Result	Result	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.19**	**0.02**	**0.02**	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.014**	<0.005	----	----
Iron	7439-89-6	0.05	mg/L	**0.27**	<0.05	<0.05	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	**7**	**13**	----	----
EP090: Organotin Compounds (Soluble)								
Monobutyltin	78763-54-9	5	ngSn/L	<5	<5	<5	----	----
Dibutyltin	1002-53-5	5	ngSn/L	<5	<5	<5	----	----
Tributyltin	56573-85-4	2	ngSn/L	<2	<2	<2	----	----
EP090S: Organotin Surrogate								
Tripropyltin	----	5	%	**98.4**	**96.9**	**73.8**	----	----

Surrogate Control Limits

Sub-Matrix: **SEDIMENT**

Compound	*CAS Number*	***Recovery Limits (%)*** *Low*	***Recovery Limits (%)*** *High*
EP090S: Organotin Surrogate			
Tripropyltin	----	35	130

Sub-Matrix: **WATER**

Compound	*CAS Number*	***Recovery Limits (%)*** *Low*	***Recovery Limits (%)*** *High*
EP090S: Organotin Surrogate			
Tripropyltin	----	24	116

QUALITY CONTROL REPORT

Work Order : **EP1902982**

Client : **WorleyParsons Services Pty Ltd**
Contact : MR PAUL NICHOLS
Address : LEVEL 4, 600 MURRAY STREET
WEST PERTH WA, AUSTRALIA 6005
Telephone : +61 08 9278 8111
Project : WEL SCABS
Order number : 401012-02698
C-O-C number : ----
Sampler : ASHLEY LEMMON
Site : ----
Quote number : EP/114/19 V3
No. of samples received : 47
No. of samples analysed : 47

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Laboratory : Environmental Division Perth
Contact : Marnie Thomsett
Address : 26 Rigali Way Wangara WA Australia 6065
Telephone : 08 9406 1311
Date Samples Received : 01-Apr-2019
Date Analysis Commenced : 02-Apr-2019
Issue Date : 02-May-2019

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

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General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2272997)									
EP1902982-037	R4T	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4880	4420	9.98	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	12700	12400	2.05	0% - 20%
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2274964)									
EP1902982-047	R4T DUP	EG005-SD: Aluminium	7429-90-5	50	mg/kg	6320	6170	2.45	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	16400	16500	0.749	0% - 20%
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2280412)									
EP1902982-001	N11B	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4170	4300	2.93	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	11300	11600	2.46	0% - 20%
EP1902982-014	N22T	EG005-SD: Aluminium	7429-90-5	50	mg/kg	2000	2300	14.1	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	8200	9820	17.9	0% - 20%
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2280415)									
EP1902982-024	N13B	EG005-SD: Aluminium	7429-90-5	50	mg/kg	5020	4890	2.59	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	11300	11200	0.441	0% - 20%
EP1902982-034	R2B	EG005-SD: Aluminium	7429-90-5	50	mg/kg	3970	3720	6.53	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	9730	9110	6.58	0% - 20%
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QC Lot: 2280418)									
EP1902982-045	R3T	EG005-SD: Aluminium	7429-90-5	50	mg/kg	4700	4490	4.67	0% - 20%
		EG005-SD: Iron	7439-89-6	50	mg/kg	12400	11600	6.69	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2272995)									
EP1902982-037	R4T	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2274965)									
EP1902982-047	R4T DUP	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2280411)									

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2280411) - continued									
EP1902982-001	N11B	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EP1902982-014	N22T	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2280416)									
EP1902982-024	N13B	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EP1902982-034	R2B	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QC Lot: 2280419)									
EP1902982-045	R3T	EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	<0.01	0.00	No Limit
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2272998)									
EP1902982-037	R4T	EA055: Moisture Content	----	0.1	%	32.6	31.9	2.23	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2274279)									
EP1902982-001	N11B	EA055: Moisture Content	----	0.1	%	35.7	35.6	0.318	0% - 20%
EP1902982-013	N20T	EA055: Moisture Content	----	0.1	%	35.3	33.1	6.28	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2274280)									
EP1902982-024	N13B	EA055: Moisture Content	----	0.1	%	33.0	33.2	0.628	0% - 20%
EP1902982-033	R2T	EA055: Moisture Content	----	0.1	%	34.1	32.7	4.16	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2274281)									
EP1902982-045	R3T	EA055: Moisture Content	----	0.1	%	35.0	35.0	0.00	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 2274969)									
EM1904779-001	Anonymous	EA055: Moisture Content	----	0.1	%	10.3	10.2	0.00	0% - 20%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2272996)									
EP1902982-037	R4T	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	14.0	13.6	3.12	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	47.8	47.1	1.44	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	6.7	6.4	3.26	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	5.7	5.5	4.01	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	16.5	16.1	2.73	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	15.4	15.2	1.19	0% - 50%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2274963)									
EP1902982-047	R4T DUP	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	14.3	14.3	0.162	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	60.5	60.6	0.00	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	8.0	8.2	1.87	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	5.9	5.9	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	17.5	17.5	0.00	0% - 50%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2274963) - continued									
EP1902982-047	R4T DUP	EG020-SD: Zinc	7440-66-6	1	mg/kg	16.5	16.3	1.50	0% - 50%
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2280413)									
EP1902982-001	N11B	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	12.0	12.2	1.71	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	28.5	29.2	2.46	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	3.2	3.3	0.00	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	3.1	3.2	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	10.1	10.0	0.00	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	8.5	9.0	5.54	No Limit
EP1902982-014	N22T	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	9.30	14.8	45.6	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	21.0	19.0	9.88	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	2.6	1.7	41.4	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	2.4	2.4	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	6.9	5.0	31.8	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	8.8	6.3	33.6	No Limit
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2280414)									
EP1902982-024	N13B	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	9.38	9.26	1.32	No Limit
		EG020-SD: Chromium	7440-47-3	1	mg/kg	30.1	29.4	2.23	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	3.9	3.6	5.96	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	3.1	3.1	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	11.0	10.9	0.00	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	9.1	8.8	2.75	No Limit
EP1902982-034	R2B	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	10.1	9.75	3.24	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	24.9	23.6	5.64	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	2.9	2.7	5.27	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	2.9	2.8	0.00	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	9.0	8.5	4.79	No Limit
		EG020-SD: Zinc	7440-66-6	1	mg/kg	6.9	6.8	1.66	No Limit
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2280417)									

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020-SD: Total Metals in Sediments by ICPMS (QC Lot: 2280417) - continued									
EP1902982-045	R3T	EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	<0.1	0.00	No Limit
		EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	<0.50	0.00	No Limit
		EG020-SD: Arsenic	7440-38-2	1	mg/kg	11.5	11.5	0.00	0% - 50%
		EG020-SD: Chromium	7440-47-3	1	mg/kg	27.6	27.3	1.22	0% - 20%
		EG020-SD: Copper	7440-50-8	1	mg/kg	3.6	3.4	5.60	No Limit
		EG020-SD: Lead	7439-92-1	1	mg/kg	3.5	3.4	3.82	No Limit
		EG020-SD: Nickel	7440-02-0	1	mg/kg	10.0	9.9	1.25	0% - 50%
		EG020-SD: Zinc	7440-66-6	1	mg/kg	9.6	9.4	1.16	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2283199)									
EP1902982-001	N11B	EP003: Total Organic Carbon	----	0.02	%	0.18	0.19	0.00	No Limit
EP1902982-014	N22T	EP003: Total Organic Carbon	----	0.02	%	0.08	0.08	0.00	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2283200)									
EP1902982-024	N13B	EP003: Total Organic Carbon	----	0.02	%	0.12	0.14	14.9	No Limit
EP1902982-034	R2B	EP003: Total Organic Carbon	----	0.02	%	0.11	0.16	35.2	No Limit
EP003: Total Organic Carbon (TOC) in Soil (QC Lot: 2283201)									
EP1902982-044	R7CB	EP003: Total Organic Carbon	----	0.02	%	0.14	0.18	21.9	No Limit
EP090: Organotin Compounds (QC Lot: 2272991)									
EP1902982-001	N11B	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP1902982-013	N20T	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP090: Organotin Compounds (QC Lot: 2272993)									
EP1902982-023	N13T	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP1902982-033	R2T	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP090: Organotin Compounds (QC Lot: 2274960)									
EM1904670-001	Anonymous	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit
EP090: Organotin Compounds (QC Lot: 2287390)									
EP1902982-038	R4B	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EP090: Organotin Compounds (QC Lot: 2287390) - continued									
EP1902982-044	R7CB	EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	<0.5	0.00	No Limit
		EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	<1	0.00	No Limit
		EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	<1	0.00	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020T: Total Metals by ICP-MS (QC Lot: 2281542)									
EP1902982-008	R4	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 2281543)									
EP1902982-008	R4	EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.19	0.19	0.00	0% - 50%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.27	0.30	8.86	No Limit
EP1903155-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0001	<0.0001	0.00	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.012	0.012	0.00	0% - 50%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.015	0.014	0.00	0% - 50%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.016	0.017	6.90	0% - 50%
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.203	0.204	0.495	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	0.34	0.36	3.37	0% - 20%
		EG020A-T: Iron	7439-89-6	0.05	mg/L	5.26	5.47	3.98	0% - 20%
EP1902982-008	R4	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2281549)									
EP1902982-010	R6	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 2272757)									
EP1902982-008	R4	EP005: Total Organic Carbon	----	1	mg/L	<1	<1	0.00	No Limit
EP090: Organotin Compounds (Soluble) (QC Lot: 2279722)									
EP1902982-008	R4	EP090S: Tributyltin	56573-85-4	2	ngSn/L	<2	<2	0.00	No Limit
		EP090S: Monobutyltin	78763-54-9	5	ngSn/L	<5	<5	0.00	No Limit
		EP090S: Dibutyltin	1002-53-5	5	ngSn/L	<5	<5	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2272997)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2274964)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2280412)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2280415)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2280418)								
EG005-SD: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005-SD: Iron	7439-89-6	50	mg/kg	<50	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2272995)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	0.0847 mg/kg	83.2	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2274965)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	0.0847 mg/kg	80.0	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2280411)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	91.9	80	120
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2280416)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	94.0	80	120
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2280419)								
EG035T-LL: Mercury	7439-97-6	0.01	mg/kg	<0.01	2.154 mg/kg	99.4	80	120
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2272996)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	116 mg/kg	105	80	124
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.8 mg/kg	100	87	122
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	20.5 mg/kg	92.3	79	129
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	52.9 mg/kg	90.6	85	118
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	66.3 mg/kg	88.7	86	119
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	14.7 mg/kg	92.2	77	123
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2272996) - continued								
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	112 mg/kg	114	71	127
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2274963)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	116 mg/kg	95.5	80	124
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.8 mg/kg	102	87	122
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	20.5 mg/kg	83.7	79	129
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	52.9 mg/kg	88.9	85	118
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	66.3 mg/kg	89.9	86	119
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	14.7 mg/kg	87.2	77	123
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	112 mg/kg	110	71	127
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280413)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	94.7	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.38 mg/kg	99.3	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	104	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	81.6	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	88.6	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	98.0	81	135
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	101	81	143
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280414)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	83.8	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.38 mg/kg	98.8	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	98.2	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	80.2	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	93.5	74	124
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	95.3	81	135
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	98.2	81	143
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280417)								
EG020-SD: Antimony	7440-36-0	0.5	mg/kg	<0.50	----	----	----	----
EG020-SD: Arsenic	7440-38-2	1	mg/kg	<1.00	21.62091 mg/kg	81.8	74	130
EG020-SD: Cadmium	7440-43-9	0.1	mg/kg	<0.1	4.38 mg/kg	101	97	113
EG020-SD: Chromium	7440-47-3	1	mg/kg	<1.0	33.904 mg/kg	98.4	72	152
EG020-SD: Copper	7440-50-8	1	mg/kg	<1.0	33.782 mg/kg	80.1	76	116
EG020-SD: Lead	7439-92-1	1	mg/kg	<1.0	40.33169 mg/kg	93.0	74	124

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280417) - continued								
EG020-SD: Nickel	7440-02-0	1	mg/kg	<1.0	51.10088 mg/kg	92.7	81	135
EG020-SD: Silver	7440-22-4	0.1	mg/kg	<0.1	----	----	----	----
EG020-SD: Zinc	7440-66-6	1	mg/kg	<1.0	61.70999 mg/kg	97.1	81	143
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2283199)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.11 %	103	70	130
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2283200)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.11 %	104	70	130
EP003: Total Organic Carbon (TOC) in Soil (QCLot: 2283201)								
EP003: Total Organic Carbon	----	0.02	%	<0.02	0.11 %	102	70	130
EP090: Organotin Compounds (QCLot: 2272991)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	78.5	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	90.7	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	93.4	52	139
EP090: Organotin Compounds (QCLot: 2272993)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	62.1	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	77.8	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	72.9	52	139
EP090: Organotin Compounds (QCLot: 2274960)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	86.4	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	88.8	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	83.9	52	139
EP090: Organotin Compounds (QCLot: 2287390)								
EP090: Monobutyltin	78763-54-9	1	µgSn/kg	<1	1.25 µgSn/kg	45.7	36	128
EP090: Dibutyltin	1002-53-5	1	µgSn/kg	<1	1.25 µgSn/kg	62.4	42	132
EP090: Tributyltin	56573-85-4	0.5	µgSn/kg	<0.5	1.25 µgSn/kg	81.5	52	139

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 2281542)								
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.02 mg/L	111	52	120
EG020T: Total Metals by ICP-MS (QCLot: 2281543)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	109	84	120
EG020A-T: Antimony	7440-36-0	0.001	mg/L	<0.001	0.02 mg/L	106	83	120
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	106	85	120
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	106	84	120
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	106	85	120
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	106	83	120

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 2281543) - continued								
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	100	86	120
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	105	83	120
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	116	84	120
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	108	77	120
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2281549)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	103	87	115
EP005: Total Organic Carbon (TOC) (QCLot: 2272757)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	104	79	111
				<1	100 mg/L	101	79	111
EP090: Organotin Compounds (Soluble) (QCLot: 2279722)								
EP090S: Monobutyltin	78763-54-9	5	ngSn/L	<5	147 ngSn/L	# 121	45	116
EP090S: Dibutyltin	1002-53-5	5	ngSn/L	<5	147 ngSn/L	107	69	111
EP090S: Tributyltin	56573-85-4	2	ngSn/L	<2	147 ngSn/L	101	20	125

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2280412)							
EP1902982-002	R5T	EG005-SD: Aluminium	7429-90-5	50 mg/kg	# Not Determined	70	130
		EG005-SD: Iron	7439-89-6	50 mg/kg	# Not Determined	70	130
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2280415)							
EP1902982-025	N14AT	EG005-SD: Aluminium	7429-90-5	50 mg/kg	# Not Determined	70	130
		EG005-SD: Iron	7439-89-6	50 mg/kg	# Not Determined	70	130
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES (QCLot: 2280418)							
EP1902982-046	R3B	EG005-SD: Aluminium	7429-90-5	50 mg/kg	# Not Determined	70	130
		EG005-SD: Iron	7439-89-6	50 mg/kg	# Not Determined	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2280411)							
EP1902982-002	R5T	EG035T-LL: Mercury	7439-97-6	10 mg/kg	103	70	130

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	Concentration	MS	Low	High
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2280416)							
EP1902982-025	N14AT	EG035T-LL: Mercury	7439-97-6	10 mg/kg	100	70	130
EG035T: Total Recoverable Mercury by FIMS (Low Level) (QCLot: 2280419)							
EP1902982-046	R3B	EG035T-LL: Mercury	7439-97-6	10 mg/kg	98.8	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280413)							
EP1902982-002	R5T	EG020-SD: Arsenic	7440-38-2	50 mg/kg	104	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	107	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	105	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	92.4	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	101	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	96.7	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	102	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280414)							
EP1902982-025	N14AT	EG020-SD: Arsenic	7440-38-2	50 mg/kg	97.1	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	106	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	97.6	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	89.6	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	104	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	92.2	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	93.8	70	130
EG020-SD: Total Metals in Sediments by ICPMS (QCLot: 2280417)							
EP1902982-046	R3B	EG020-SD: Arsenic	7440-38-2	50 mg/kg	99.1	70	130
		EG020-SD: Cadmium	7440-43-9	50 mg/kg	108	70	130
		EG020-SD: Chromium	7440-47-3	50 mg/kg	97.7	70	130
		EG020-SD: Copper	7440-50-8	50 mg/kg	89.1	70	130
		EG020-SD: Lead	7439-92-1	50 mg/kg	104	70	130
		EG020-SD: Nickel	7440-02-0	50 mg/kg	93.0	70	130
		EG020-SD: Zinc	7440-66-6	50 mg/kg	94.2	70	130
EP090: Organotin Compounds (QCLot: 2272991)							
EP1902982-002	R5T	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	37.4	20	130
		EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	90.2	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	105	20	130
EP090: Organotin Compounds (QCLot: 2272993)							
EP1902982-024	N13B	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	30.2	20	130
		EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	82.1	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	78.3	20	130
EP090: Organotin Compounds (QCLot: 2274960)							
EM1904670-002	Anonymous	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	70.6	20	130

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP090: Organotin Compounds (QCLot: 2274960) - continued							
EM1904670-002	Anonymous	EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	90.2	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	77.9	20	130
EP090: Organotin Compounds (QCLot: 2287390)							
EP1902982-039	R7AT	EP090: Monobutyltin	78763-54-9	1.25 µgSn/kg	32.2	20	130
		EP090: Dibutyltin	1002-53-5	1.25 µgSn/kg	84.5	20	130
		EP090: Tributyltin	56573-85-4	1.25 µgSn/kg	97.3	20	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 2281543)							
EP1902982-009	R5	EG020A-T: Arsenic	7440-38-2	1 mg/L	121	70	130
		EG020A-T: Cadmium	7440-43-9	0.25 mg/L	124	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	117	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	118	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	126	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	119	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	116	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2281549)							
EP1903173-001	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	89.1	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 2272757)							
EP1902982-009	R5	EP005: Total Organic Carbon	----	100 mg/L	100.0	70	130
EP090: Organotin Compounds (Soluble) (QCLot: 2279722)							
EP1902982-009	R5	EP090S: Monobutyltin	78763-54-9	147 ngSn/L	122	20	130
		EP090S: Dibutyltin	1002-53-5	147 ngSn/L	122	20	130
		EP090S: Tributyltin	56573-85-4	147 ngSn/L	98.8	20	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EP1902982**	Page	: 1 of 16
Client	: **WorleyParsons Services Pty Ltd**	Laboratory	: Environmental Division Perth
Contact	: MR PAUL NICHOLS	Telephone	: 08 9406 1311
Project	: WEL SCABS	Date Samples Received	: 01-Apr-2019
Site	: ----	Issue Date	: 02-May-2019
Sampler	: ASHLEY LEMMON	No. of samples received	: 47
Order number	: 401012-02698	No. of samples analysed	: 47

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **Laboratory Control outliers exist - please see following pages for full details.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **Surrogate recovery outliers exist for all regular sample matrices - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

- **NO Analysis Holding Time Outliers exist.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Matrix Spike (MS) Recoveries							
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902982--002	R5T	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902982--025	N14AT	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902982--046	R3B	**Aluminium**	7429-90-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902982--002	R5T	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902982--025	N14AT	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG005(ED093)-SD: Total Metals in Sediments by ICP-A	EP1902982--046	R3B	**Iron**	7439-89-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Laboratory Control Spike (LCS) Recoveries							
EP090: Organotin Compounds (Soluble)	QC-2279722-002	----	**Monobutyltin**	78763-54-9	121 %	45-116%	**Recovery greater than upper control limit**

Regular Sample Surrogates

Sub-Matrix: **SEDIMENT**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Samples Submitted							
EP090S: Organotin Surrogate	EP1902982-004	R6T	**Tripropyltin**	----	148 %	35-130 %	**Recovery greater than upper data quality objective**

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Matrix Spikes (MS)					
Total Mercury by FIMS (Low Level)	0	2	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	0	2	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA055: Moisture Content (Dried @ 105-110°C)							
Snap Lock Bag (EA055) N13T	**30-Mar-2019**	**----**	----	----	**03-Apr-2019**	13-Apr-2019	✓
Soil Glass Jar - Unpreserved (EA055) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**----**	----	----	**03-Apr-2019**	12-Apr-2019	✓
Soil Glass Jar - Unpreserved (EA055) R1T, R1B, N20T, N22T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**----**	----	----	**03-Apr-2019**	13-Apr-2019	✓
Soil Glass Jar - Unpreserved (EA055) R4T	**31-Mar-2019**	**----**	----	----	**02-Apr-2019**	14-Apr-2019	✓
Soil Glass Jar - Unpreserved (EA055) N22BT, N22CT, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B, R4T DUP	**31-Mar-2019**	**----**	----	----	**03-Apr-2019**	14-Apr-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA150: Particle Sizing							
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**----**	----	----	**01-May-2019**	25-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) R1T, R1B, N20T, N22T, N13T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**----**	----	----	**01-May-2019**	26-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) N22BT, N22CT, R4T, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B, R4T DUP	**31-Mar-2019**	**----**	----	----	**01-May-2019**	27-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA150: Soil Classification based on Particle Size							
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**----**	----	----	**01-May-2019**	25-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) R1T, R1B, N20T, N22T, N13T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**----**	----	----	**01-May-2019**	26-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA150H) N22BT, N22CT, R4T, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B, R4T DUP	**31-Mar-2019**	**----**	----	----	**01-May-2019**	27-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*		***Sample Date***	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA152: Soil Particle Density								
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152)								
N11B, R5B, R6B, N12B, N8B, N9B, N10B, N11T DUP	R5T, R6T, N12T, N8T, N9T, N10T, N11T,	**29-Mar-2019**	**----**	----	----	**02-May-2019**	25-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152)								
R1T, N20T, N13T, N14AT, N14BT, N14CT, N15T, R2T,	R1B, N22T, N13B, N14AB, N14BB, N14CB, N15B, R2B	**30-Mar-2019**	**----**	----	----	**02-May-2019**	26-Sep-2019	✓
Snap Lock Bag - Friable Asbestos/PSD Bag (EA152)								
N22BT, R4T, R7AT, R7BT, R7CT, R3T, R4T DUP	N22CT, R4B, R7AB, R7BB, R7CB, R3B,	**31-Mar-2019**	**----**	----	----	**02-May-2019**	27-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES							
Snap Lock Bag (EG005-SD) N13T	**30-Mar-2019**	**08-Apr-2019**	26-Sep-2019	✓	**08-Apr-2019**	26-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**08-Apr-2019**	25-Sep-2019	✓	**08-Apr-2019**	25-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD) R1T, R1B, N20T, N22T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**08-Apr-2019**	26-Sep-2019	✓	**08-Apr-2019**	26-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD) R4T	**31-Mar-2019**	**03-Apr-2019**	27-Sep-2019	✓	**04-Apr-2019**	27-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD) R4T DUP	**31-Mar-2019**	**04-Apr-2019**	27-Sep-2019	✓	**05-Apr-2019**	27-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG005-SD) N22BT, N22CT, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B	**31-Mar-2019**	**08-Apr-2019**	27-Sep-2019	✓	**08-Apr-2019**	27-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG020-SD: Total Metals in Sediments by ICPMS							
Snap Lock Bag (EG020-SD) N13T	**30-Mar-2019**	**08-Apr-2019**	26-Sep-2019	✓	**08-Apr-2019**	26-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**08-Apr-2019**	25-Sep-2019	✓	**08-Apr-2019**	25-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) R1T, R1B, N20T, N22T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**08-Apr-2019**	26-Sep-2019	✓	**08-Apr-2019**	26-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) R4T	**31-Mar-2019**	**03-Apr-2019**	27-Sep-2019	✓	**04-Apr-2019**	27-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) R4T DUP	**31-Mar-2019**	**04-Apr-2019**	27-Sep-2019	✓	**05-Apr-2019**	27-Sep-2019	✓
Soil Glass Jar - Unpreserved (EG020-SD) N22BT, N22CT, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B	**31-Mar-2019**	**08-Apr-2019**	27-Sep-2019	✓	**08-Apr-2019**	27-Sep-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG035T: Total Recoverable Mercury by FIMS							
Snap Lock Bag (EG035T-LL) N13T	**30-Mar-2019**	**08-Apr-2019**	27-Apr-2019	✓	**09-Apr-2019**	27-Apr-2019	✓
Soil Glass Jar - Unpreserved (EG035T-LL) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**08-Apr-2019**	26-Apr-2019	✓	**09-Apr-2019**	26-Apr-2019	✓
Soil Glass Jar - Unpreserved (EG035T-LL) R1T, R1B, N20T, N22T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**08-Apr-2019**	27-Apr-2019	✓	**09-Apr-2019**	27-Apr-2019	✓
Soil Glass Jar - Unpreserved (EG035T-LL) R4T	**31-Mar-2019**	**03-Apr-2019**	28-Apr-2019	✓	**04-Apr-2019**	28-Apr-2019	✓
Soil Glass Jar - Unpreserved (EG035T-LL) R4T DUP	**31-Mar-2019**	**04-Apr-2019**	28-Apr-2019	✓	**05-Apr-2019**	28-Apr-2019	✓
Soil Glass Jar - Unpreserved (EG035T-LL) N22BT, N22CT, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B	**31-Mar-2019**	**08-Apr-2019**	28-Apr-2019	✓	**09-Apr-2019**	28-Apr-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EP003: Total Organic Carbon (TOC) in Soil							
Soil Glass Jar - Unpreserved (EP003) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**08-Apr-2019**	26-Apr-2019	✓	**08-Apr-2019**	26-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP003) R1T, R1B, N20T, N22T, N13T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**08-Apr-2019**	27-Apr-2019	✓	**08-Apr-2019**	27-Apr-2019	✓
Soil Glass Jar - Unpreserved (EP003) N22BT, N22CT, R4T, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B, R4T DUP	**31-Mar-2019**	**08-Apr-2019**	28-Apr-2019	✓	**08-Apr-2019**	28-Apr-2019	✓

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP090: Organotin Compounds							
Soil Glass Jar - Unpreserved (EP090) N11B, R5T, R5B, R6T, R6B, N12T, N12B, N8T, N8B, N9T, N9B, N10T, N10B, N11T, N11T DUP	**29-Mar-2019**	**08-Apr-2019**	12-Apr-2019	✓	**09-Apr-2019**	18-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) N13T, N13B, N14AT, N14AB, N14BT, N14BB, N14CT, N14CB, N15T, N15B, R2T, R2B	**30-Mar-2019**	**05-Apr-2019**	13-Apr-2019	✓	**10-Apr-2019**	15-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) R1T, R1B, N20T, N22T	**30-Mar-2019**	**08-Apr-2019**	13-Apr-2019	✓	**09-Apr-2019**	18-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) R4T DUP	**31-Mar-2019**	**05-Apr-2019**	14-Apr-2019	✓	**10-Apr-2019**	15-May-2019	✓
Soil Glass Jar - Unpreserved (EP090) N22BT, N22CT, R4T, R4B, R7AT, R7AB, R7BT, R7BB, R7CT, R7CB, R3T, R3B	**31-Mar-2019**	**10-Apr-2019**	14-Apr-2019	✓	**11-Apr-2019**	20-May-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) R4	**29-Mar-2019**	**08-Apr-2019**	25-Sep-2019	✓	**08-Apr-2019**	25-Sep-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) R5	**30-Mar-2019**	**08-Apr-2019**	26-Sep-2019	✓	**08-Apr-2019**	26-Sep-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) R6	**31-Mar-2019**	**08-Apr-2019**	27-Sep-2019	✓	**08-Apr-2019**	27-Sep-2019	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) R4	**29-Mar-2019**	**----**	----	----	**08-Apr-2019**	26-Apr-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) R5	**30-Mar-2019**	**----**	----	----	**08-Apr-2019**	27-Apr-2019	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) R6	**31-Mar-2019**	**----**	----	----	**08-Apr-2019**	28-Apr-2019	✓
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid (EP005) R4	**29-Mar-2019**	**----**	----	----	**02-Apr-2019**	26-Apr-2019	✓
Amber TOC Vial - Sulfuric Acid (EP005) R5	**30-Mar-2019**	**----**	----	----	**02-Apr-2019**	27-Apr-2019	✓
Amber TOC Vial - Sulfuric Acid (EP005) R6	**31-Mar-2019**	**----**	----	----	**02-Apr-2019**	28-Apr-2019	✓
EP090: Organotin Compounds (Soluble)							
Amber Glass Bottle - Unpreserved (EP090S) R4	**29-Mar-2019**	**05-Apr-2019**	05-Apr-2019	✓	**08-Apr-2019**	15-May-2019	✓
Amber Glass Bottle - Unpreserved (EP090S) R5	**30-Mar-2019**	**05-Apr-2019**	06-Apr-2019	✓	**08-Apr-2019**	15-May-2019	✓
Amber Glass Bottle - Unpreserved (EP090S) R6	**31-Mar-2019**	**05-Apr-2019**	07-Apr-2019	✓	**08-Apr-2019**	15-May-2019	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Moisture Content	EA055	2	9	**22.22**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Organotin Analysis	EP090	7	55	**12.73**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Fe and Al in Sediments by ICPAES	EG005-SD	2	2	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	2	2	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	2	2	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	5	44	**11.36**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Organotin Analysis	EP090	4	55	**7.27**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	2	2	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	2	2	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	3	44	**6.82**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Organotin Analysis	EP090	4	55	**7.27**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Fe and Al in Sediments by ICPAES	EG005-SD	2	2	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	2	2	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	2	2	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP003	3	44	**6.82**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Organotin Analysis	EP090	4	55	**7.27**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Fe and Al in Sediments by ICPAES	EG005-SD	3	42	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS (Low Level)	EG035T-LL	0	2	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Total Metals in Sediments by ICPMS	EG020-SD	0	2	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	9	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	3	20	**15.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	8	**12.50**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Reqular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Total Metals by ICP-MS - Suite B	EG020B-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	8	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Organotin Compounds (Soluble)	EP090S	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	8	**12.50**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM (2013) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Particle Size Analysis by Hydrometer	EA150H	SOIL	Particle Size Analysis by Hydrometer according to AS1289.3.6.3 - 2003
Soil Particle Density	EA152	SOIL	Soil Particle Density by AS 1289.3.5.1-2006 : Methods of testing soils for engineering purposes - Soil classification tests - Determination of the soil particle density of a soil - Standard method
Settling Rate by Hydrometer	* EA157H	SOIL	Settling Rate calculation from Hydrometer analysis according to AS1289.3.6.3 - 2003
Total Fe and Al in Sediments by ICPAES	EG005-SD	SOIL	In house: Referenced to APHA 3120; USEPA SW 846 - 6010. Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (2013) Schedule B(3). LORs per NODG
Total Metals in Sediments by ICPMS	EG020-SD	SOIL	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector. Analyte list and LORs per NODG.
Total Mercury by FIMS (Low Level)	EG035T-LL	SOIL	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Organic Carbon	EP003	SOIL	In house C-IR17. Dried and pulverised sample is reacted with acid to remove inorganic Carbonates, then combusted in a LECO furnace in the presence of strong oxidants / catalysts. The evolved (Organic) Carbon (as CO2) is automaticaly measured by infra-red detector.
Organotin Analysis	EP090	SOIL	In house: Referenced to USEPA SW 846 - 8270D Prepared sample extracts are analysed by GC/MS coupled with high volume injection, and quanitified against an established calibration curve.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
Organotin Compounds (Soluble)	EP090S	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by GC/MS coupled with high volume injection and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	In house: Referenced to USEPA 200.2. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (2013) Schedule B(3) (Method 202)
Dry and Pulverise (up to 100g)	GEO30	SOIL	#
Organotin Sample Preparation	ORG35	SOIL	In house: 20g sample is spiked with surrogate and leached in a methanol:acetic acid:UHP water mix and vacuum filtered. Reagents and solvents are added to the sample and the mixture tumbled. The butyltin compounds are simultaneously derivatised and extracted. The extract is further extracted with petroleum ether. The resultant extracts are combined and concentrated for analysis.
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Organotin Sample Preparation	ORG34	WATER	In house. A specified volume of sample is spiked with surrogate, acidified and vacuum filtered. Reagents and solvent are added and the mixture tumbled. The butyltin compounds is derivitisated, extracted and the subtitution reaction completed. The extract is transferred to a separatory funnel and further extracted two times with petroleum ether. The resultant extracts are combined and concentrated for analysis.

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☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
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CLIENT: ADVISIAN (WORPAR)

OFFICE: PERTH

PROJECT: WEL SCABS

PURCHASE ORDER NUMBER:

PROJECT MANAGER: P Nichols

CONTACT PH: +618 63116577

SAMPLER: A Lemmon

SAMPLER MOBILE: 041756144

COC Emailed to ALS? (YES / [✓ NO] **)**

EDD FORMAT (or default):

Email Reports to: ashley.lemmon@advisian.com

Email Invoice to:

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☑ Standard TAT **(List due date):**

☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EP/114/19 V3

COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)

COC: [✓ 1] 2 3 4 5 6 7

OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact? [✓ Yes] No N/A

Free ice / frozen ice bricks present upon receipt? [✓ Yes] No N/A

Random Sample Temperature on Receipt: 5.1 °C

Other comment:

RELINQUISHED BY: A. Lemmon
DATE/TIME: 1/4/19 1145

RECEIVED BY: RMeere.
DATE/TIME: 01/04/19 12.19

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price)
Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).

Additional Information
Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		SEDIMENT				RINSATE				Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		
1	N11B	29/3/19 1320	S		3	✓	✓	✓	✓					
2	R5T	1420	S		4	✓	✓	✓	✓					
3	R5B	1420	S		4	✓	✓	✓	✓					
4	R6T	1500	S		4	✓	✓	✓	✓					
5	R6B	1500	S		4	✓	✓	✓	✓					
6	N12T	1545	S		4	✓	✓	✓	✓					
7	N12B	1545	S		4	✓	✓	✓	✓					
8	R4	29/3/19 1630	W	AG, P, VS	4					✓	✓	✓		
9	R5	30/3/19	W	AG, P, VS	4					✓	✓	✓		
10	R6	31/3/19	W	AG, P, VS	4					✓	✓	✓		
				TOTAL	39									

Environmental Division
Perth
Work Order Reference
EP1902982

Telephone : + 61-8-9406 1301

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = F
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

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Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: ADVISIAN (WORPAR)
OFFICE: PERTH
PROJECT:
PURCHASE ORDER NUMBER:
PROJECT MANAGER:
CONTACT PH:
SAMPLER:
SAMPLER MOBILE:
COC Emailed to ALS? (YES / NO)
EDD FORMAT (or default):
Email Reports to:
Email Invoice to:

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.: EP/114/19 V3
COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)
COC: 1 [✓ 2] 3 4 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? [✓ Yes] No N/A
Free ice / frozen ice bricks present upon receipt? [✓ Yes] No N/A
Random Sample Temperature on Receipt: 5.1 °C
Other comment:

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY: RHeere
DATE/TIME: 1/4/19 12-19

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).							Additional Information
						SEDIMENT				RINSATE			Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins	
11	R1T	30/3/19 1135	S		4	✓	✓	✓	✓				
12	R1B	30/3/19 1135	S		3	✓	✓	✓	✓				
13	N20T	30/3/19 1320	S		3	✓	✓	✓	✓				
14	N22T	30/3/19 1515	S	B	3	✓	✓	✓	✓				
15	N8T	29/3/19 1005	S		4	✓	✓	✓	✓				
16	N8B	1005	S	S	4	✓	✓	✓	✓				
17	N9T	1115	S		4	✓	✓	✓	✓				
18	N9B	1115	S		4	✓	✓	✓	✓				
19	N10T	1155	S		4	✓	✓	✓	✓				
20	N10B	1155	S		4	✓	✓	✓	✓				
21	N11T	1320	S		3	✓	✓	✓	✓				
22	N11T DUP	1320	S		3	✓	✓	✓	✓				
				TOTAL	43								

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V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

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FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	[✓ Yes]	No	N/A
Free ice / [✓ frozen ice bricks] present upon receipt?	[✓ Yes]	No	N/A
Random Sample Temperature on Receipt:	5.1	°C	

Other comment:

TURNAROUND REQUIREMENTS :
(~~Standard TAT may be longer for some tests~~
e.g.. Ultra Trace Organics)

☐ Standard TAT (List due date):

☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: EP/114/19 V3

COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)

COC: 1 2 [✓ 3] 4 5 6 7

OF: 1 2 3 [✓ 4] 5 6 7

ENT: ADVISIAN (WORPAR)

FICE: PERTH

OJECT:

RCHASE ORDER NUMBER:

CONTACT PH:

ROJECT MANAGER:

SAMPLER MOBILE:

AMPLER:

EDD FORMAT (or default):

COC Emailed to ALS? (YES / NO)

Email Reports to:

Email Invoice to:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

RELINQUISHED BY:

DATE/TIME:

RECEIVED BY: Rkeene.

DATE/TIME: 1/4/19 12.19

RELINQUISHED BY:

DATE/TIME:

RECEIVED BY:

DATE/TIME:

ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price)
Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required)

Additional Information
Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		SEDIMENT				RINSATE				Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		
23	N13T	30/3/19 0800		S, B	4	✓	✓	✓	✓					
24	N13B	0800			4	✓	✓	✓	✓					
25	N14AT	0835			4	✓	✓	✓	✓					
26	N14AB	0835			4	✓	✓	✓	✓					
27	N14BT	0910			4	✓	✓	✓	✓					
28	N14BB	0910			4	✓	✓	✓	✓					
29	N14CT	0940			4	✓	✓	✓	✓					
30	N14CB	0940			4	✓	✓	✓	✓					
31	N15T	1025			4	✓	✓	✓	✓					
32	N15B	1025			4	✓	✓	✓	✓					
33	R2T	1100			4	✓	✓	✓	✓					
34	R2B	1100			4	✓	✓	✓	✓					
				TOTAL	48									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Approved Date: 27/03/2012

Form Page 1 of 1

ENFM (204/10)

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Ph: 08 9406 1301 E: samples.perth@alsglobal.com

☐ SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐ TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

☐ WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g., Ultra Trace Organics)
☐ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EP/114/19 V3

COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 [✓ 4] 5 6 7
OF: 1 2 3 [✓ 4] 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? [✓ Yes] No N/A
Free ice / frozen ice bricks present upon receipt? [✓ Yes] No N/A
Random Sample Temperature on Receipt: 5·1 °C
Other comment:

CLIENT: ADVISIAN (WORPAR)
OFFICE: PERTH
PROJECT:
PURCHASE ORDER NUMBER:
PROJECT MANAGER:
SAMPLER:
COC Emailed to ALS? (YES / NO)
Email Reports to:
Email Invoice to:
COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

CONTACT PH:
SAMPLER MOBILE:
EDD FORMAT (or default):

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY: RReeve.
DATE/TIME: 01/04/19 12.19

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY:
DATE/TIME:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
						SEDIMENT				RINSATE				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES 3 bags	(EP090) Organotins	(EG020-SD, EG005-SD, EG035-SD) Total Metals	(EP003) TOC	(EA152 & EA157H) PSD & Settling Rate by Hydrometer	(EG035T & EG020T) Total Metals	(EP005) TOC	(EP090S-EP) Organotins		
35	N22BT	31/3/19 0830	S		3	✓	✓	✓	✓					Duplicate required
36	N22BCT	31/3/19 0900	S		3	✓	✓	✓	✓					
37	R4T	31/3/19 1055	S		4	✓	✓	✓	✓					
38	R4B	31/3/19 1055	S	ST, B	4	✓	✓	✓	✓					
39	R7AT	31/3/19 1135	S		4	✓	✓	✓	✓					
40	R7AB	31/3/19 1135	S		4	✓	✓	✓	✓					
41	R7BT	31/3/19 1205	S		4	✓	✓	✓	✓					
42	R7BB	31/3/19 1205	S		4	✓	✓	✓	✓					
43	R7CT	31/3/19 1240	S		4	✓	✓	✓	✓					
44	R7CB	31/3/19 1240	S		4	✓	✓	✓	✓					
45	R3T	31/3/19 1305	S		4	✓	✓	✓	✓					
46	R3B	31/3/19 1305	S											
				TOTAL	46									
47	R4T Dup													

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Form Page 1 of 1

Approved Date 27/03/2012

ENFM (204/10)

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

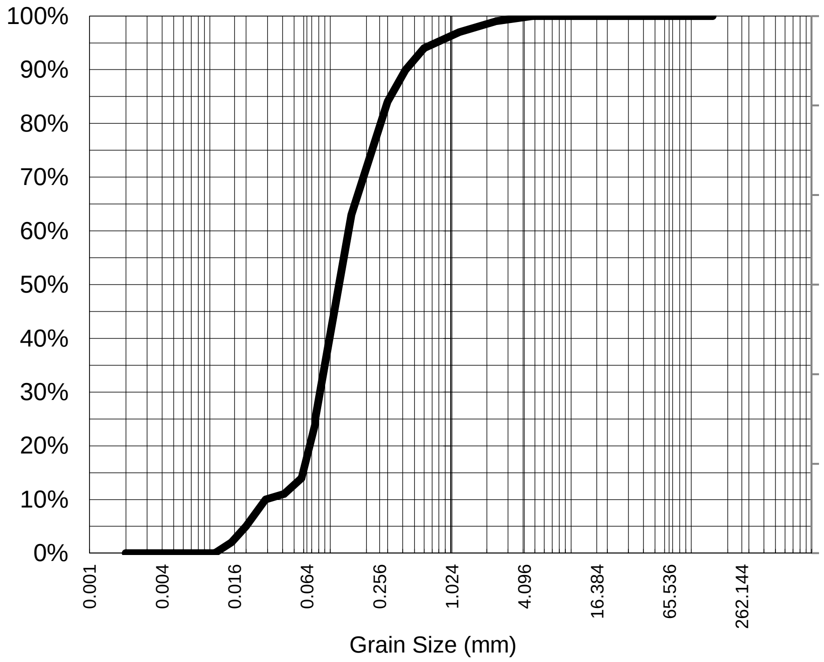
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-001 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N11B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	97%
0.600	94%
0.425	90%
0.300	84%
0.150	63%
0.075	25%
Particle Size (microns)	
58	14%
41	11%
29	10%
20	5%
15	2%
11	0%

Median Particle Size (mm)*	0.124

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

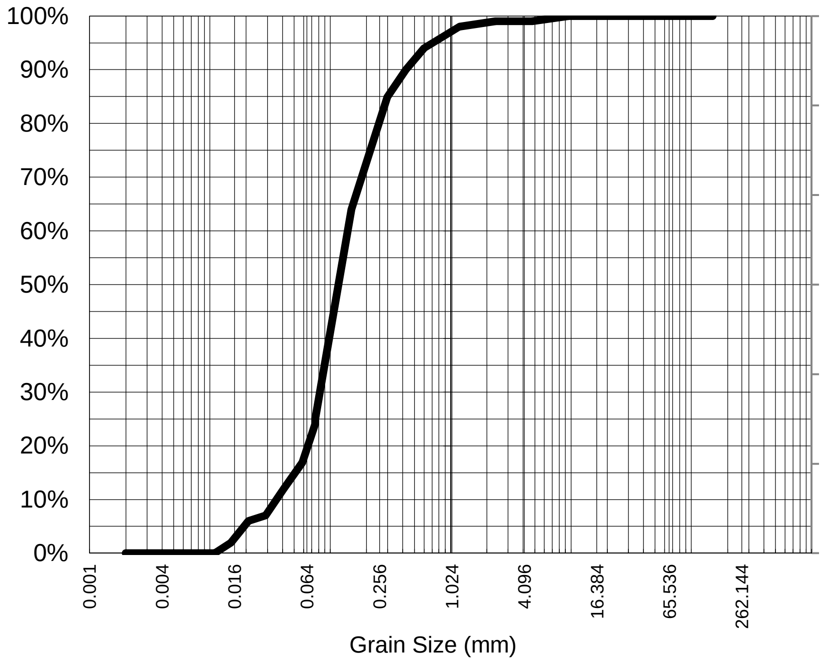
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-002 / PSD

PROJECT: WEL SCABS

SAMPLE ID: R5T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	99%
1.18	98%
0.600	94%
0.425	90%
0.300	85%
0.150	64%
0.075	25%
Particle Size (microns)	
59	17%
41	12%
29	7%
21	6%
15	2%
11	0%

Median Particle Size (mm)*	0.123

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.59

NATA Accreditation: 825 Site: Newcastle
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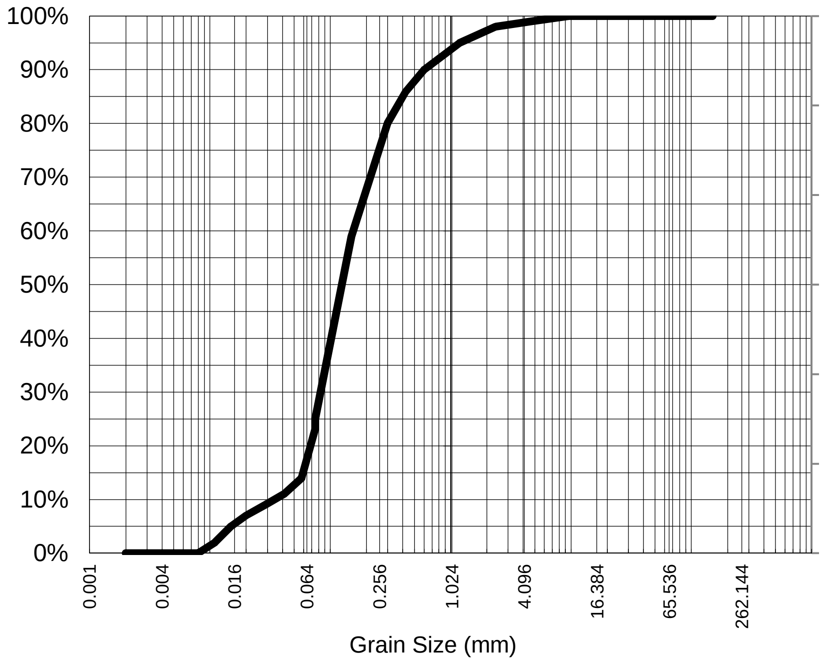
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-003 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R5B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	95%
0.600	90%
0.425	86%
0.300	80%
0.150	59%
0.075	25%
Particle Size (microns)	
58	14%
41	11%
29	9%
20	7%
15	5%
11	2%
8	0%

Median Particle Size (mm)*	0.130

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825   Site: Newcastle
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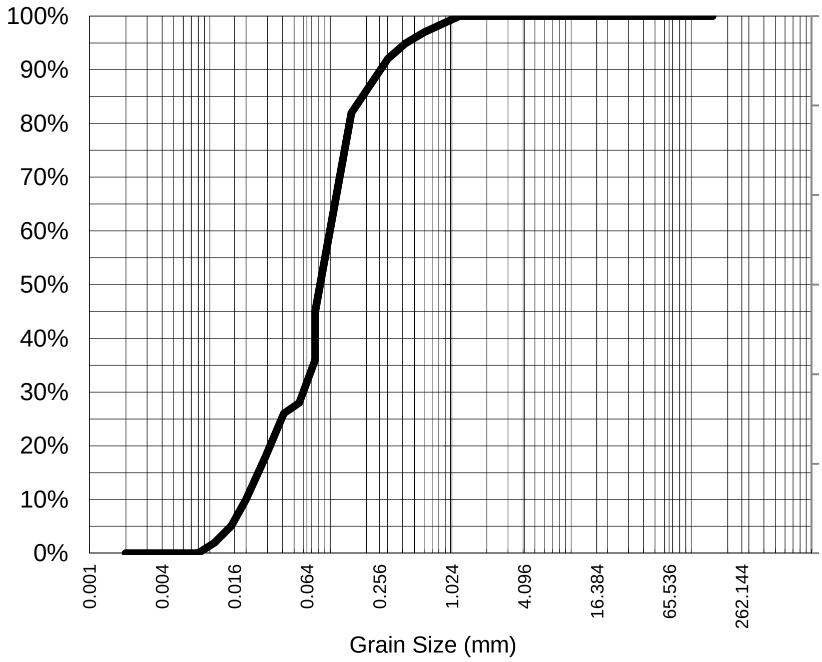
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-004 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R6T

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	97%
0.425	95%
0.300	92%
0.150	82%
0.075	45%
Particle Size (microns)	
55	28%
41	26%
29	18%
20	10%
15	5%
11	2%
8	0%

Median Particle Size (mm)*	0.085

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

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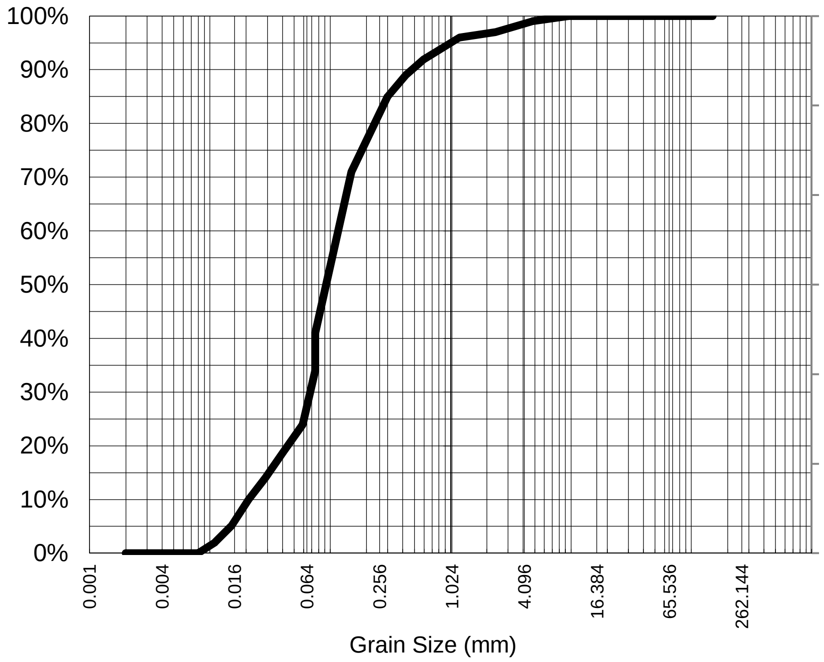
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-005 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R6B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	97%
1.18	96%
0.600	92%
0.425	89%
0.300	85%
0.150	71%
0.075	41%
Particle Size (microns)	
59	24%
41	19%
29	14%
21	10%
15	5%
11	2%
8	0%

Median Particle Size (mm)*	0.098

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.58

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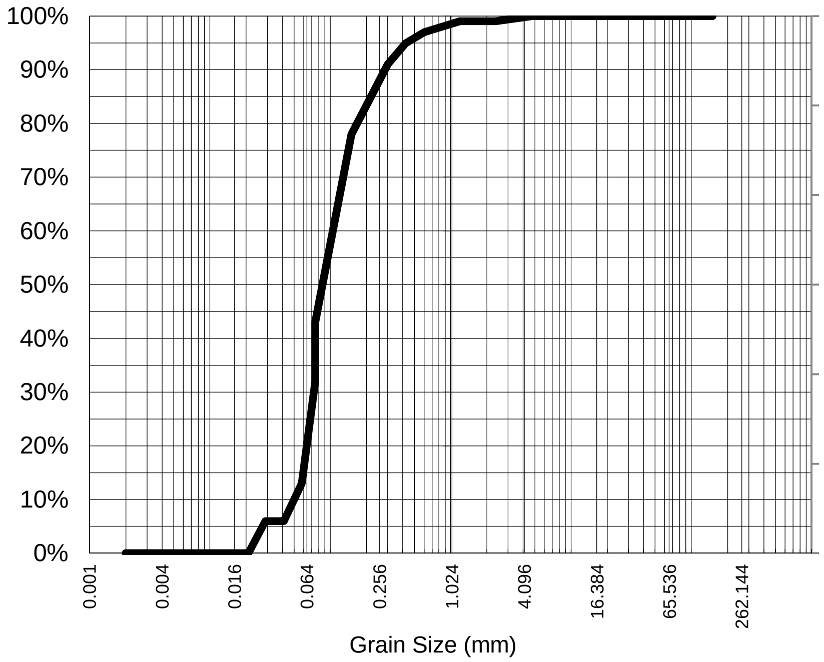
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-006 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N12T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	97%
0.425	95%
0.300	91%
0.150	78%
0.075	43%
Particle Size (microns)	
58	13%
41	6%
29	6%
21	0%

Median Particle Size (mm)*	0.090

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

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samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

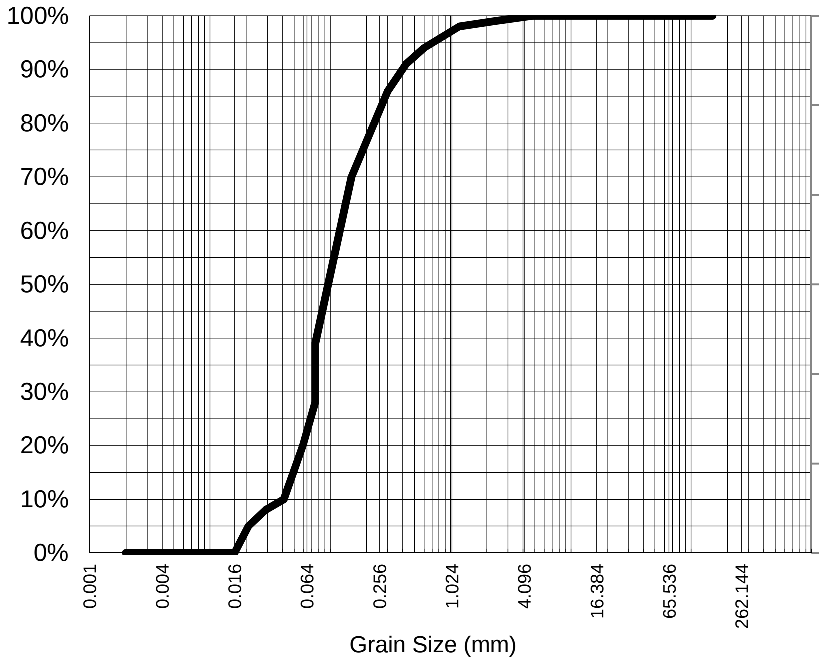
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-007 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N12B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	94%
0.425	91%
0.300	86%
0.150	70%
0.075	39%
Particle Size (microns)	
59	20%
41	10%
29	8%
21	5%
16	0%

Median Particle Size (mm)*	0.102

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.57

NATA Accreditation: 825 Site: Newcastle
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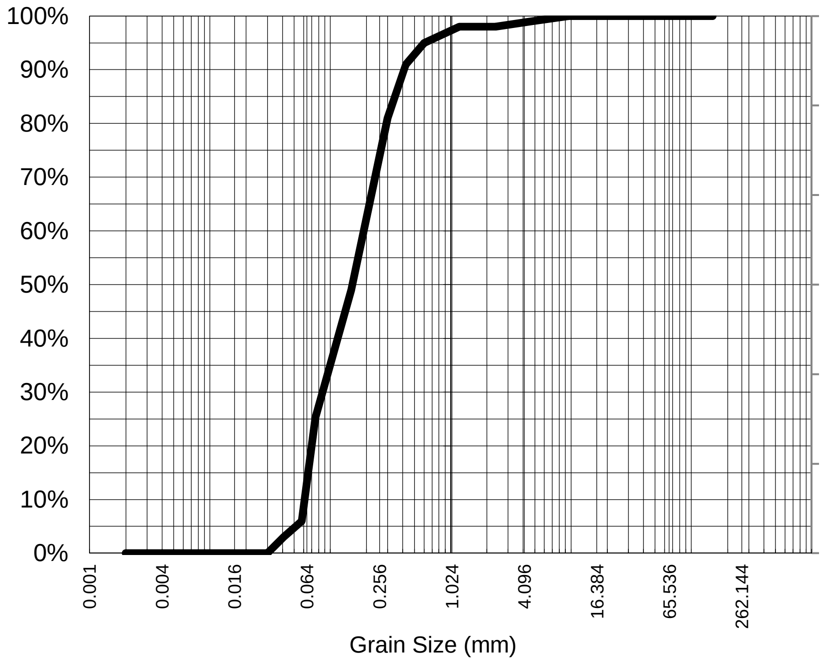
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-011 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R1T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	98%
0.600	95%
0.425	91%
0.300	81%
0.150	49%
0.075	25%
Particle Size (microns)	
58	6%
41	3%
30	0%

Median Particle Size (mm)*	0.155

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

NATA Accreditation: 825 Site: Newcastle
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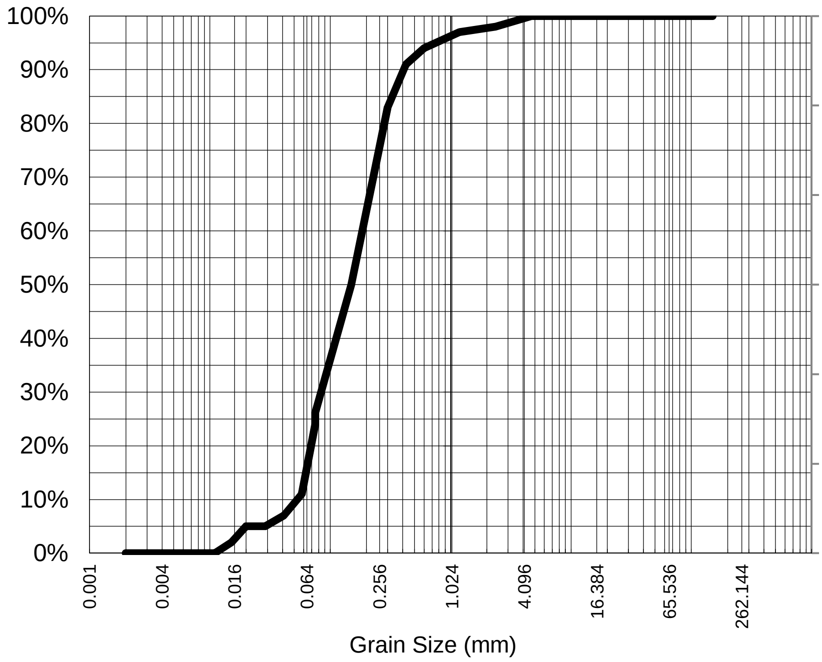
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-012 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R1B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	98%
1.18	97%
0.600	94%
0.425	91%
0.300	83%
0.150	50%
0.075	26%
Particle Size (microns)	
58	11%
41	7%
29	5%
20	5%
15	2%
11	0%

Median Particle Size (mm)*	0.150

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

NATA Accreditation: 825 Site: Newcastle
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Mayfield West, NSW 2304
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fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

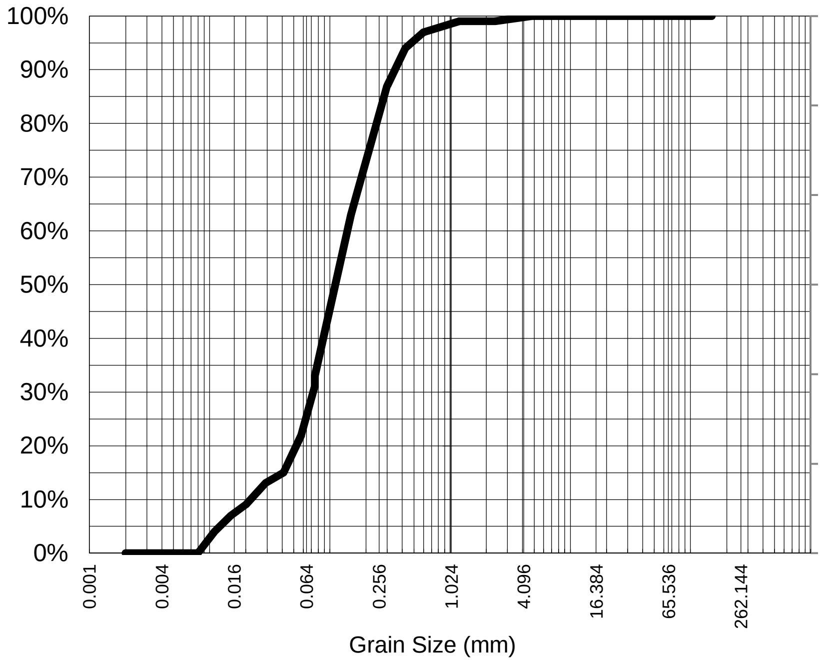
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-013 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N20T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	97%
0.425	94%
0.300	87%
0.150	63%
0.075	33%
Particle Size (microns)	
58	22%
41	15%
29	13%
20	9%
15	7%
11	4%
8	0%

Median Particle Size (mm)*	0.118

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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Authorised Signatory

Certificate of Analysis

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

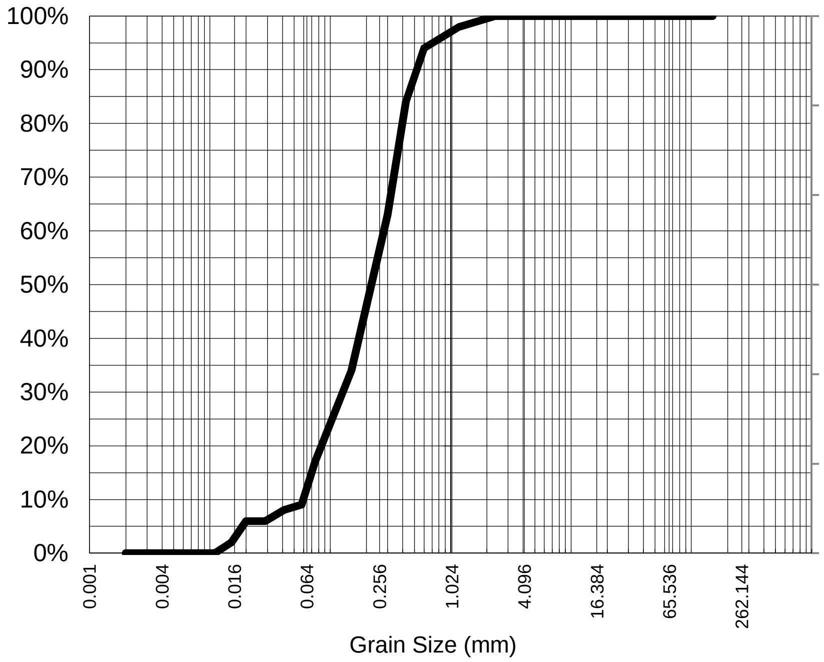
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-014 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N22T

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	98%
0.600	94%
0.425	84%
0.300	63%
0.150	34%
0.075	17%
Particle Size (microns)	
58	9%
41	8%
29	6%
20	6%
15	2%
11	0%

Median Particle Size (mm)*	0.233

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

NATA Accreditation: 825 Site: Newcastle
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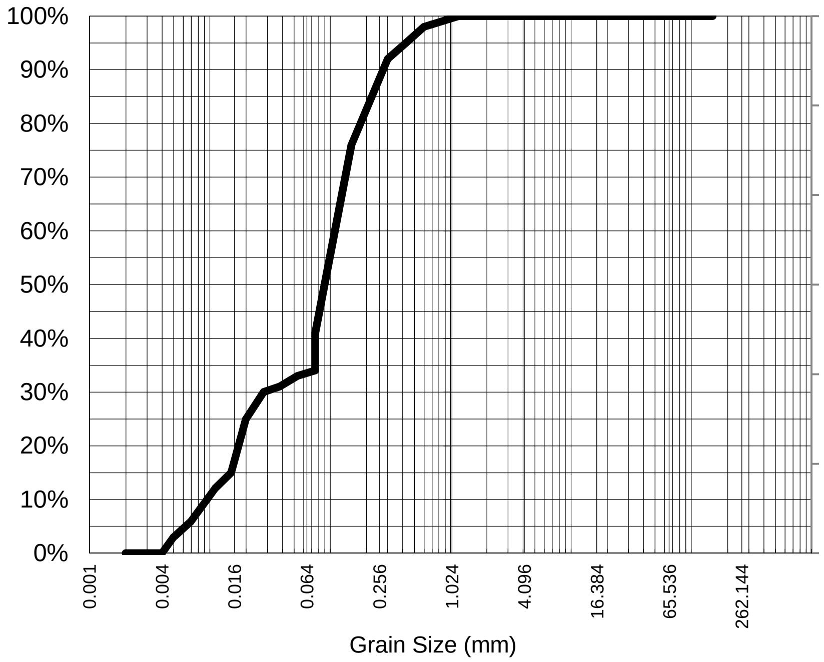
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-015 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N8T

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	98%
0.425	95%
0.300	92%
0.150	76%
0.075	41%
Particle Size (microns)	
53	33%
38	31%
28	30%
20	25%
15	15%
11	12%
7	6%
5	3%
2	0%

Median Particle Size (mm)*	0.094

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

NATA Accreditation: 825 Site: Newcastle
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ALS Environmental
Newcastle, NSW

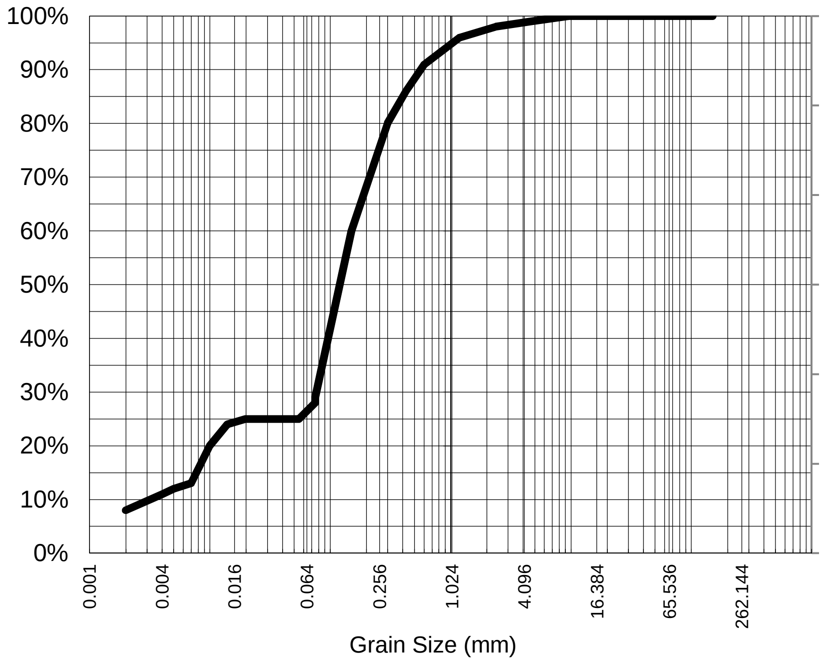
CLIENT: PAUL NICHOLS
DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd
DATE RECEIVED: 1-Apr-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA
REPORT NO: EP1902982-016 / PSD

PROJECT: WEL SCABS
SAMPLE ID: N8B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	96%
0.600	91%
0.425	86%
0.300	80%
0.150	60%
0.075	29%
Particle Size (microns)	
55	25%
39	25%
28	25%
20	25%
14	24%
10	20%
7	13%
5	12%
2	8%

Median Particle Size (mm)*	0.126

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

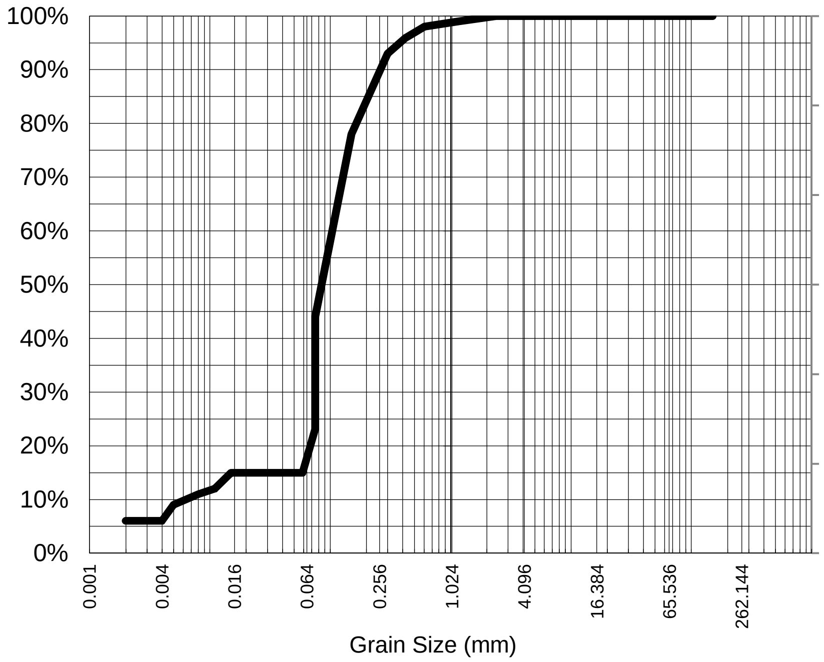
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-017 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N9T

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	98%
0.425	96%
0.300	93%
0.150	78%
0.075	44%
Particle Size (microns)	
59	15%
41	15%
29	15%
21	15%
15	15%
11	12%
8	11%
5	9%
2	6%

Median Particle Size (mm)*	0.088

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.59

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

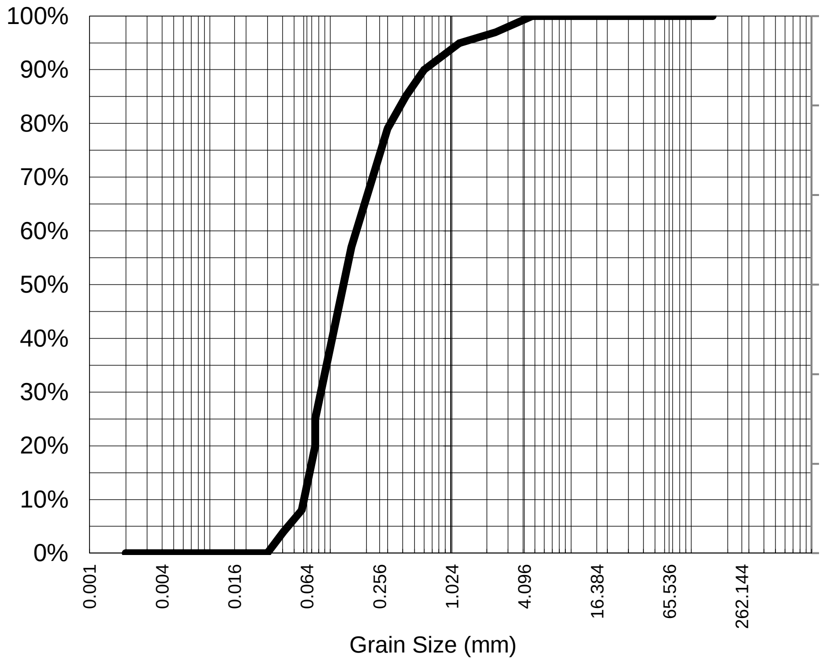
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-018 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N9B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	97%
1.18	95%
0.600	90%
0.425	85%
0.300	79%
0.150	57%
0.075	25%
Particle Size (microns)	
58	8%
41	4%
30	0%

Median Particle Size (mm)*	0.134

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

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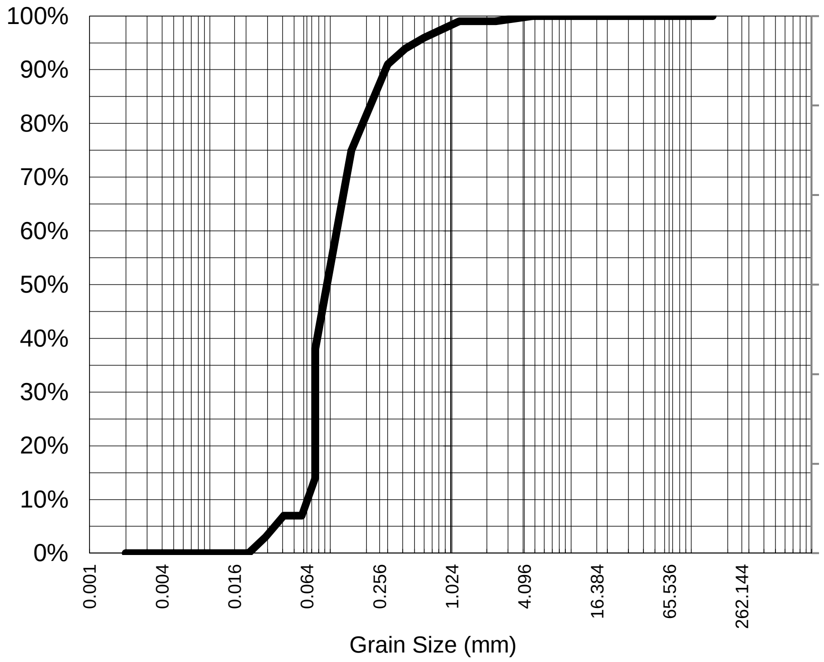
CLIENT: PAUL NICHOLS
DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd
DATE RECEIVED: 1-Apr-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA
REPORT NO: EP1902982-019 / PSD

PROJECT: WEL SCABS
SAMPLE ID: N10T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	96%
0.425	94%
0.300	91%
0.150	75%
0.075	38%
Particle Size (microns)	
58	7%
41	7%
29	3%
21	0%

Median Particle Size (mm)*	0.099

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

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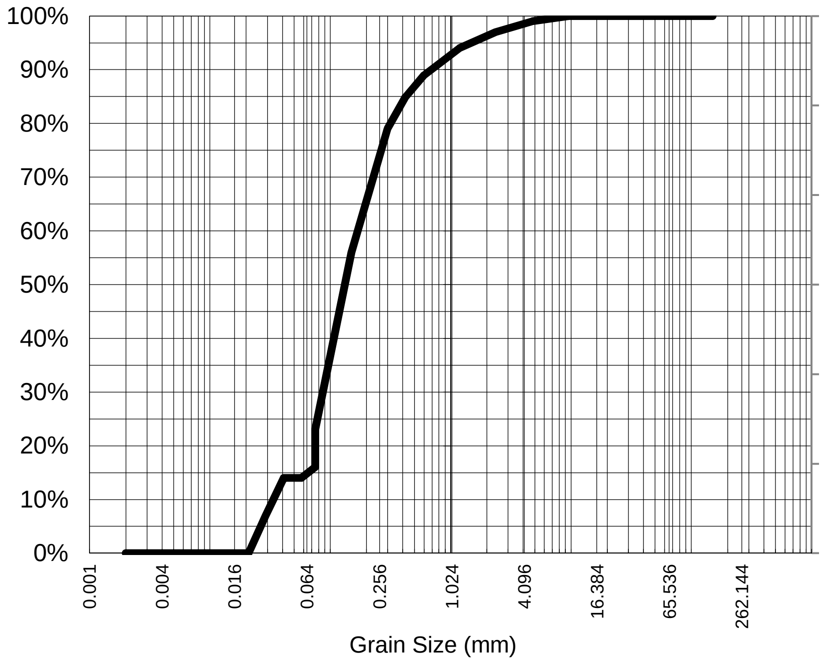
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-020 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N10B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	97%
1.18	94%
0.600	89%
0.425	85%
0.300	79%
0.150	56%
0.075	23%
Particle Size (microns)	
58	14%
41	14%
29	7%
21	0%

Median Particle Size (mm)*	0.136

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825 Site: Newcastle
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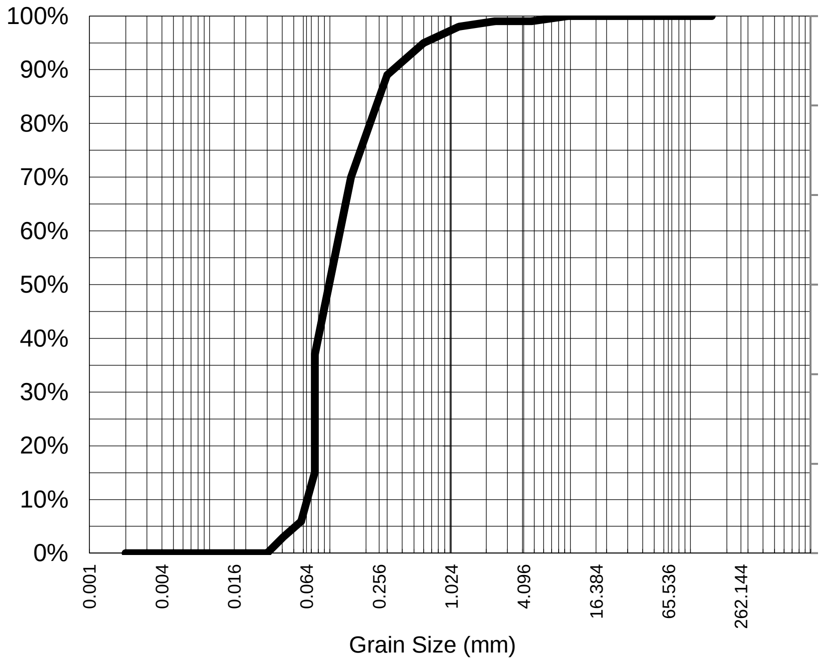
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-021 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N11T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	99%
1.18	98%
0.600	95%
0.425	92%
0.300	89%
0.150	70%
0.075	37%
Particle Size (microns)	
58	6%
41	3%
30	0%

Median Particle Size (mm)*	0.105

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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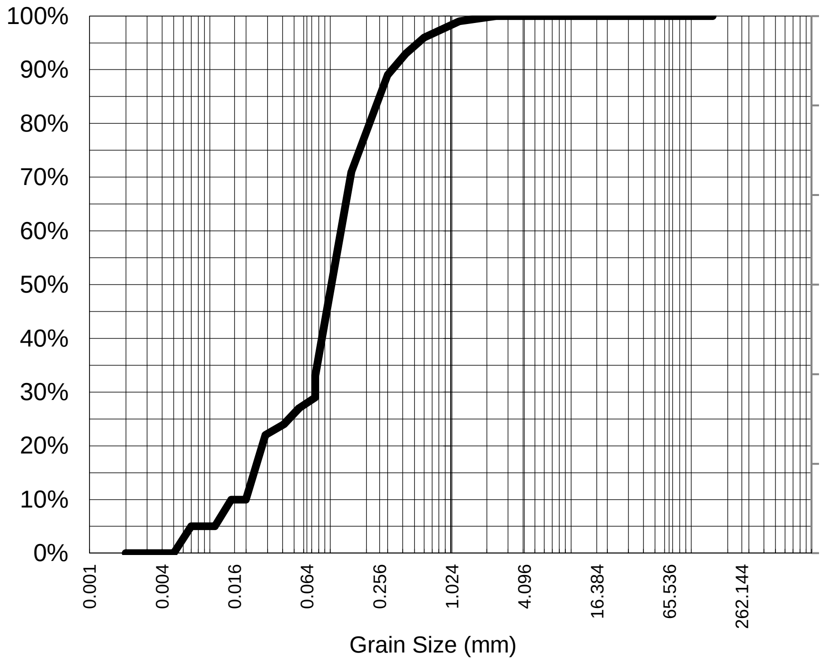
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-022 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N11T DUP

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	96%
0.425	93%
0.300	89%
0.150	71%
0.075	33%
Particle Size (microns)	
55	27%
41	24%
29	22%
20	10%
15	10%
11	5%
7	5%
5	0%

Median Particle Size (mm)*	0.109

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments:

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

NATA Accreditation: 825 Site: Newcastle
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ALS Environmental
Newcastle, NSW

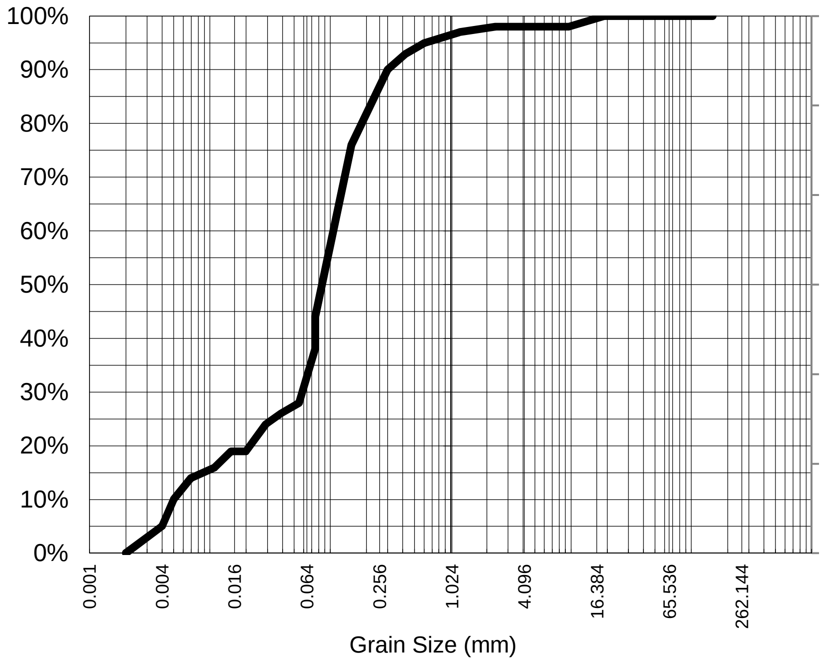
CLIENT: PAUL NICHOLS
DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd
DATE RECEIVED: 1-Apr-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA
REPORT NO: EP1902982-023 / PSD

PROJECT: WEL SCABS
SAMPLE ID: N13T

Particle Size Distribution



Particle Size (mm)	% Passing
19.0	100%
9.50	98%
4.75	98%
2.36	98%
1.18	97%
0.600	95%
0.425	93%
0.300	90%
0.150	76%
0.075	44%
Particle Size (microns)	
55	28%
39	26%
29	24%
20	19%
15	19%
11	16%
7	14%
5	10%
2	0%

Median Particle Size (mm)*	0.089

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825 Site: Newcastle
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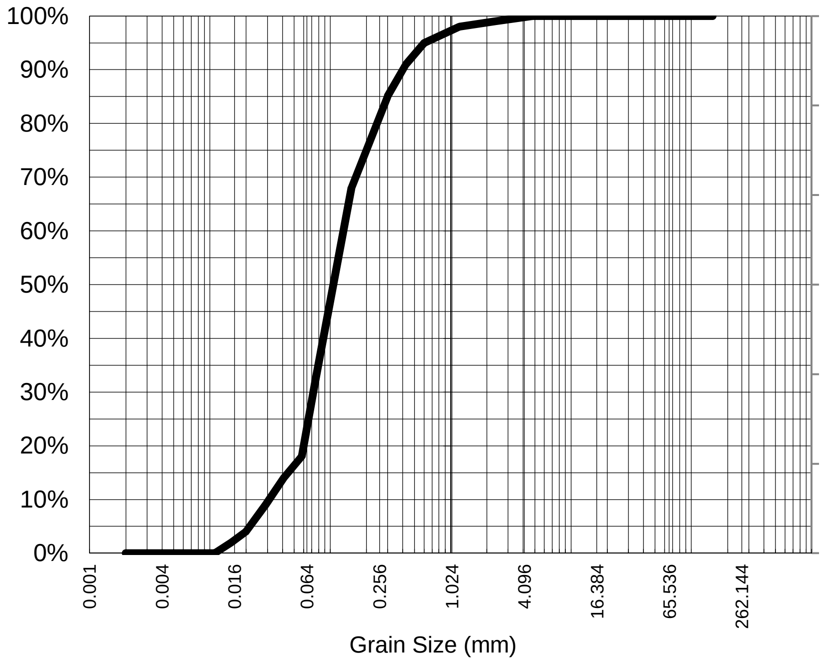
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-024 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N13B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	95%
0.425	91%
0.300	85%
0.150	68%
0.075	32%
Particle Size (microns)	
58	18%
41	14%
29	9%
20	4%
15	2%
11	0%

Median Particle Size (mm)*	0.113

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825 Site: Newcastle
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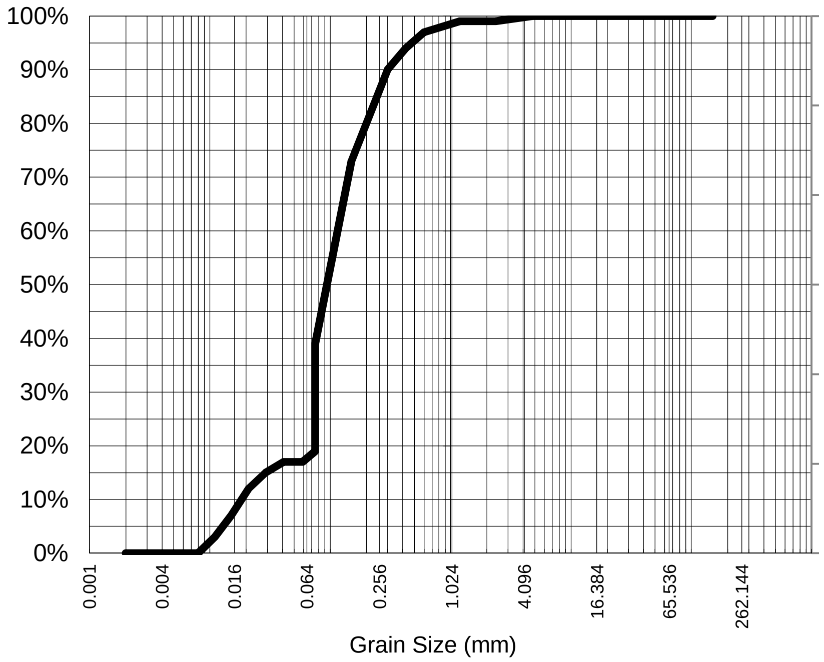
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-025 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14AT

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	97%
0.425	94%
0.300	90%
0.150	73%
0.075	39%
Particle Size (microns)	
59	17%
41	17%
29	15%
21	12%
15	7%
11	3%
8	0%

Median Particle Size (mm)*	0.099

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.59

NATA Accreditation: 825 Site: Newcastle
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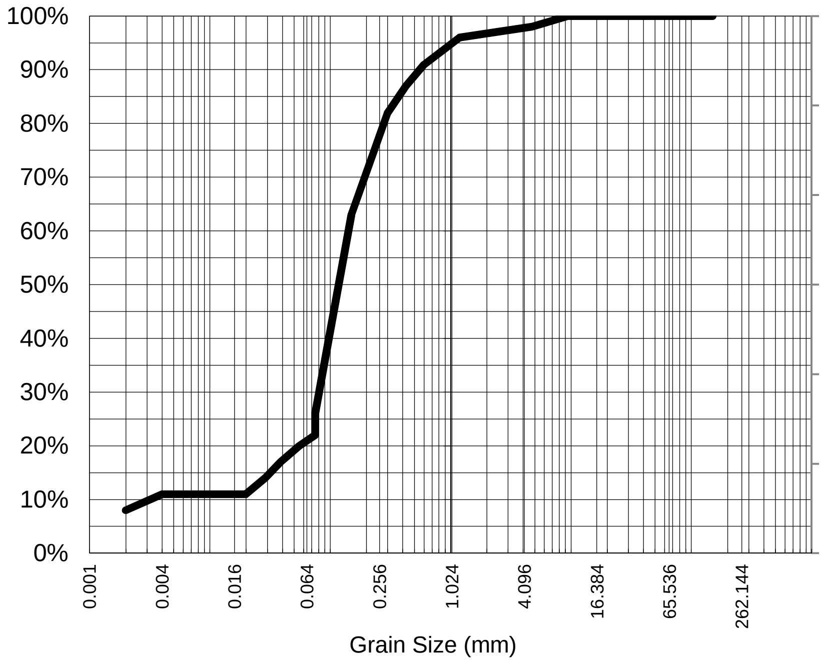
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-026 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14AB

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	97%
1.18	96%
0.600	91%
0.425	87%
0.300	82%
0.150	63%
0.075	26%
Particle Size (microns)	
55	20%
39	17%
29	14%
20	11%
15	11%
11	11%
7	11%
5	11%
2	8%

Median Particle Size (mm)*	0.124

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

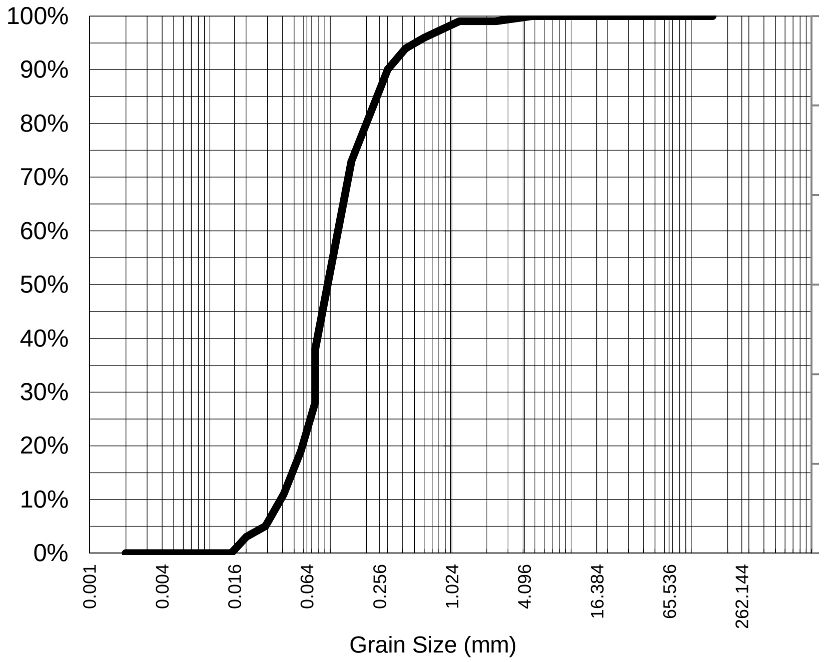
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-027 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N14BT

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	99%
0.600	96%
0.425	94%
0.300	90%
0.150	73%
0.075	38%
Particle Size (microns)	
57	19%
41	11%
29	5%
20	3%
15	0%

Median Particle Size (mm)*	0.101

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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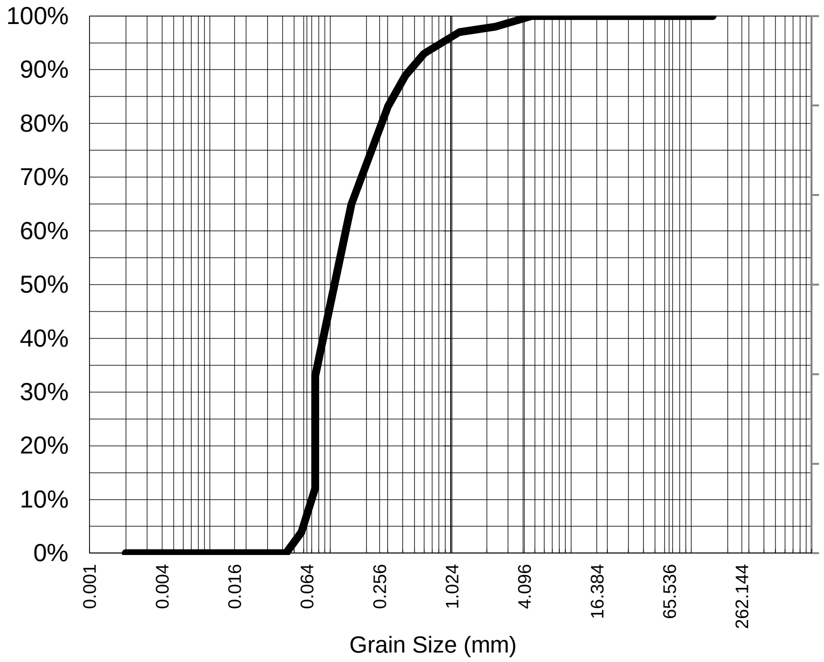
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-028 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14BB

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	98%
1.18	97%
0.600	93%
0.425	89%
0.300	83%
0.150	65%
0.075	33%
Particle Size (microns)	
58	4%
43	0%

Median Particle Size (mm)*	0.115

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.56

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

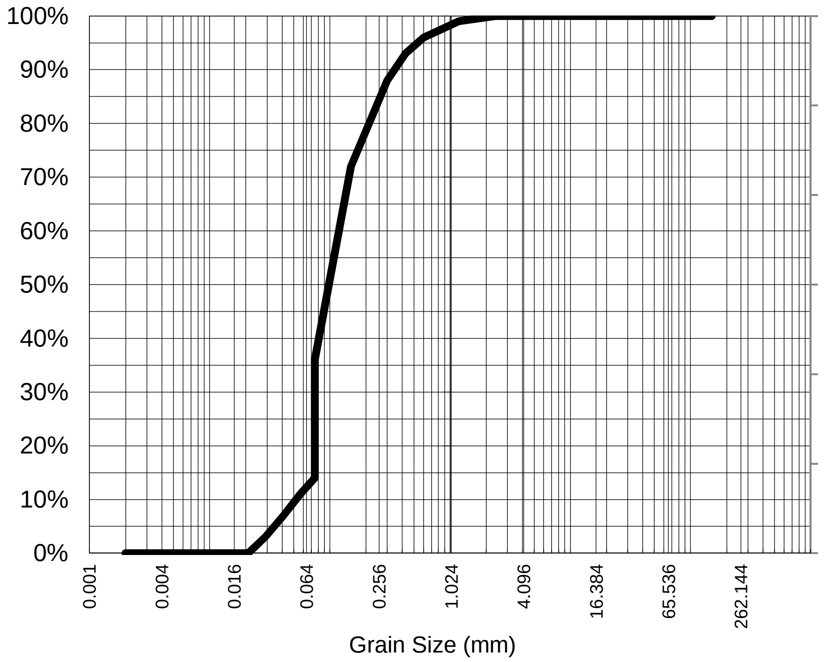
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-029 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N14CT

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	96%
0.425	93%
0.300	88%
0.150	72%
0.075	36%
Particle Size (microns)	
57	11%
41	7%
29	3%
21	0%

Median Particle Size (mm)*	0.104

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.61

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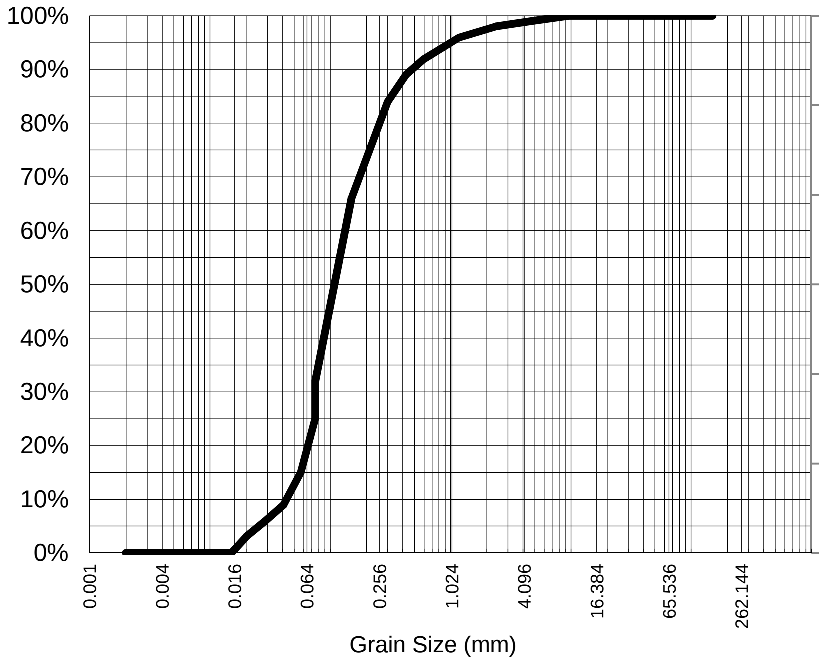
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-030 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14CB

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	96%
0.600	92%
0.425	89%
0.300	84%
0.150	66%
0.075	32%
Particle Size (microns)	
57	15%
41	9%
29	6%
20	3%
15	0%

Median Particle Size (mm)*	0.115

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

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CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

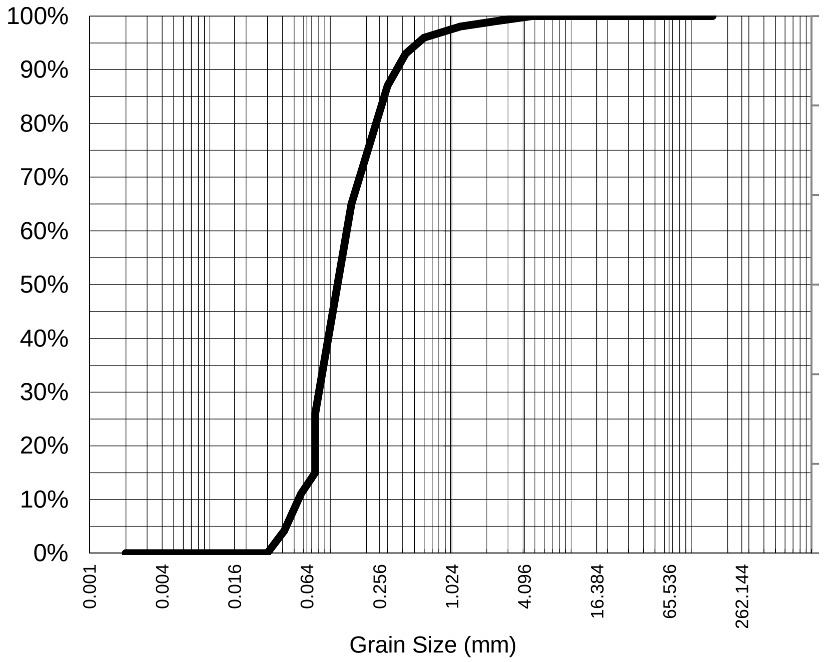
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-031 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N15T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	96%
0.425	93%
0.300	87%
0.150	65%
0.075	26%
Particle Size (microns)	
57	11%
41	4%
30	0%

Median Particle Size (mm)*	0.121

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.64

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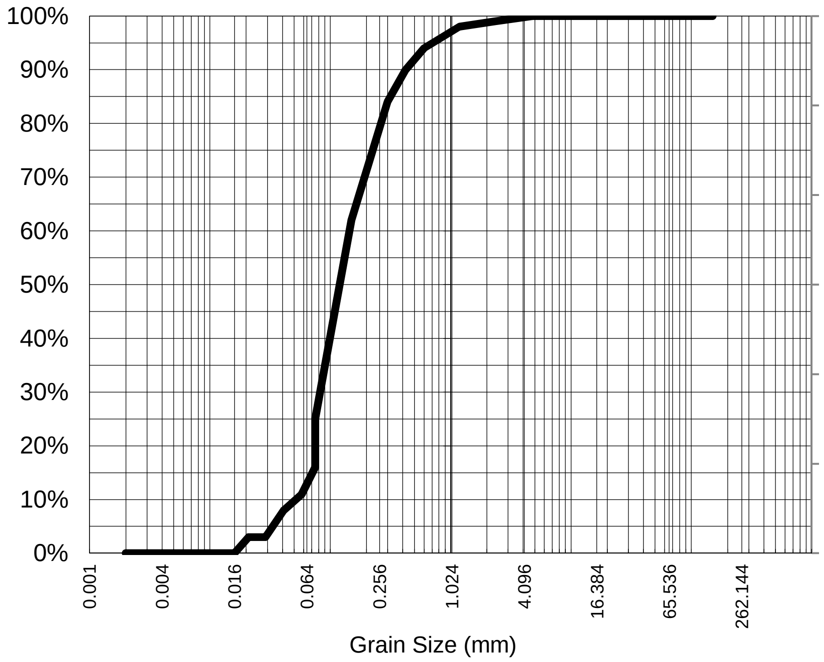
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-032 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	N15B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	94%
0.425	90%
0.300	84%
0.150	62%
0.075	25%
Particle Size (microns)	
58	11%
41	8%
29	3%
21	3%
16	0%

Median Particle Size (mm)*	0.126

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.59

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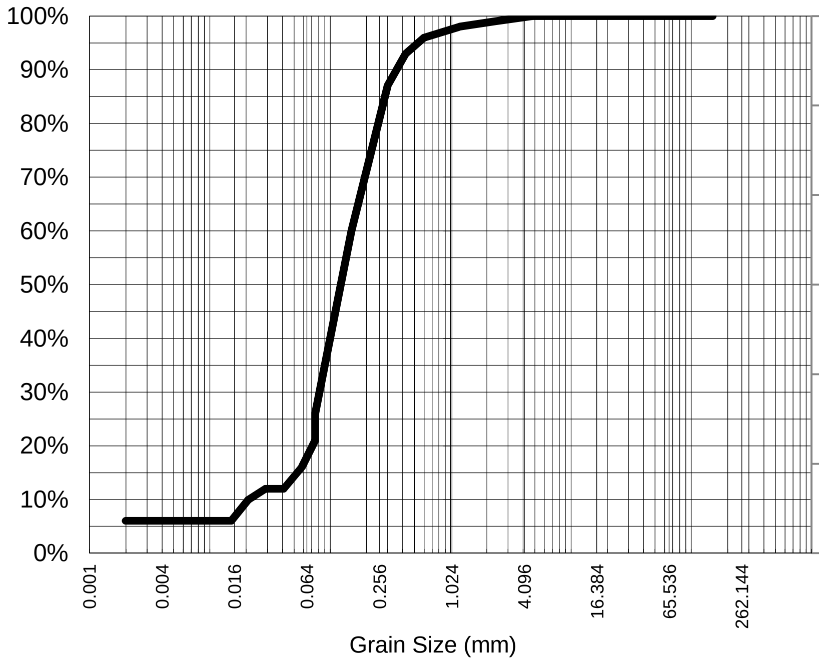
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-033 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R2T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	96%
0.425	93%
0.300	87%
0.150	60%
0.075	26%
Particle Size (microns)	
58	16%
41	12%
29	12%
21	10%
15	6%
11	6%
8	6%
5	6%
2	6%

Median Particle Size (mm)*	0.128

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.56

NATA Accreditation: 825 Site: Newcastle
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ALS Environmental
Newcastle, NSW

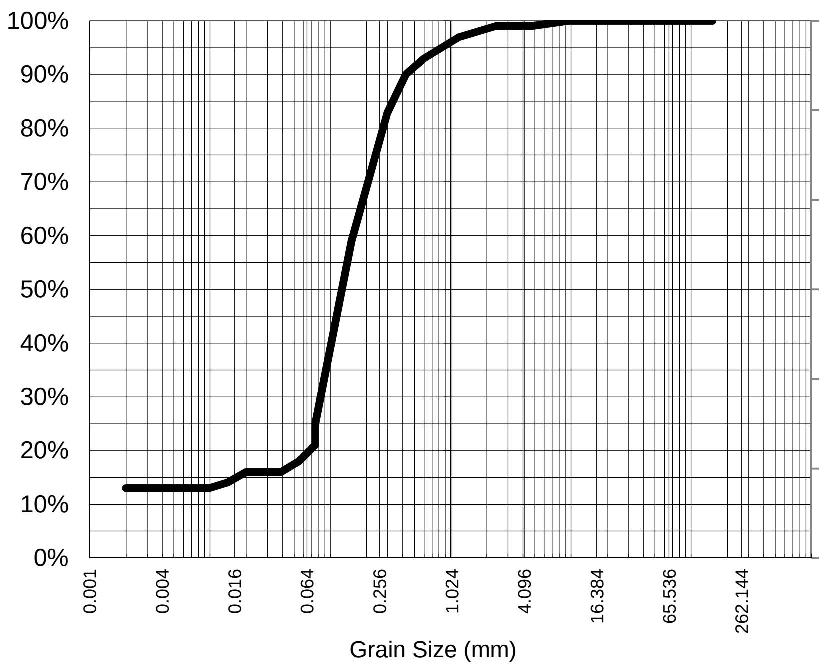
CLIENT: PAUL NICHOLS
DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd
DATE RECEIVED: 1-Apr-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA
REPORT NO: EP1902982-034 / PSD

PROJECT: WEL SCABS
SAMPLE ID: R2B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	99%
1.18	97%
0.600	93%
0.425	90%
0.300	83%
0.150	59%
0.075	25%
Particle Size (microns)	
55	18%
39	16%
28	16%
20	16%
14	14%
10	13%
7	13%
5	13%
2	13%

Median Particle Size (mm)*	0.130

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

NATA Accreditation: 825 Site: Newcastle
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ALS Environmental
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CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

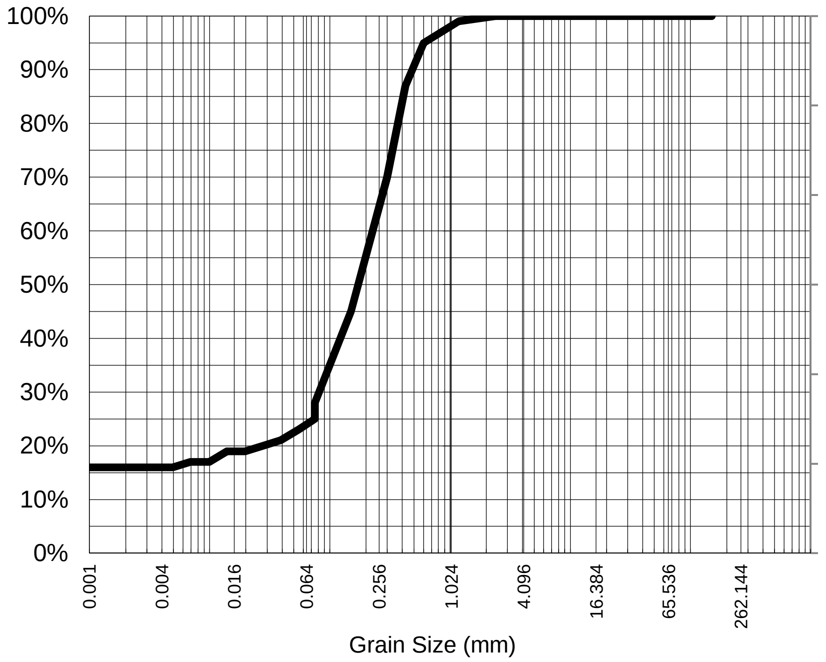
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-035 / PSD

PROJECT: WEL SCABS

SAMPLE ID: N22BT

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	95%
0.425	87%
0.300	70%
0.150	45%
0.075	28%
Particle Size (microns)	
55	23%
39	21%
28	20%
20	19%
14	19%
10	17%
7	17%
5	16%
1	16%

Median Particle Size (mm)*	0.180

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.64

NATA Accreditation: 825 Site: Newcastle
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Newcastle, NSW

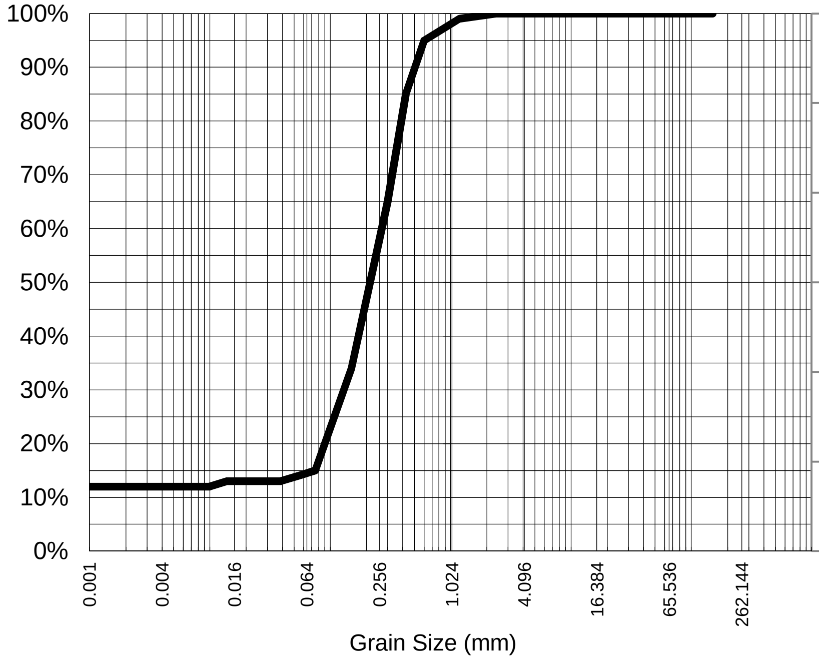
CLIENT: PAUL NICHOLS
DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd
DATE RECEIVED: 1-Apr-2019

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA
REPORT NO: EP1902982-036 / PSD

PROJECT: WEL SCABS
SAMPLE ID: N22CT

Particle Size Distribution



Particle Size (mm)	% Passing
2.36	100%
1.18	99%
0.600	95%
0.425	85%
0.300	65%
0.150	34%
0.075	15%
Particle Size (microns)	
55	14%
39	13%
28	13%
20	13%
14	13%
10	12%
7	12%
5	12%
1	12%

Median Particle Size (mm)*	0.227

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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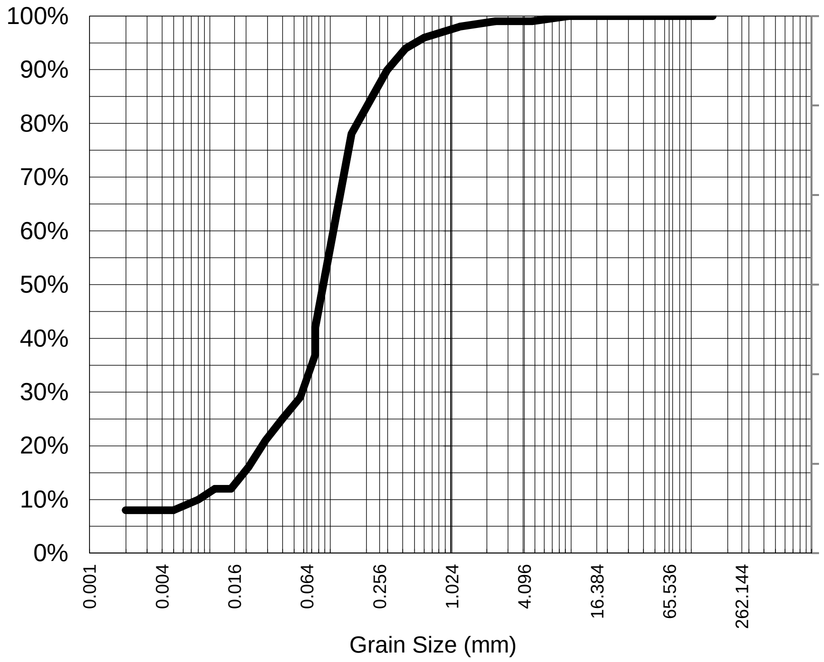
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-037 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R4T

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	99%
1.18	98%
0.600	96%
0.425	94%
0.300	90%
0.150	78%
0.075	42%
Particle Size (microns)	
56	29%
40	25%
29	21%
21	16%
15	12%
11	12%
8	10%
5	8%
2	8%

Median Particle Size (mm)*	0.092

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.57

NATA Accreditation: 825 Site: Newcastle
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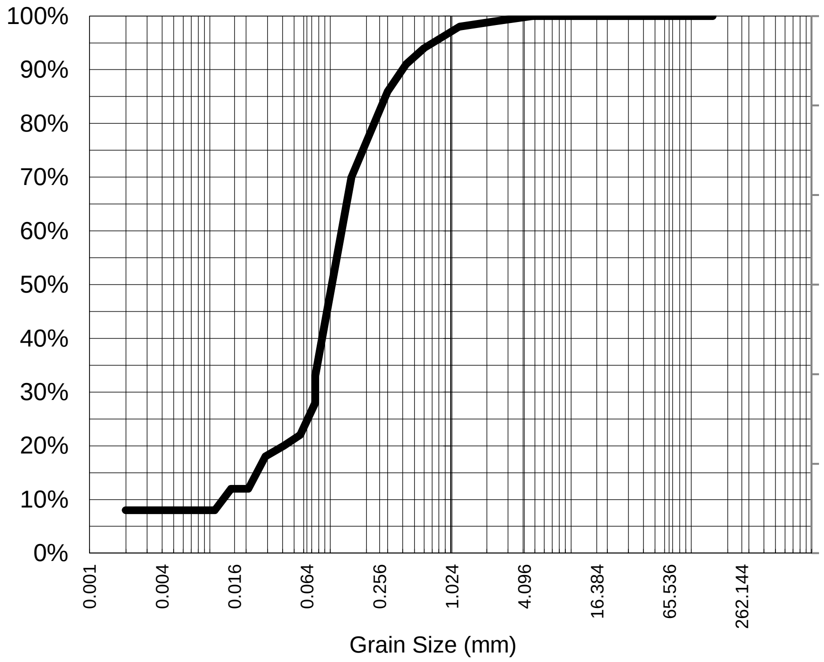
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-038 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R4B

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	98%
0.600	94%
0.425	91%
0.300	86%
0.150	70%
0.075	33%
Particle Size (microns)	
56	22%
41	20%
29	18%
21	12%
15	12%
11	8%
8	8%
5	8%
2	8%

Median Particle Size (mm)*	0.109

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.58

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
Technical Manager - Air
Authorised Signatory

Certificate of Analysis

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pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

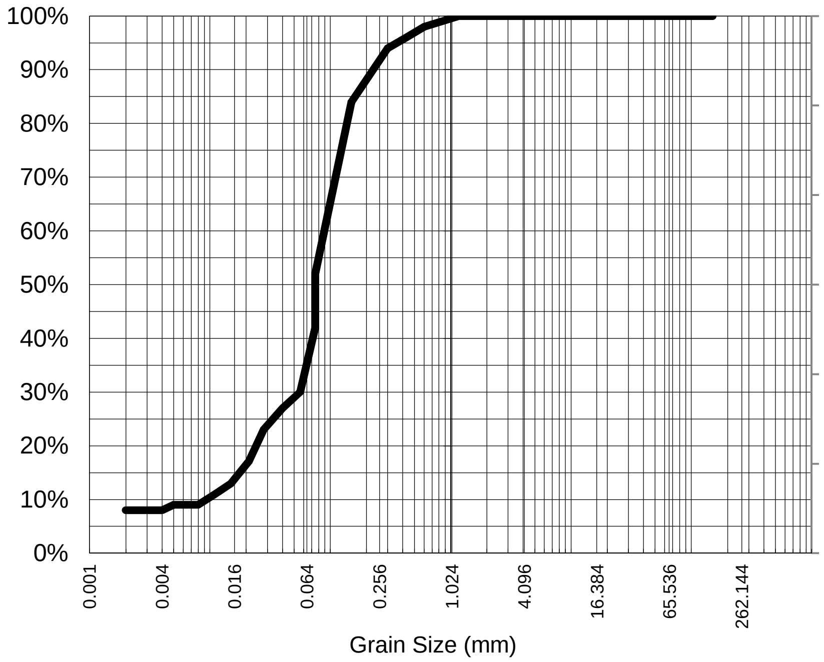
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-039 / PSD

PROJECT: WEL SCABS

SAMPLE ID: R7AT

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	98%
0.425	96%
0.300	94%
0.150	84%
0.075	52%
Particle Size (microns)	
56	30%
40	27%
28	23%
21	17%
15	13%
11	11%
8	9%
5	9%
2	8%

Median Particle Size (mm)*	0.075

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.59

NATA Accreditation: 825 Site: Newcastle
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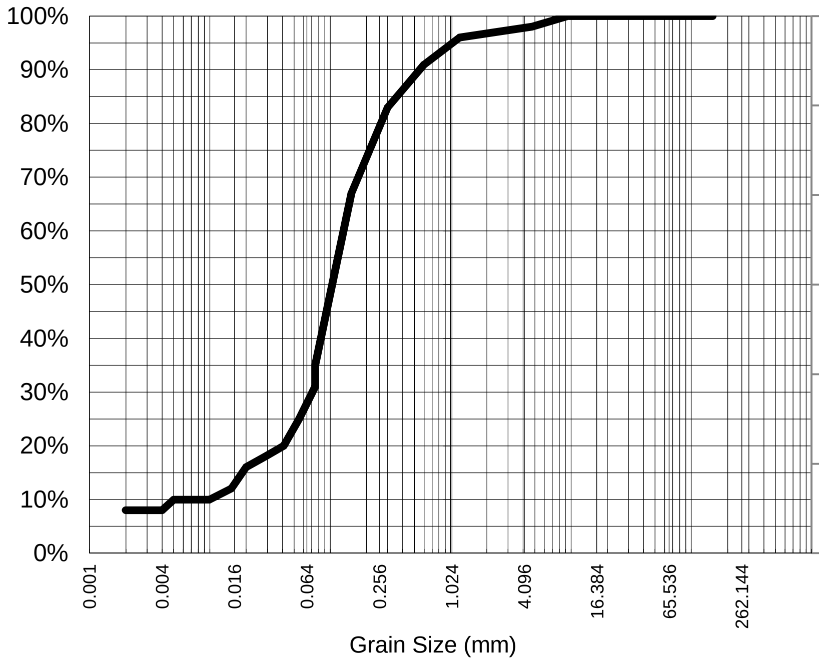
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-040 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7AB

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	98%
2.36	97%
1.18	96%
0.600	91%
0.425	87%
0.300	83%
0.150	67%
0.075	35%
Particle Size (microns)	
55	25%
41	20%
29	18%
20	16%
15	12%
10	10%
7	10%
5	10%
2	8%

Median Particle Size (mm)*	0.110

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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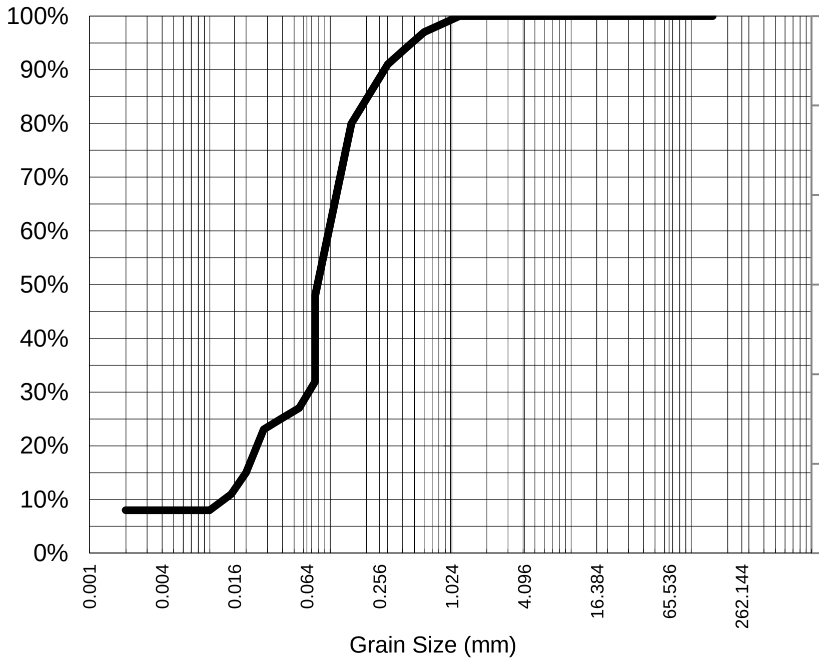
CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-041 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7BT

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	97%
0.425	94%
0.300	91%
0.150	80%
0.075	48%
Particle Size (microns)	
55	27%
39	25%
28	23%
20	15%
15	11%
10	8%
7	8%
5	8%
2	8%

Median Particle Size (mm)*	0.080

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825 Site: Newcastle
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ALS Environmental
Newcastle, NSW

CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

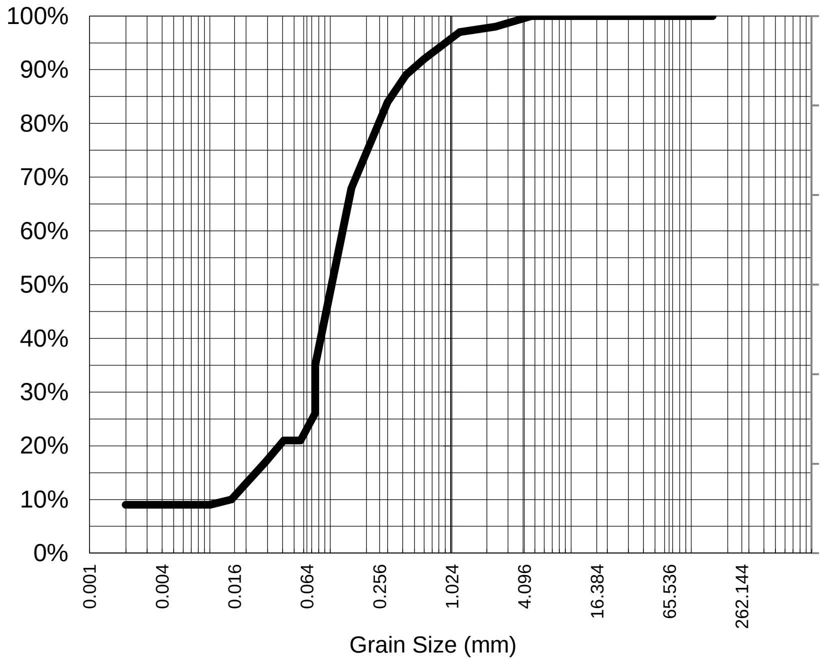
ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-042 / PSD

PROJECT: WEL SCABS

SAMPLE ID: R7BB

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	98%
1.18	97%
0.600	92%
0.425	89%
0.300	84%
0.150	68%
0.075	35%
Particle Size (microns)	
57	21%
41	21%
29	17%
20	13%
15	10%
10	9%
7	9%
5	9%
2	9%

Median Particle Size (mm)*	0.109

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

NATA Accreditation: 825 Site: Newcastle
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CLIENT: PAUL NICHOLS

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

DATE RECEIVED: 1-Apr-2019

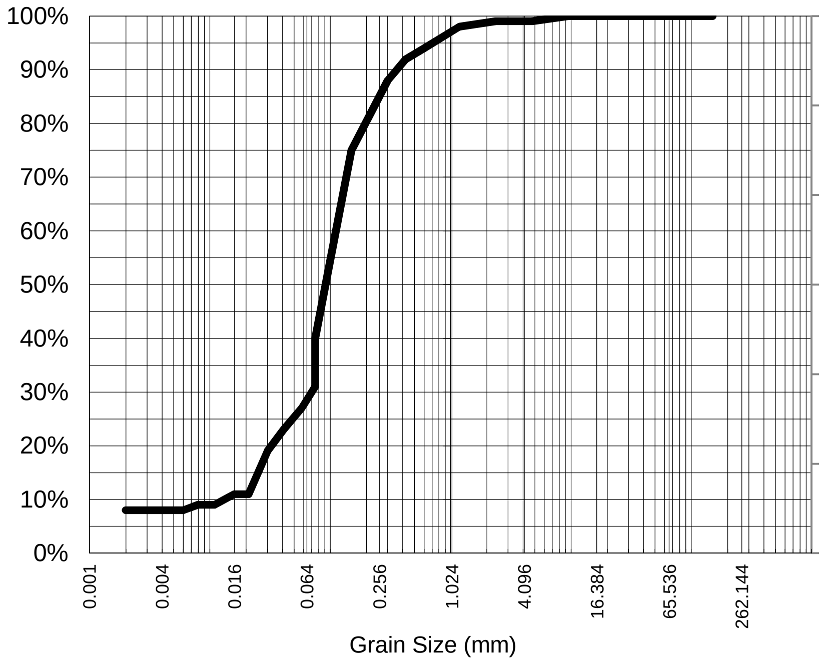
ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NO: EP1902982-043 / PSD

PROJECT: WEL SCABS

SAMPLE ID: R7CT

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	99%
1.18	98%
0.600	94%
0.425	92%
0.300	88%
0.150	75%
0.075	40%
Particle Size (microns)	
58	27%
41	23%
30	19%
21	11%
16	11%
11	9%
8	9%
6	8%
2	8%

Median Particle Size (mm)*	0.096

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.46

NATA Accreditation: 825   Site: Newcastle
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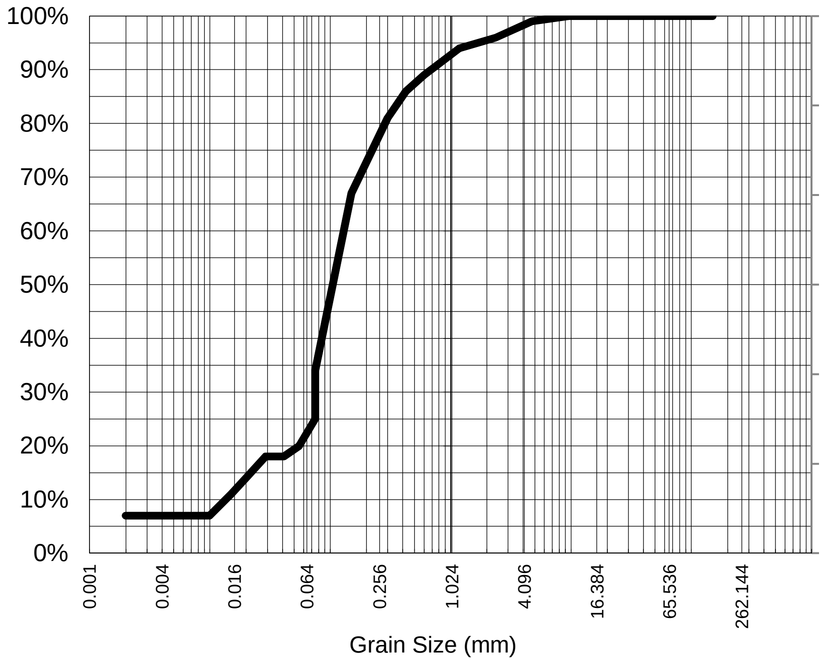
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-044 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7CB

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	96%
1.18	94%
0.600	89%
0.425	86%
0.300	81%
0.150	67%
0.075	34%
Particle Size (microns)	
55	20%
41	18%
29	18%
20	14%
15	11%
10	7%
7	7%
5	7%
2	7%

Median Particle Size (mm)*	0.111

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.63

NATA Accreditation: 825   Site: Newcastle
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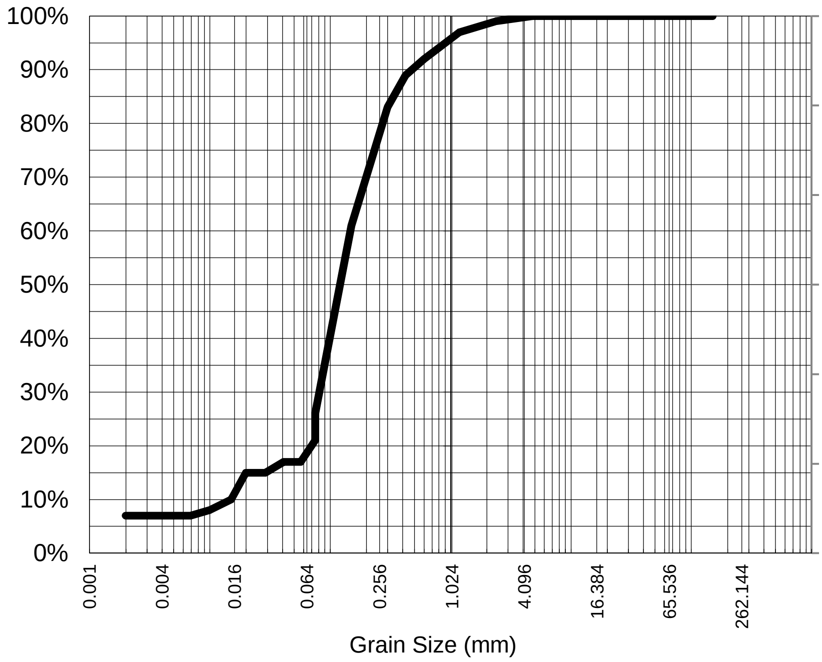
ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-045 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R3T

Particle Size Distribution



Particle Size (mm)	% Passing
4.75	100%
2.36	99%
1.18	97%
0.600	92%
0.425	89%
0.300	83%
0.150	61%
0.075	26%
Particle Size (microns)	
57	17%
41	17%
29	15%
20	15%
15	10%
10	8%
7	7%
5	7%
2	7%

Median Particle Size (mm)*	0.126

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.64

NATA Accreditation: 825 Site: Newcastle
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Certificate of Analysis

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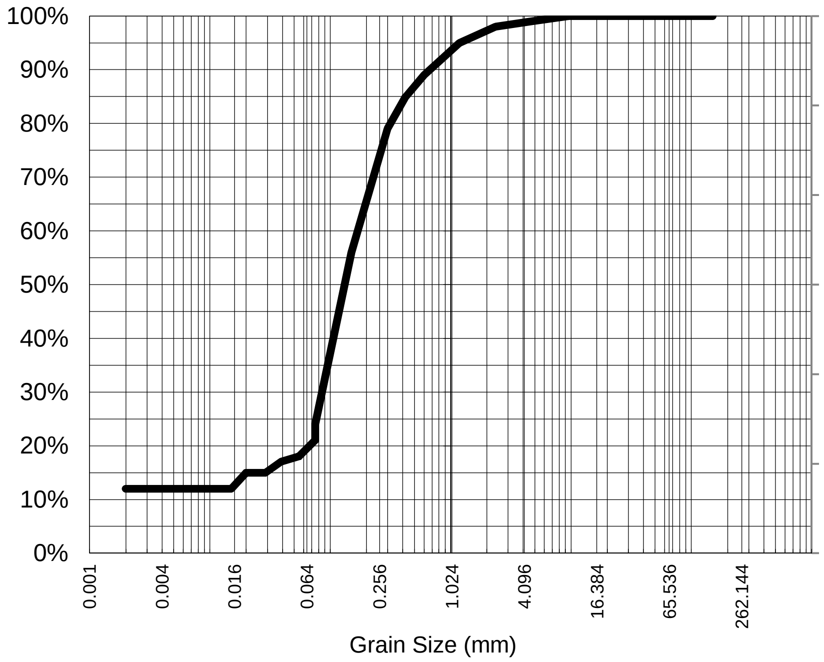
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-046 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R3B

Particle Size Distribution



Particle Size (mm)	% Passing
9.50	100%
4.75	99%
2.36	98%
1.18	95%
0.600	89%
0.425	85%
0.300	79%
0.150	56%
0.075	24%
Particle Size (microns)	
55	18%
39	17%
29	15%
20	15%
15	12%
10	12%
7	12%
5	12%
2	12%

Median Particle Size (mm)*	0.136

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.62

NATA Accreditation: 825 Site: Newcastle
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Authorised Signatory

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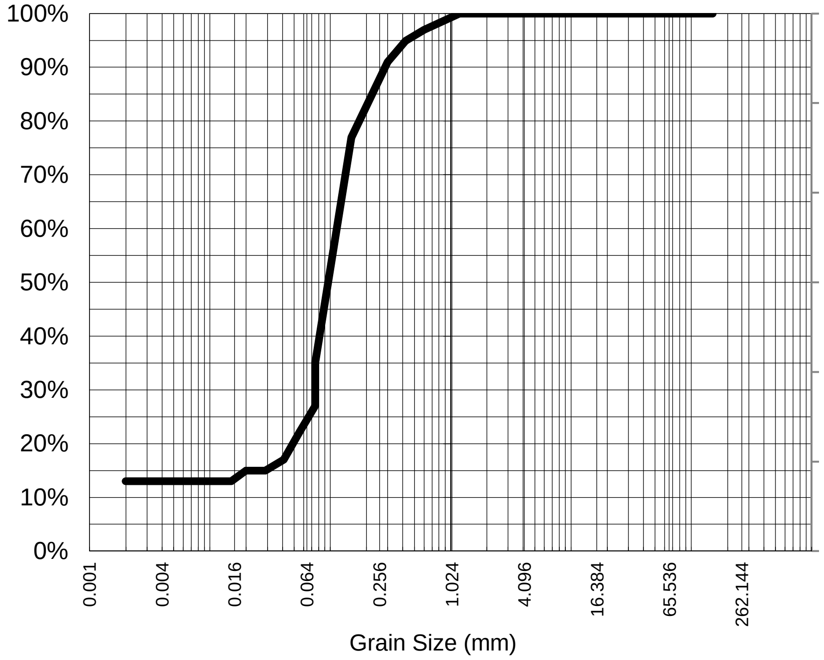
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental
Newcastle, NSW

CLIENT:	PAUL NICHOLS	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	1-Apr-2019
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NO:**	EP1902982-047 / PSD
PROJECT:	WEL SCABS	**SAMPLE ID:**	R4T DUP

Particle Size Distribution



Particle Size (mm)	% Passing
1.18	100%
0.600	97%
0.425	95%
0.300	91%
0.150	77%
0.075	35%
Particle Size (microns)	
55	22%
41	17%
29	15%
20	15%
15	13%
10	13%
7	13%
5	13%
2	13%

Median Particle Size (mm)*	0.102

Analysis Notes

Samples analysed as received.
Median Particle Size is not covered under the current scope of ALS's NATA accreditation.
Samples were dispersed in synthetic seawater for hydrometer analysis and results were corrected for differences in salinity. As a consequence of this method variation, NATA accreditation does not apply

Sample Comments: Mass percentages are reported relative to total insoluble solids

Analysed: 17-Apr-19

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: FINE, SAND, SHELL

Dispersion Method Shaker

Test Method: AS1289.3.6.2/AS1289.3.6.3

Soil Particle Density (<2.36mm) 2.6

NATA Accreditation: 825 Site: Newcastle
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Peter Keyte
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Authorised Signatory

Certificate of Analysis

Settling Rates

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pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

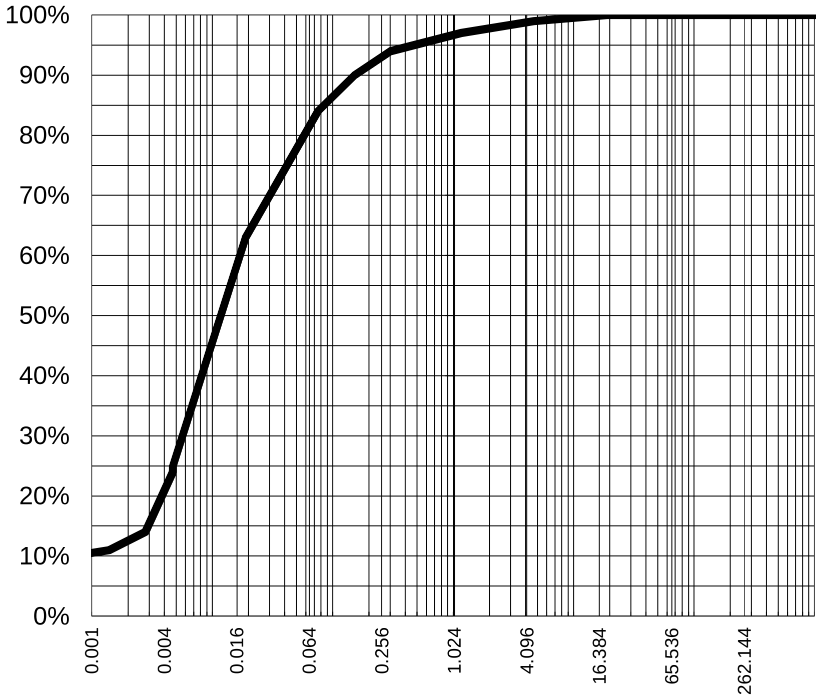
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-001 / SR

PROJECT: WEL SCABS

SAMPLE ID: N11B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.8E-04
2.36	99%	4.7	3.6E-03
1.18	97%	1.2	1.4E-02
0.600	94%	0.30	5.5E-02
0.425	90%	0.15	1.1E-01
0.300	84%	0.076	2.2E-01
0.150	63%	0.019	8.8E-01
0.075	25%	0.005	3.5E+00
µm			
58	14%	2.8E-03	5.974
41	11%	1.4E-03	11.948
29	10%	7.0E-04	23.896
20	5%	3.5E-04	47.793
11	0%	1.0E-04	166.54
5	0%	2.5E-05	666.17
2	0%	2.1E-06	7994.01

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.79
Time for 90% to Settle 100cm	23.90
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Certificate of Analysis

Settling Rates

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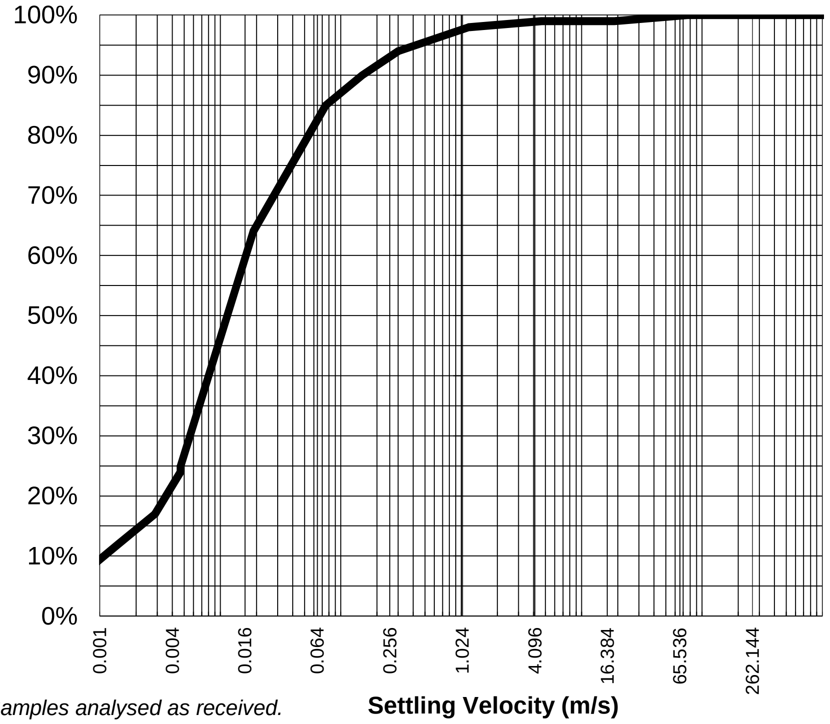
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-002 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R5T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	75	2.2E-04
4.75	99%	19	8.9E-04
2.36	99%	4.6	3.6E-03
1.18	98%	1.2	1.4E-02
0.600	94%	0.30	5.5E-02
0.425	90%	0.15	1.1E-01
0.300	85%	0.075	2.2E-01
0.150	64%	0.019	8.9E-01
0.075	25%	0.005	3.6E+00
µm			
59	17%	2.9E-03	5.824
41	12%	1.4E-03	11.647
29	7%	7.2E-04	23.294
21	6%	3.6E-04	46.589
11	0%	1.0E-04	162.35
6	0%	2.6E-05	649.38
2	0%	2.1E-06	7792.62

Time for 50% to Settle 100cm	1.85
Time for 90% to Settle 100cm	16.31
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Settling Velocity in: Typical seawater (density 1.025)

Limit of Reporting: 1%

Analysed: 17-Apr-19

Dispersion Method Shaker

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

ALS Laboratory Group Pty Ltd
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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

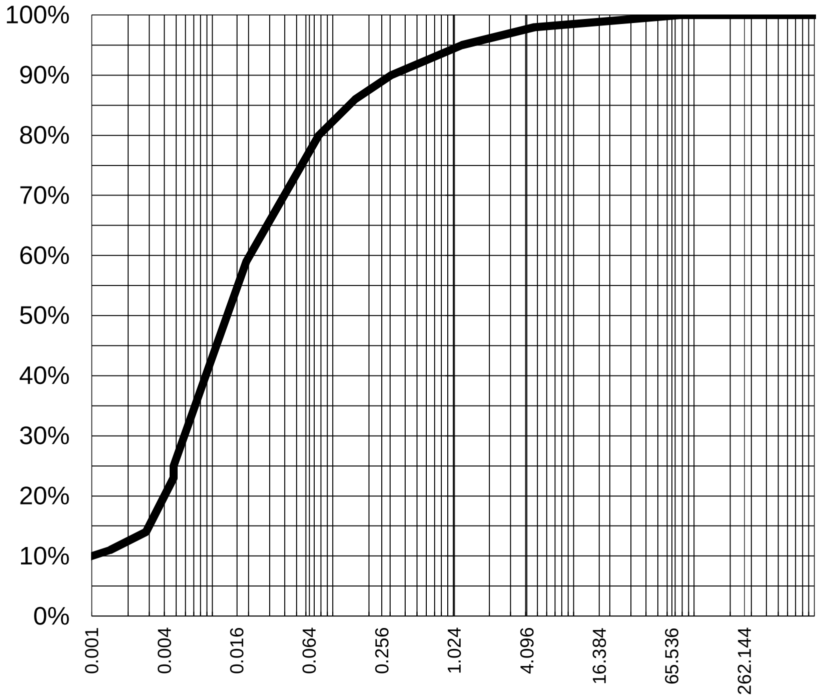
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-003 / SR

PROJECT: WEL SCABS

SAMPLE ID: R5B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.7E-04
2.36	98%	4.7	3.5E-03
1.18	95%	1.2	1.4E-02
0.600	90%	0.31	5.4E-02
0.425	86%	0.15	1.1E-01
0.300	80%	0.077	2.2E-01
0.150	59%	0.019	8.7E-01
0.075	25%	0.005	3.5E+00
µm			
58	14%	2.8E-03	5.899
41	11%	1.4E-03	11.798
29	9%	7.1E-04	23.597
20	7%	3.5E-04	47.193
11	2%	9.4E-05	176.98
5	0%	2.5E-05	657.81
2	0%	2.1E-06	7893.77

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.56
Time for 90% to Settle 100cm	17.70
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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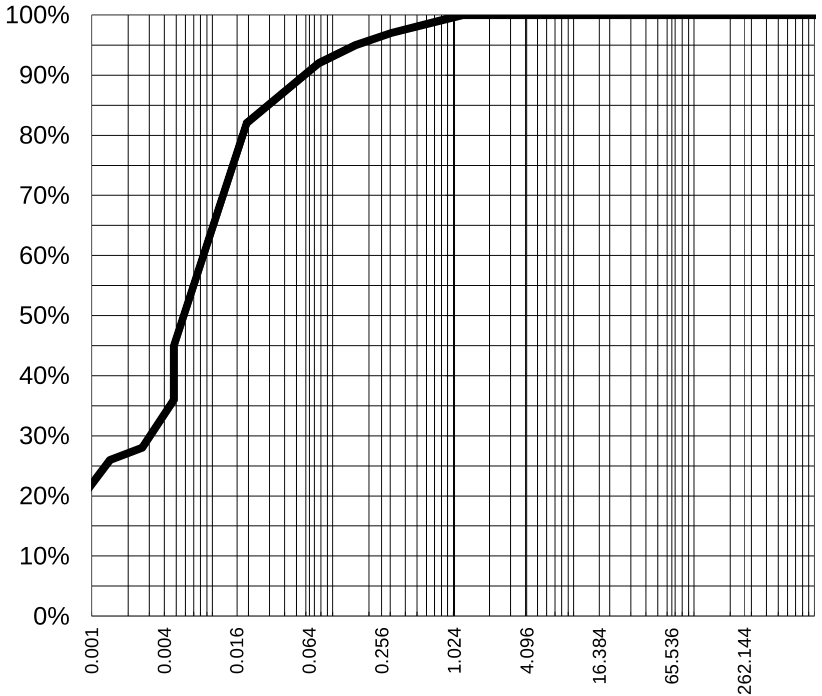
Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-004 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R6T



Samples analysed as received.

Settling Velocity (m/s)

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
1.18	100%	1.2	1.4E-02
0.600	97%	0.31	5.4E-02
0.425	95%	0.15	1.1E-01
0.300	92%	0.077	2.2E-01
0.150	82%	0.019	8.7E-01
0.075	45%	0.005	3.5E+00
µm			
55	28%	2.6E-03	6.349
41	26%	1.4E-03	11.725
29	18%	7.1E-04	23.450
20	10%	3.6E-04	46.899
11	2%	9.5E-05	175.87
5	0%	2.5E-05	653.72
2	0%	2.1E-06	7844.58

Time for 50% to Settle 100cm	3.11
Time for 90% to Settle 100cm	46.90
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Settling Velocity in: Typical seawater (density 1.025)

Limit of Reporting: 1%

Analysed: 17-Apr-19

Dispersion Method Shaker

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
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Certificate of Analysis

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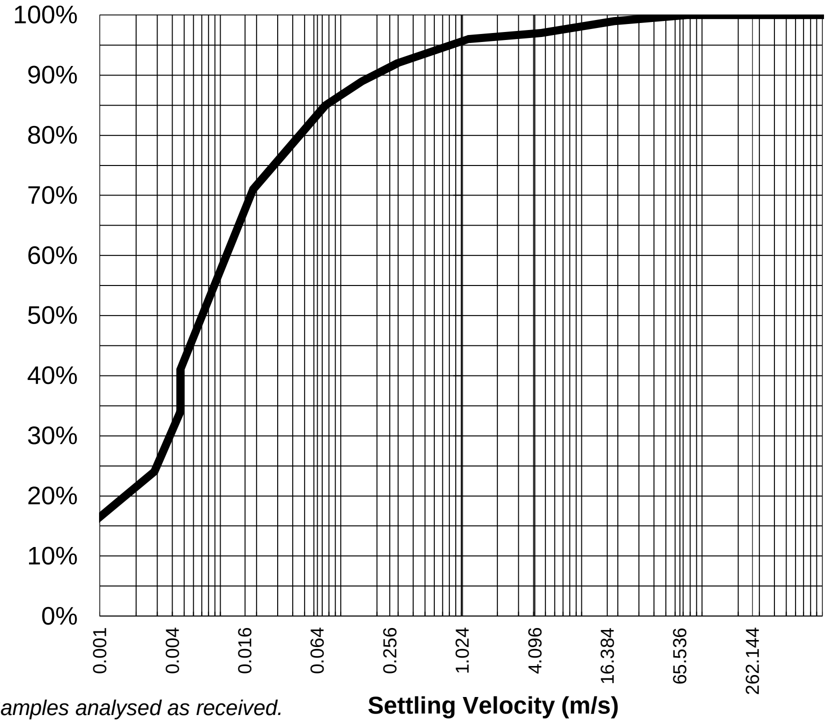
Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-005 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R6B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	75	2.2E-04
4.75	99%	19	8.9E-04
2.36	97%	4.6	3.6E-03
1.18	96%	1.2	1.4E-02
0.600	92%	0.30	5.6E-02
0.425	89%	0.15	1.1E-01
0.300	85%	0.075	2.2E-01
0.150	71%	0.019	8.9E-01
0.075	41%	0.005	3.6E+00
µm			
59	24%	2.8E-03	5.861
41	19%	1.4E-03	11.722
29	14%	7.1E-04	23.444
21	10%	3.6E-04	46.888
11	2%	9.5E-05	175.83
6	0%	2.6E-05	653.56
2	0%	2.1E-06	7842.73

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.77
Time for 90% to Settle 100cm	46.89
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Technical Manager Air
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Certificate of Analysis

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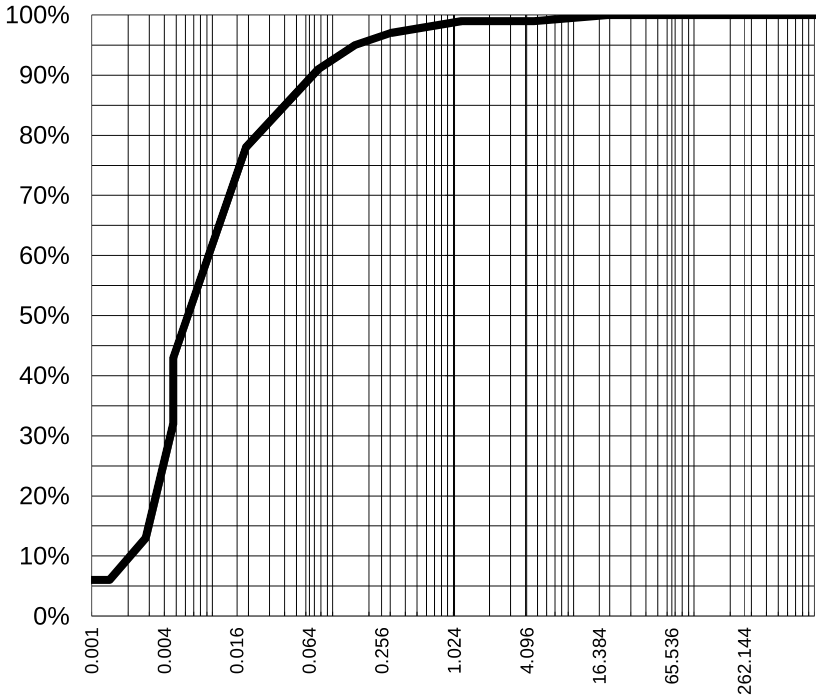
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-006 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N12T



Samples analysed as received.

Settling Velocity (m/s)

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.7E-04
2.36	99%	4.7	3.5E-03
1.18	99%	1.2	1.4E-02
0.600	97%	0.30	5.5E-02
0.425	95%	0.15	1.1E-01
0.300	91%	0.076	2.2E-01
0.150	78%	0.019	8.8E-01
0.075	43%	0.005	3.5E+00
µm			
58	13%	2.8E-03	5.936
41	6%	1.4E-03	11.873
29	6%	7.0E-04	23.746
21	0%	3.8E-04	44.131
11	0%	1.0E-04	165.49
5	0%	2.5E-05	661.96
2	0%	2.1E-06	7943.57

Time for 50% to Settle 100cm	2.98
Time for 90% to Settle 100cm	8.48
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Template Version SRv2-190502

Certificate of Analysis

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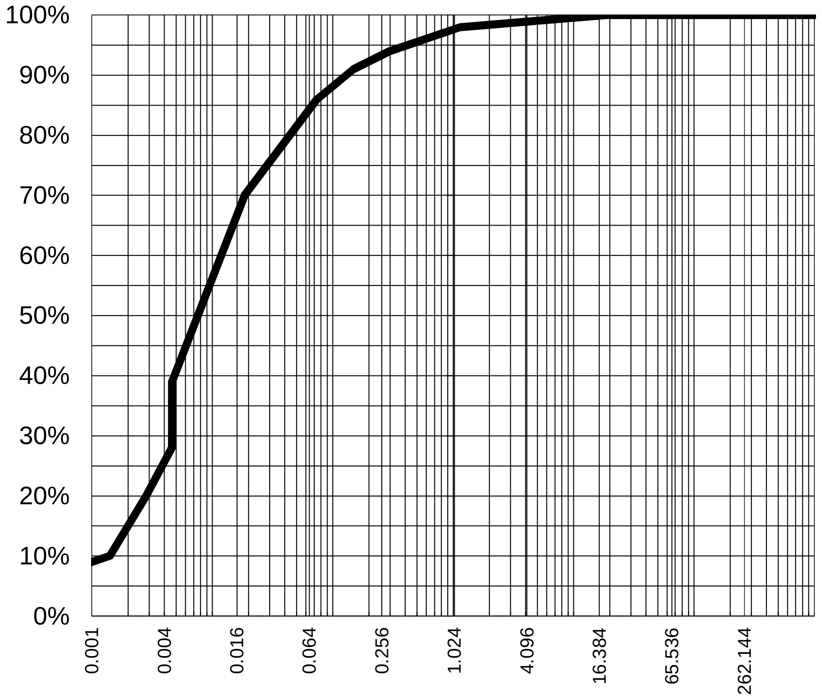
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-007 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N12B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	9.0E-04
2.36	99%	4.6	3.6E-03
1.18	98%	1.1	1.5E-02
0.600	94%	0.30	5.6E-02
0.425	91%	0.15	1.1E-01
0.300	86%	0.074	2.2E-01
0.150	70%	0.019	9.0E-01
0.075	39%	0.005	3.6E+00
µm			
59	20%	2.8E-03	5.899
41	10%	1.4E-03	11.798
29	8%	7.1E-04	23.596
21	5%	3.5E-04	47.192
11	0%	1.0E-04	164.45
6	0%	2.5E-05	657.79
2	0%	2.1E-06	7893.49

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.64
Time for 90% to Settle 100cm	11.80
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINE, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Template Version SRv2-190502

Certificate of Analysis

Settling Rates

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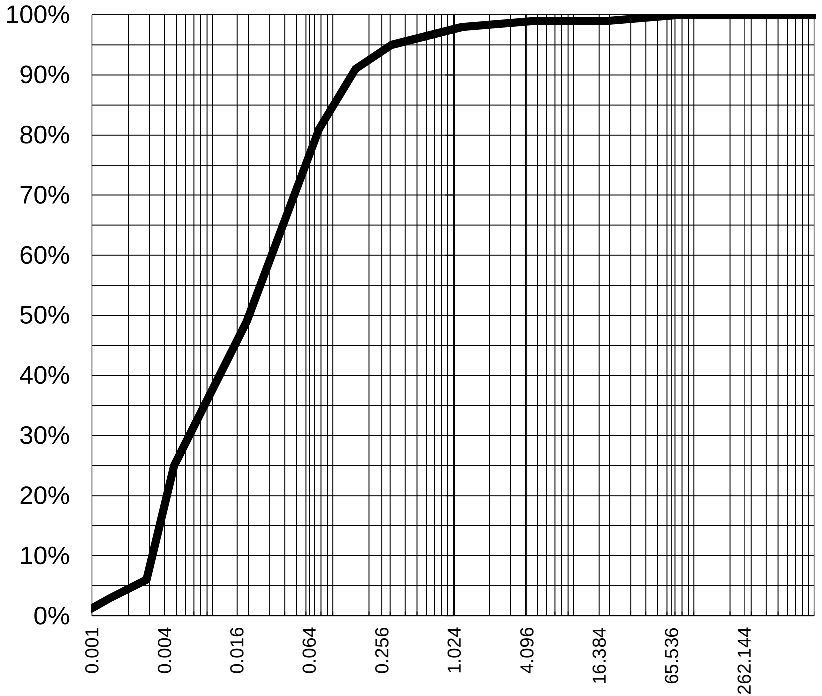
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-011 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R1T



Samples analysed as received.

Particle Size **mm**	Percent Passing **%**	Settling Velocity **m/s**	Time to Settle 100cm **min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.6E-04
2.36	99%	4.8	3.5E-03
1.18	98%	1.2	1.4E-02
0.600	95%	0.31	5.4E-02
0.425	91%	0.15	1.1E-01
0.300	81%	0.077	2.2E-01
0.150	49%	0.019	8.7E-01
0.075	25%	0.005	3.5E+00
µm			
58	6%	2.8E-03	5.862
41	3%	1.4E-03	11.725
30	0%	7.6E-04	21.791
21	0%	3.8E-04	43.581
11	0%	1.0E-04	163.43
5	0%	2.5E-05	653.72
2	0%	2.1E-06	7844.58

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	0.85
Time for 90% to Settle 100cm	5.25
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Certificate of Analysis

Settling Rates

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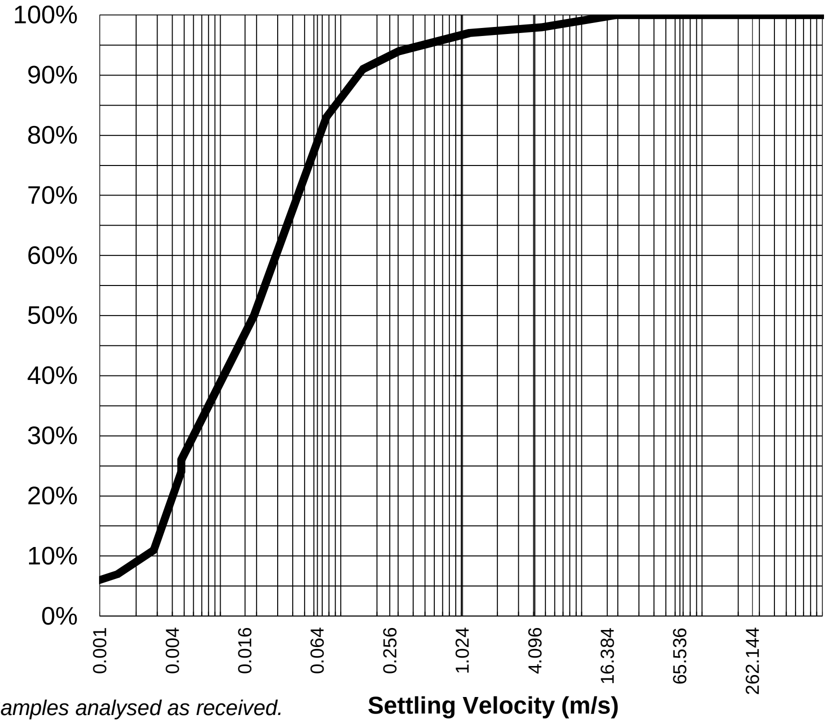
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-012 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R1B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.7E-04
2.36	98%	4.7	3.5E-03
1.18	97%	1.2	1.4E-02
0.600	94%	0.30	5.5E-02
0.425	91%	0.15	1.1E-01
0.300	83%	0.076	2.2E-01
0.150	50%	0.019	8.8E-01
0.075	26%	0.005	3.5E+00
µm			
58	11%	2.8E-03	5.936
41	7%	1.4E-03	11.873
29	5%	7.0E-04	23.746
20	5%	3.5E-04	47.491
11	0%	1.0E-04	165.49
5	0%	2.5E-05	661.96
2	0%	2.1E-06	7943.57

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	0.88
Time for 90% to Settle 100cm	7.42
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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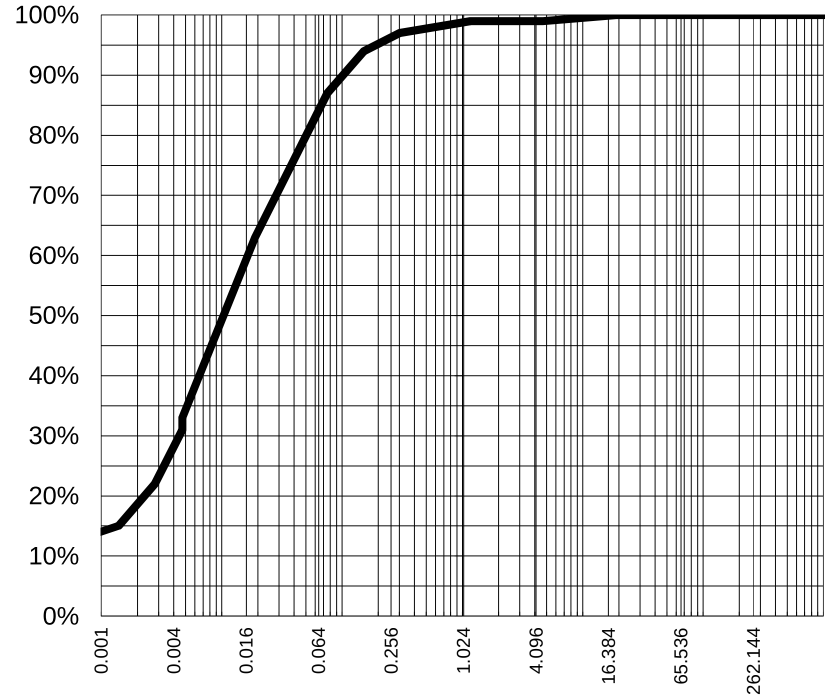
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-013 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N20T



Samples analysed as received.

Particle Size **mm**	Percent Passing **%**	Settling Velocity **m/s**	Time to Settle 100cm **min**
4.75	100%	19	8.8E-04
2.36	99%	4.7	3.6E-03
1.18	99%	1.2	1.4E-02
0.600	97%	0.30	5.5E-02
0.425	94%	0.15	1.1E-01
0.300	87%	0.076	2.2E-01
0.150	63%	0.019	8.8E-01
0.075	33%	0.005	3.5E+00
µm			
58	22%	2.8E-03	5.974
41	15%	1.4E-03	11.948
29	13%	7.0E-04	23.896
20	9%	3.5E-04	47.793
11	4%	9.3E-05	179.22
5	0%	2.5E-05	666.17
2	0%	2.1E-06	7994.01

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.03
Time for 90% to Settle 100cm	41.82
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
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Certificate of Analysis

Settling Rates

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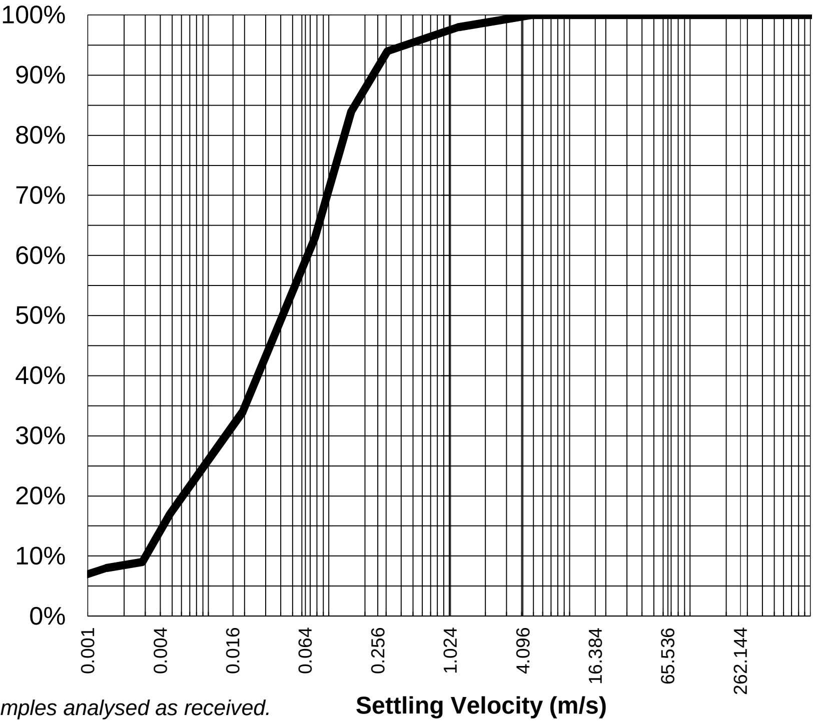
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-014 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N22T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.8	3.5E-03
1.18	98%	1.2	1.4E-02
0.600	94%	0.31	5.4E-02
0.425	84%	0.15	1.1E-01
0.300	63%	0.077	2.2E-01
0.150	34%	0.019	8.7E-01
0.075	17%	0.005	3.5E+00
µm			
58	9%	2.8E-03	5.862
41	8%	1.4E-03	11.725
29	6%	7.1E-04	23.450
20	6%	3.6E-04	46.899
11	0%	1.0E-04	163.43
5	0%	2.5E-05	653.72
2	0%	2.1E-06	7844.58

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	0.51
Time for 90% to Settle 100cm	5.50
Settling Rate at 50% settled (m/s)	0.05
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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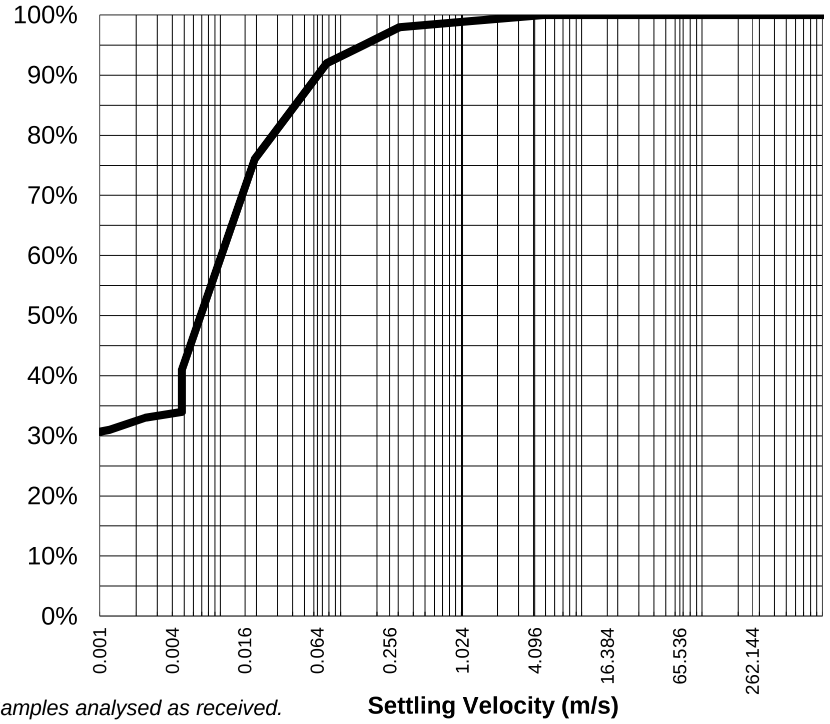
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-015 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N8T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.8	3.5E-03
1.18	99%	1.2	1.4E-02
0.600	98%	0.31	5.4E-02
0.425	95%	0.15	1.1E-01
0.300	92%	0.077	2.2E-01
0.150	76%	0.019	8.7E-01
0.075	41%	0.005	3.5E+00
µm			
53	33%	2.4E-03	6.916
38	31%	1.2E-03	13.831
28	30%	6.6E-04	25.398
20	25%	3.3E-04	50.796
11	12%	9.5E-05	175.87
5	3%	2.4E-05	703.49
2	0%	2.1E-06	7844.58

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.80
Time for 90% to Settle 100cm	234.50
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINE, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

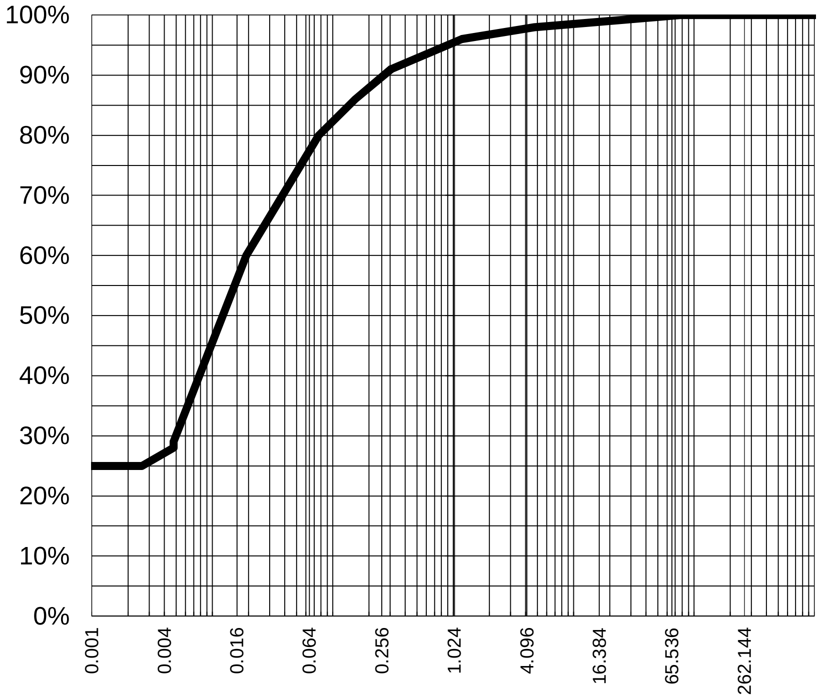
Settling Rates

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-016 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N8B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.7E-04
2.36	98%	4.7	3.5E-03
1.18	96%	1.2	1.4E-02
0.600	91%	0.31	5.4E-02
0.425	86%	0.15	1.1E-01
0.300	80%	0.077	2.2E-01
0.150	60%	0.019	8.7E-01
0.075	29%	0.005	3.5E+00
µm			
55	25%	2.6E-03	6.389
39	25%	1.3E-03	12.779
28	25%	6.5E-04	25.557
20	25%	3.3E-04	51.114
10	20%	8.7E-05	191.68
5	12%	2.4E-05	707.90
2	8%	2.0E-06	8494.82

Time for 50% to Settle 100cm	1.72
Time for 90% to Settle 100cm	3775.47
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

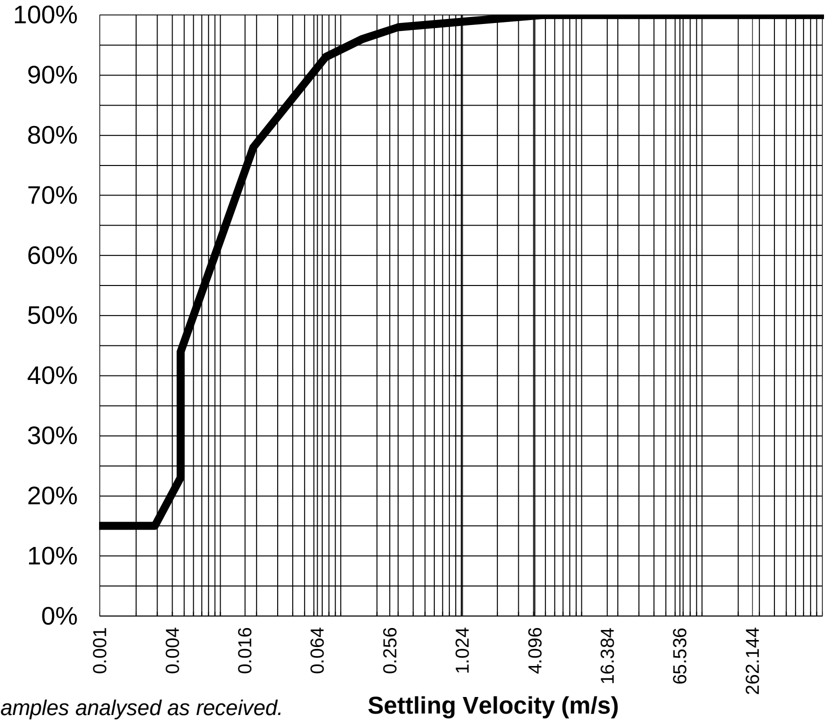
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-017 / SR

PROJECT: WEL SCABS

SAMPLE ID: N9T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.6	3.6E-03
1.18	99%	1.2	1.4E-02
0.600	98%	0.30	5.5E-02
0.425	96%	0.15	1.1E-01
0.300	93%	0.075	2.2E-01
0.150	78%	0.019	8.9E-01
0.075	44%	0.005	3.6E+00
µm			
59	15%	2.9E-03	5.824
41	15%	1.4E-03	11.647
29	15%	7.2E-04	23.294
21	15%	3.6E-04	46.589
11	12%	9.5E-05	174.71
5	9%	2.4E-05	698.83
2	6%	2.0E-06	8385.96

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	3.08
Time for 90% to Settle 100cm	524.12
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Certificate of Analysis

Settling Rates

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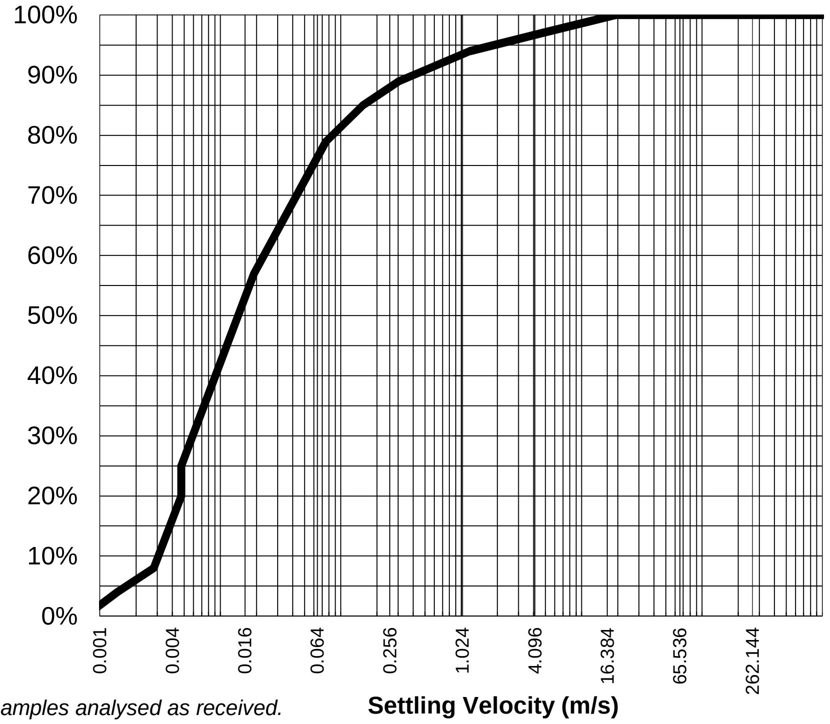
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-018 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N9B



Samples analysed as received.

Particle Size mm	Percent Passing %	Settling Velocity m/s	Time to Settle 100cm min
4.75	100%	19	8.7E-04
2.36	97%	4.7	3.5E-03
1.18	94%	1.2	1.4E-02
0.600	89%	0.30	5.5E-02
0.425	85%	0.15	1.1E-01
0.300	79%	0.076	2.2E-01
0.150	57%	0.019	8.8E-01
0.075	25%	0.005	3.5E+00
µm			
58	8%	2.8E-03	5.936
41	4%	1.4E-03	11.873
30	0%	7.6E-04	22.065
21	0%	3.8E-04	44.131
11	0%	1.0E-04	165.49
5	0%	2.5E-05	661.96
2	0%	2.1E-06	7943.57

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.45
Time for 90% to Settle 100cm	5.44
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINE, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Certificate of Analysis

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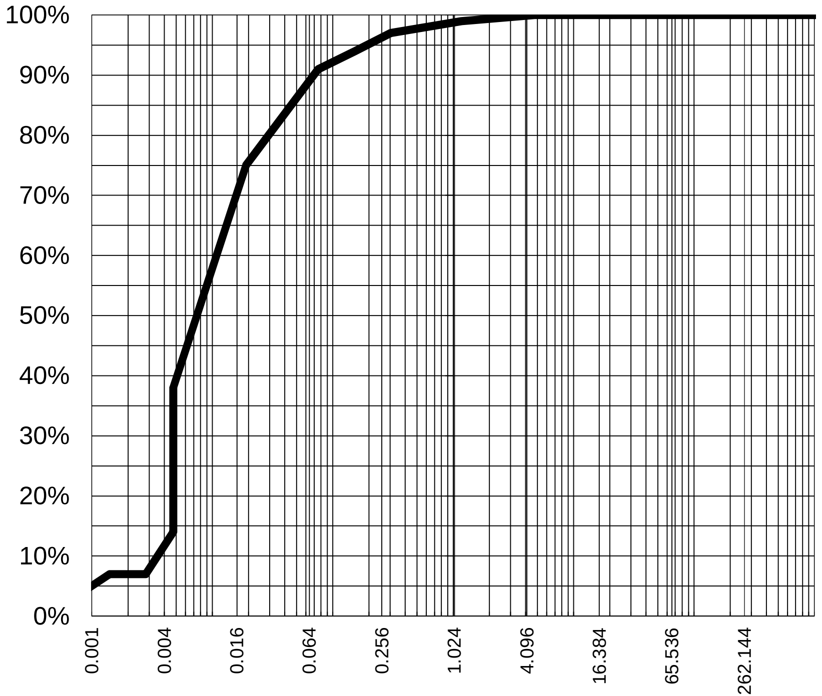
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-019 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N10T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.7	3.5E-03
1.18	99%	1.2	1.4E-02
0.600	97%	0.30	5.5E-02
0.425	94%	0.15	1.1E-01
0.300	91%	0.076	2.2E-01
0.150	75%	0.019	8.8E-01
0.075	38%	0.005	3.5E+00
µm			
58	7%	2.8E-03	5.936
41	7%	1.4E-03	11.873
29	3%	7.0E-04	23.746
21	0%	3.8E-04	44.131
11	0%	1.0E-04	165.49
5	0%	2.5E-05	661.96
2	0%	2.1E-06	7943.57

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.65
Time for 90% to Settle 100cm	4.66
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Template Version SRv2-190502

Certificate of Analysis

Settling Rates

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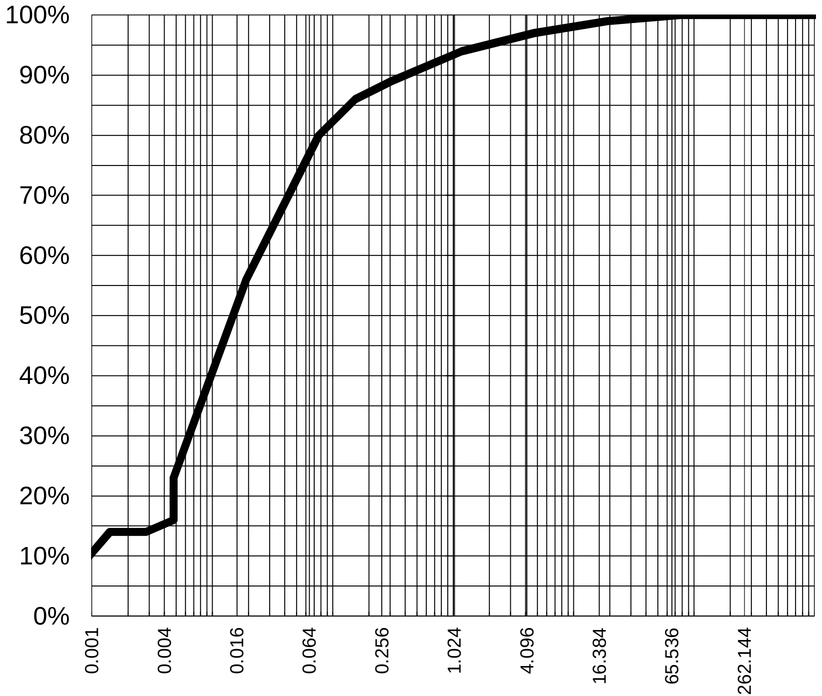
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-020 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N10B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.7E-04
2.36	97%	4.7	3.5E-03
1.18	94%	1.2	1.4E-02
0.600	89%	0.31	5.4E-02
0.425	86%	0.15	1.1E-01
0.300	80%	0.077	2.2E-01
0.150	56%	0.019	8.7E-01
0.075	23%	0.005	3.5E+00
µm			
58	14%	2.8E-03	5.899
41	14%	1.4E-03	11.798
29	7%	7.1E-04	23.597
21	0%	3.8E-04	43.854
11	0%	1.0E-04	164.45
5	0%	2.5E-05	657.81
2	0%	2.1E-06	7893.77

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.35
Time for 90% to Settle 100cm	18.54
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

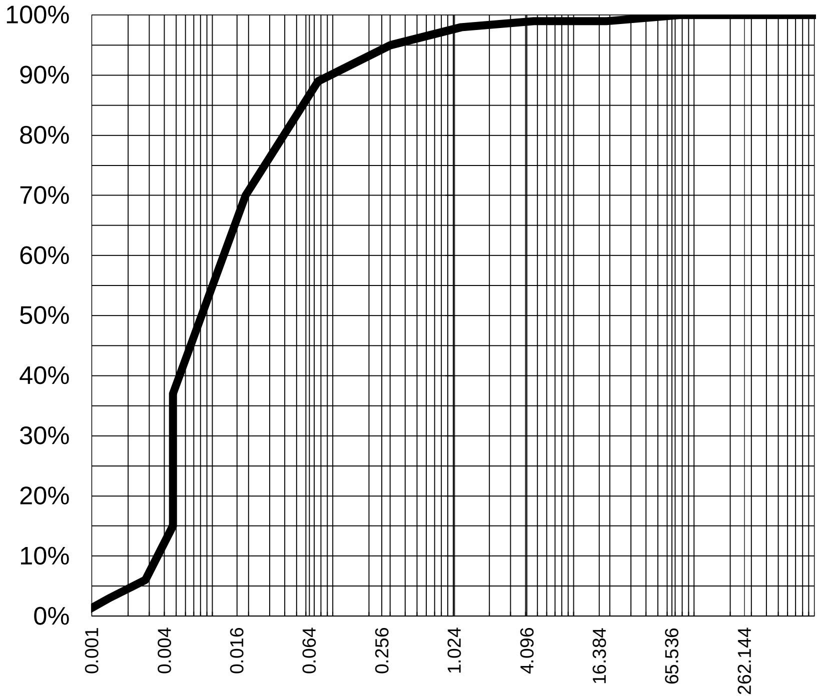
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-021 / SR

PROJECT: WEL SCABS

SAMPLE ID: N11T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	%	m/s	min
9.50	100%	76	2.2E-04
4.75	99%	19	8.8E-04
2.36	99%	4.7	3.6E-03
1.18	98%	1.2	1.4E-02
0.600	95%	0.30	5.5E-02
0.425	92%	0.15	1.1E-01
0.300	89%	0.076	2.2E-01
0.150	70%	0.019	8.8E-01
0.075	37%	0.005	3.5E+00
µm			
58	6%	2.8E-03	5.974
41	3%	1.4E-03	11.948
30	0%	7.5E-04	22.206
21	0%	3.8E-04	44.411
11	0%	1.0E-04	166.54
5	0%	2.5E-05	666.17
2	0%	2.1E-06	7994.01

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.49
Time for 90% to Settle 100cm	4.65
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

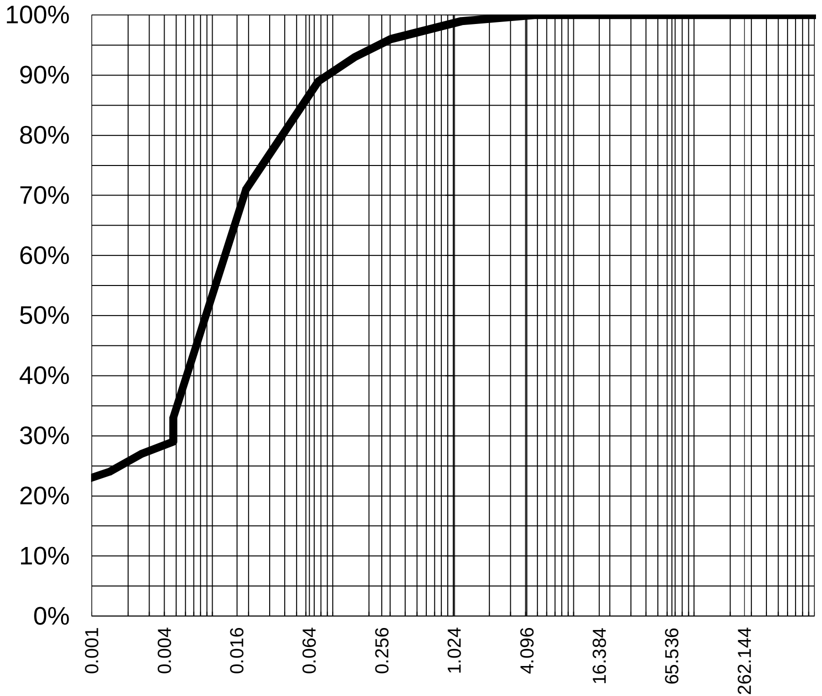
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-022 / SR

PROJECT: WEL SCABS

SAMPLE ID: N11T DUP



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.7	3.5E-03
1.18	99%	1.2	1.4E-02
0.600	96%	0.30	5.5E-02
0.425	93%	0.15	1.1E-01
0.300	89%	0.076	2.2E-01
0.150	71%	0.019	8.8E-01
0.075	33%	0.005	3.5E+00
µm			
55	27%	2.6E-03	6.430
41	24%	1.4E-03	11.873
29	22%	7.0E-04	23.746
20	10%	3.5E-04	47.491
11	5%	9.4E-05	178.09
5	0%	2.5E-05	661.96
2	0%	2.1E-06	7943.57

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.33
Time for 90% to Settle 100cm	89.05
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
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Certificate of Analysis

Settling Rates

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

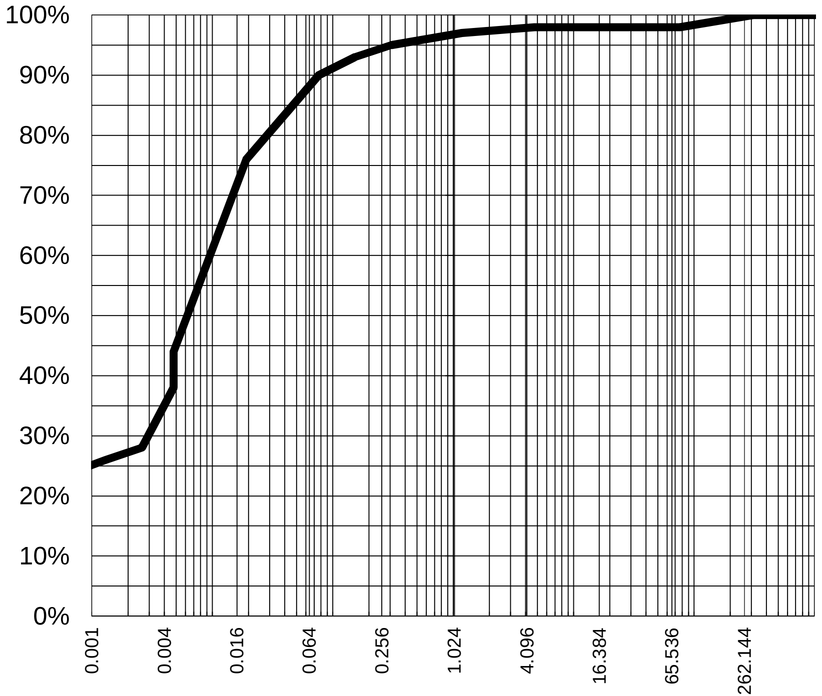
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-023 / SR

PROJECT: WEL SCABS

SAMPLE ID: N13T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
19.0	100%	307	5.4E-05
9.50	98%	77	2.2E-04
4.75	98%	19	8.7E-04
2.36	98%	4.7	3.5E-03
1.18	97%	1.2	1.4E-02
0.600	95%	0.31	5.4E-02
0.425	93%	0.15	1.1E-01
0.300	90%	0.077	2.2E-01
0.150	76%	0.019	8.7E-01
0.075	44%	0.005	3.5E+00
µm			
55	28%	2.6E-03	6.389
39	26%	1.3E-03	12.779
29	24%	7.1E-04	23.597
20	19%	3.5E-04	47.193
11	16%	9.4E-05	176.98
5	10%	2.4E-05	707.90
2	0%	2.1E-06	7893.77

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	3.00
Time for 90% to Settle 100cm	707.90
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Certificate of Analysis

Settling Rates

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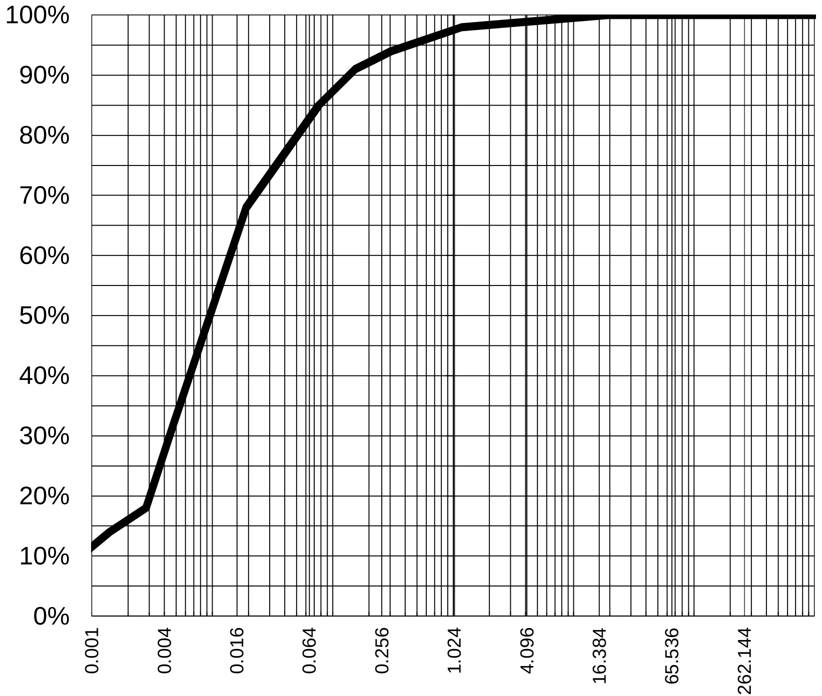
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-024 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N13B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.7E-04
2.36	99%	4.7	3.5E-03
1.18	98%	1.2	1.4E-02
0.600	94%	0.31	5.4E-02
0.425	91%	0.15	1.1E-01
0.300	85%	0.077	2.2E-01
0.150	68%	0.019	8.7E-01
0.075	32%	0.005	3.5E+00
µm			
58	18%	2.8E-03	5.899
41	14%	1.4E-03	11.798
29	9%	7.1E-04	23.597
20	4%	3.5E-04	47.193
11	0%	1.0E-04	164.45
5	0%	2.5E-05	657.81
2	0%	2.1E-06	7893.77

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.18
Time for 90% to Settle 100cm	21.24
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
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Certificate of Analysis

Settling Rates

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

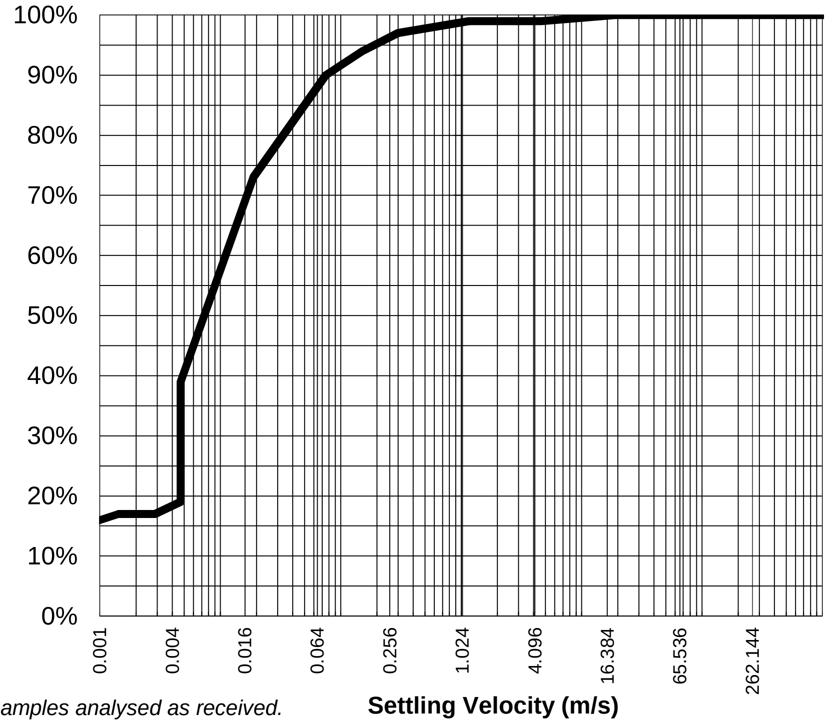
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-025 / SR

PROJECT: WEL SCABS

SAMPLE ID: N14AT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.9E-04
2.36	99%	4.6	3.6E-03
1.18	99%	1.2	1.4E-02
0.600	97%	0.30	5.5E-02
0.425	94%	0.15	1.1E-01
0.300	90%	0.075	2.2E-01
0.150	73%	0.019	8.9E-01
0.075	39%	0.005	3.6E+00
µm			
59	17%	2.9E-03	5.824
41	17%	1.4E-03	11.647
29	15%	7.2E-04	23.294
21	12%	3.6E-04	46.589
11	3%	9.5E-05	174.71
6	0%	2.6E-05	649.38
2	0%	2.1E-06	7792.62

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.69
Time for 90% to Settle 100cm	62.90
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
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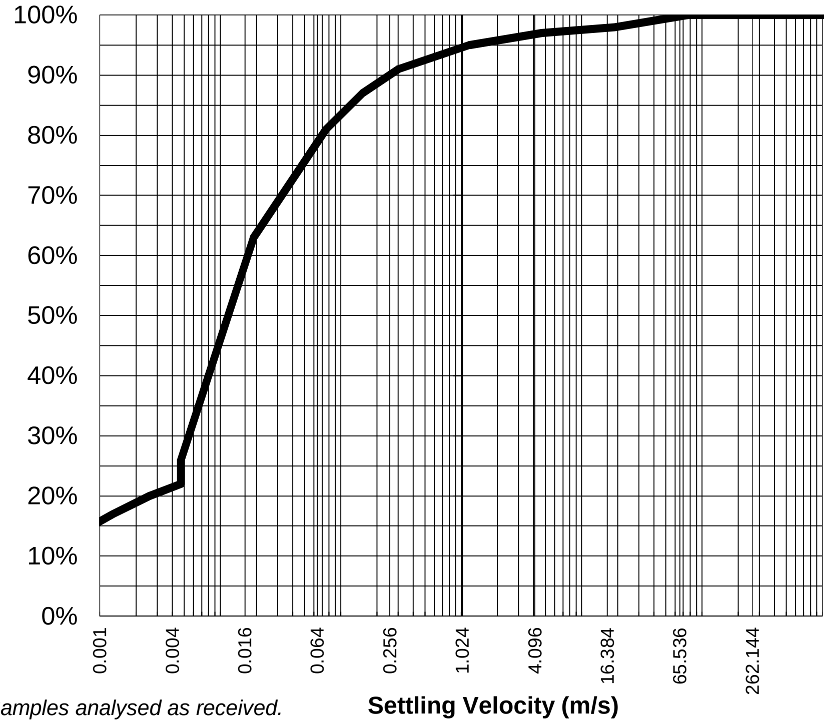
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-026 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14AB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	76	2.2E-04
4.75	98%	19	8.8E-04
2.36	97%	4.7	3.6E-03
1.18	95%	1.2	1.4E-02
0.600	91%	0.30	5.5E-02
0.425	87%	0.15	1.1E-01
0.300	81%	0.076	2.2E-01
0.150	63%	0.019	8.8E-01
0.075	26%	0.005	3.5E+00
µm			
55	20%	2.6E-03	6.470
39	17%	1.3E-03	12.941
29	14%	7.0E-04	23.896
20	11%	3.5E-04	47.793
11	11%	9.3E-05	179.22
5	11%	2.3E-05	716.89
2	8%	1.9E-06	8602.69

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.81
Time for 90% to Settle 100cm	3823.42
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

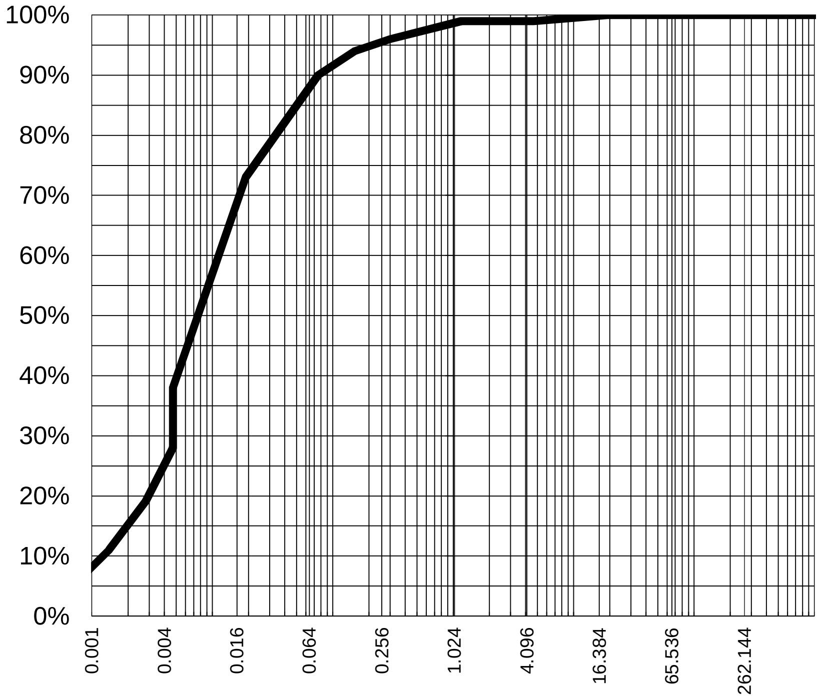
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-027 / SR

PROJECT: WEL SCABS

SAMPLE ID: N14BT



Samples analysed as received.

Particle Size mm	Percent Passing %	Settling Velocity m/s	Time to Settle 100cm min
4.75	100%	19	8.8E-04
2.36	99%	4.7	3.6E-03
1.18	99%	1.2	1.4E-02
0.600	96%	0.30	5.5E-02
0.425	94%	0.15	1.1E-01
0.300	90%	0.076	2.2E-01
0.150	73%	0.019	8.8E-01
0.075	38%	0.005	3.5E+00
µm			
57	19%	2.8E-03	6.005
41	11%	1.4E-03	12.009
29	5%	6.9E-04	24.018
20	3%	3.5E-04	48.037
11	0%	1.0E-04	167.42
5	0%	2.5E-05	669.68
2	0%	2.1E-06	8036.12

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.62
Time for 90% to Settle 100cm	14.01
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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Certificate of Analysis

Settling Rates

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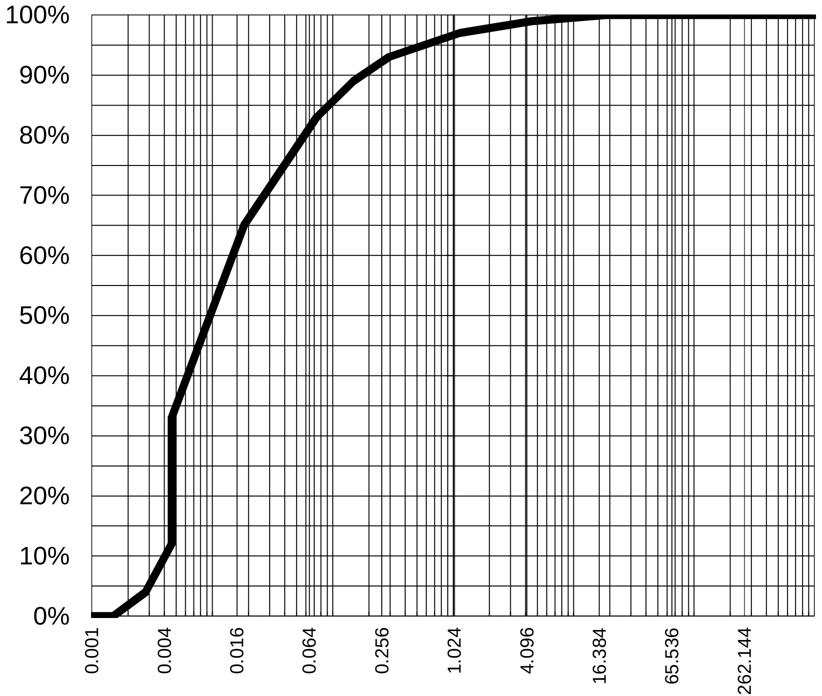
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-028 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14BB



Samples analysed as received. **Settling Velocity (m/s)**

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	18	9.0E-04
2.36	99%	4.6	3.7E-03
1.18	97%	1.1	1.5E-02
0.600	93%	0.29	5.7E-02
0.425	89%	0.15	1.1E-01
0.300	83%	0.074	2.3E-01
0.150	65%	0.018	9.1E-01
0.075	33%	0.005	3.6E+00
µm			
58	4%	2.8E-03	5.968
43	0%	1.5E-03	11.093
30	0%	7.5E-04	22.185
21	0%	3.8E-04	44.371
11	0%	1.0E-04	166.39
6	0%	2.5E-05	665.56
2	0%	2.1E-06	7986.77

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.18
Time for 90% to Settle 100cm	3.73
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINE, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

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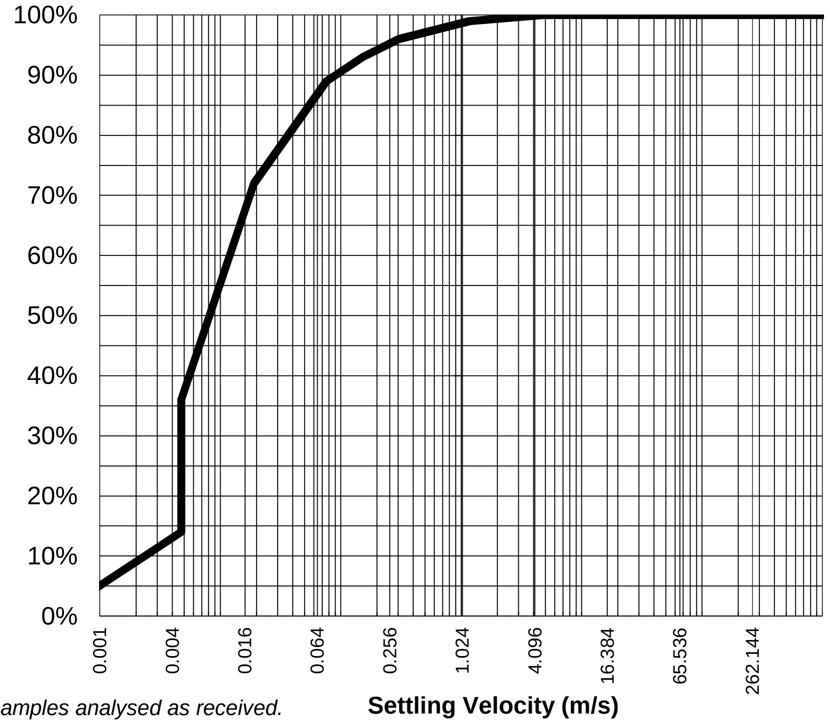
Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-029 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14CT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.7	3.5E-03
1.18	99%	1.2	1.4E-02
0.600	96%	0.30	5.5E-02
0.425	93%	0.15	1.1E-01
0.300	89%	0.076	2.2E-01
0.150	72%	0.019	8.8E-01
0.075	36%	0.005	3.5E+00
µm			
57	11%	2.8E-03	5.967
41	7%	1.4E-03	11.933
29	3%	7.0E-04	23.867
21	0%	3.8E-04	44.363
11	0%	1.0E-04	166.36
5	0%	2.5E-05	665.45
2	0%	2.1E-06	7985.42

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.48
Time for 90% to Settle 100cm	7.46
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Template Version SRv2-190502

Certificate of Analysis

Settling Rates

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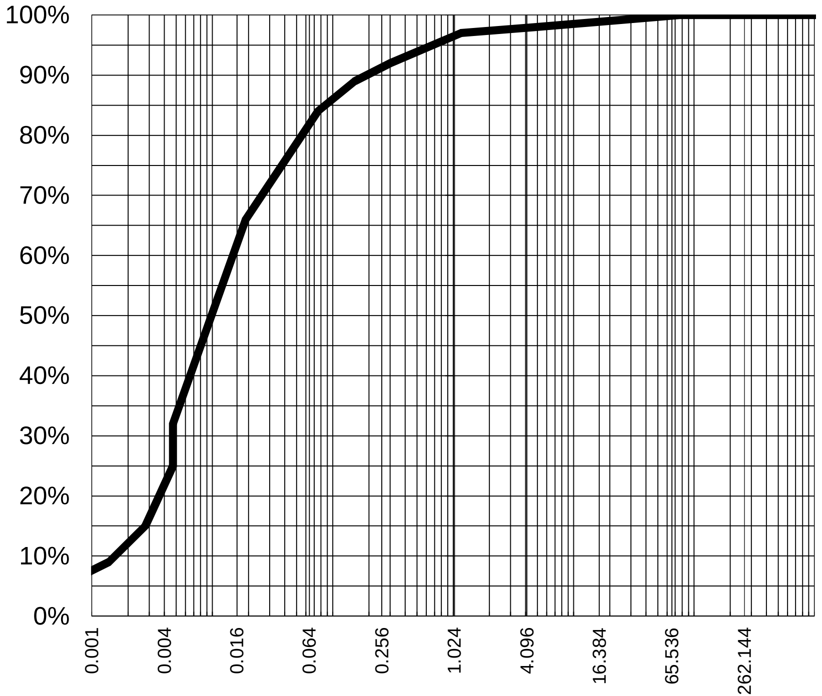
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-030 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N14CB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	76	2.2E-04
4.75	99%	19	8.8E-04
2.36	98%	4.7	3.6E-03
1.18	97%	1.2	1.4E-02
0.600	92%	0.30	5.5E-02
0.425	89%	0.15	1.1E-01
0.300	84%	0.076	2.2E-01
0.150	66%	0.019	8.8E-01
0.075	32%	0.005	3.5E+00
µm			
57	15%	2.8E-03	6.005
41	9%	1.4E-03	12.009
29	6%	6.9E-04	24.018
20	3%	3.5E-04	48.037
11	0%	1.0E-04	167.42
5	0%	2.5E-05	669.68
2	0%	2.1E-06	8036.12

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.13
Time for 90% to Settle 100cm	11.01
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Settling Velocity in: Typical seawater (density 1.025)

Limit of Reporting: 1%

Analysed: 17-Apr-19

Dispersion Method Shaker

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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ALS Environmental

Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

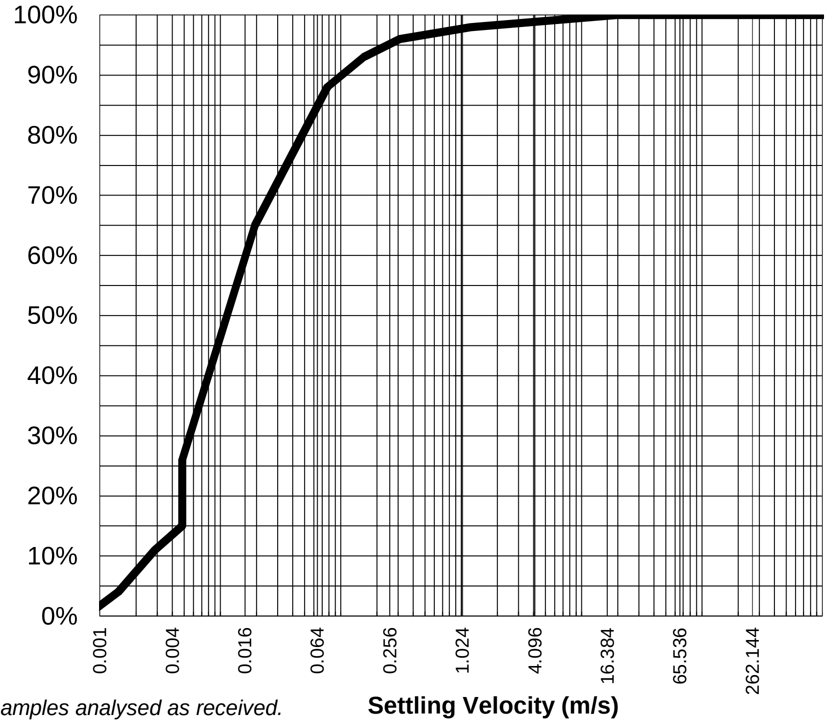
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-031 / SR

PROJECT: WEL SCABS

SAMPLE ID: N15T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.6E-04
2.36	99%	4.8	3.5E-03
1.18	98%	1.2	1.4E-02
0.600	96%	0.31	5.4E-02
0.425	93%	0.16	1.1E-01
0.300	88%	0.077	2.2E-01
0.150	65%	0.019	8.6E-01
0.075	26%	0.005	3.4E+00
µm			
57	11%	2.8E-03	5.856
41	4%	1.4E-03	11.712
30	0%	7.7E-04	21.770
21	0%	3.8E-04	43.539
11	0%	1.0E-04	163.27
5	0%	2.6E-05	653.09
2	0%	2.1E-06	7837.09

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.85
Time for 90% to Settle 100cm	6.69
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

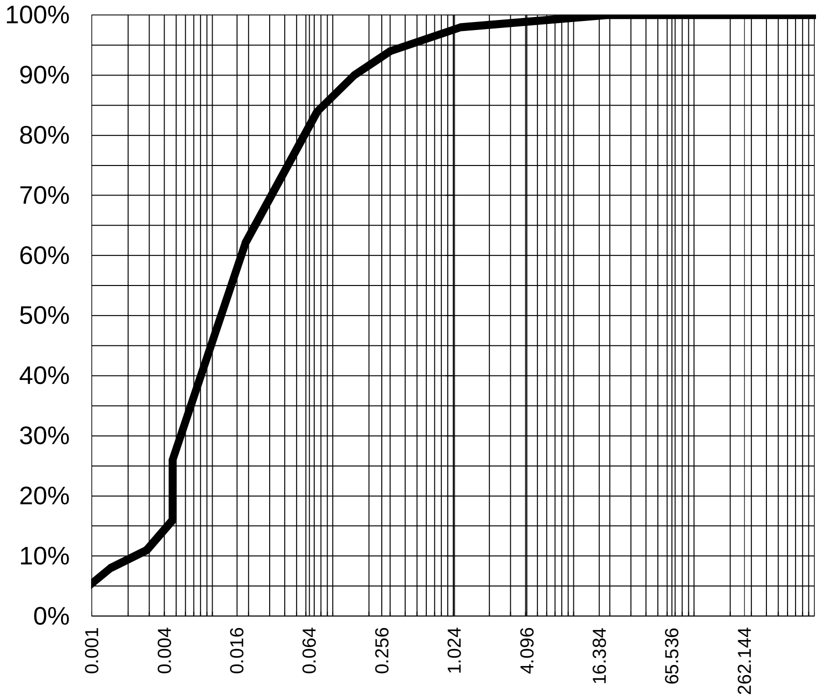
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-032 / SR

PROJECT: WEL SCABS

SAMPLE ID: N15B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.9E-04
2.36	99%	4.6	3.6E-03
1.18	98%	1.2	1.4E-02
0.600	94%	0.30	5.5E-02
0.425	90%	0.15	1.1E-01
0.300	84%	0.075	2.2E-01
0.150	62%	0.019	8.9E-01
0.075	26%	0.005	3.6E+00
µm			
58	11%	2.8E-03	5.853
41	8%	1.4E-03	11.707
29	3%	7.1E-04	23.413
21	3%	3.6E-04	46.826
11	0%	1.0E-04	163.20
6	0%	2.6E-05	652.81
2	0%	2.1E-06	7833.67

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.78
Time for 90% to Settle 100cm	7.81
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
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Certificate of Analysis

Settling Rates

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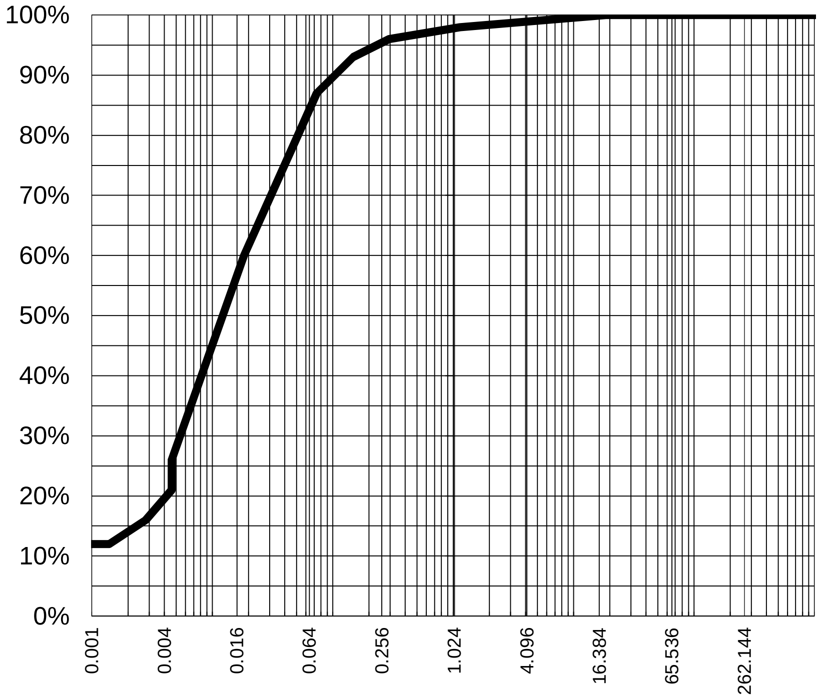
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-033 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R2T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	18	9.0E-04
2.36	99%	4.6	3.7E-03
1.18	98%	1.1	1.5E-02
0.600	96%	0.29	5.7E-02
0.425	93%	0.15	1.1E-01
0.300	87%	0.074	2.3E-01
0.150	60%	0.018	9.1E-01
0.075	26%	0.005	3.6E+00
µm			
58	16%	2.8E-03	5.968
41	12%	1.4E-03	11.935
29	12%	7.0E-04	23.871
21	10%	3.5E-04	47.742
11	6%	9.3E-05	179.03
5	6%	2.3E-05	716.12
2	6%	1.9E-06	8593.48

Time for 50% to Settle 100cm	1.71
Time for 90% to Settle 100cm	47.74
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Settling Velocity in: Typical seawater (density 1.025)

Limit of Reporting: 1%

Analysed: 17-Apr-19

Dispersion Method Shaker

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Template Version SRv2-190502

Certificate of Analysis

Settling Rates

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

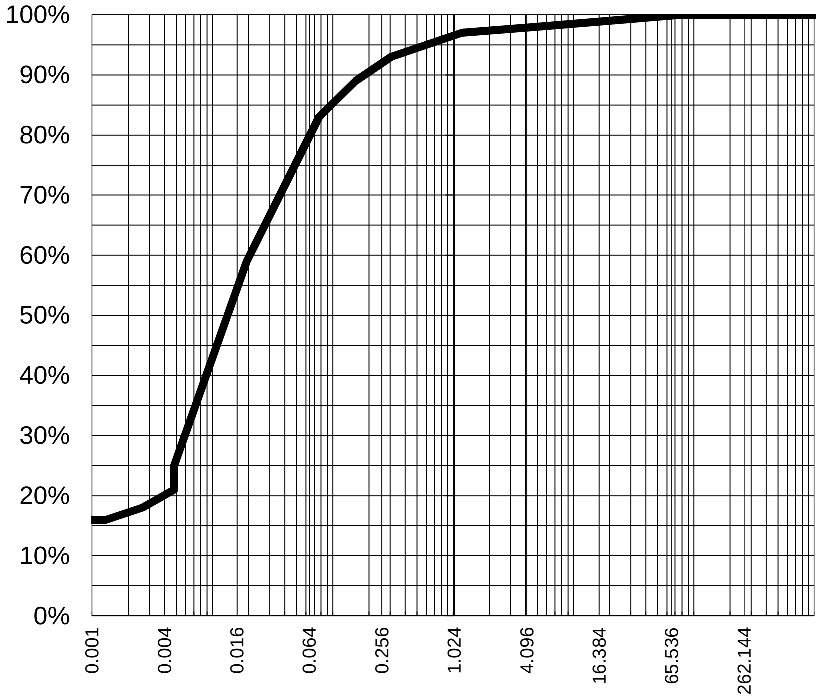
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-034 / SR

PROJECT: WEL SCABS

SAMPLE ID: R2B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.6E-04
2.36	98%	4.8	3.5E-03
1.18	97%	1.2	1.4E-02
0.600	93%	0.31	5.4E-02
0.425	89%	0.15	1.1E-01
0.300	83%	0.077	2.2E-01
0.150	59%	0.019	8.7E-01
0.075	25%	0.005	3.5E+00
µm			
55	18%	2.6E-03	6.385
39	16%	1.3E-03	12.769
28	16%	6.5E-04	25.538
20	16%	3.3E-04	51.077
10	13%	9.4E-05	176.77
5	13%	2.4E-05	707.08
2	13%	2.0E-06	8484.96

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.55
Time for 90% to Settle 100cm	>1440
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	<0.0005

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

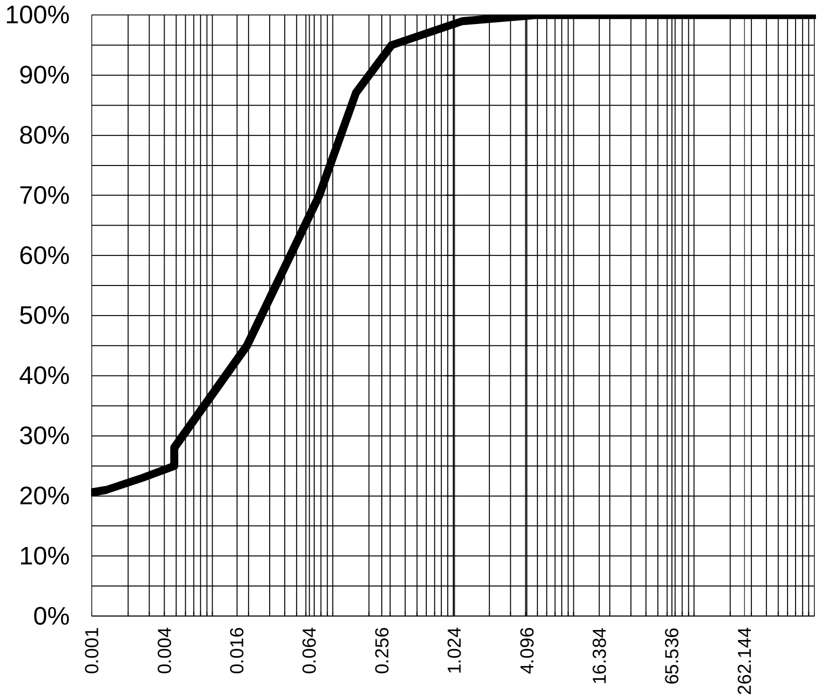
Settling Rates

ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW   2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-035 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N22BT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.8	3.5E-03
1.18	99%	1.2	1.4E-02
0.600	95%	0.31	5.4E-02
0.425	87%	0.16	1.1E-01
0.300	70%	0.077	2.2E-01
0.150	45%	0.019	8.6E-01
0.075	28%	0.005	3.4E+00
µm			
55	23%	2.6E-03	6.345
39	21%	1.3E-03	12.690
28	20%	6.6E-04	25.380
20	19%	3.3E-04	50.760
10	17%	8.8E-05	190.35
5	16%	2.2E-05	761.40
1	16%	1.8E-06	9136.85

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	0.73
Time for 90% to Settle 100cm	>1440
Settling Rate at 50% settled (m/s)	0.03
Settling Rate at 90% settled (m/s)	<0.0005

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
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Certificate of Analysis

Settling Rates

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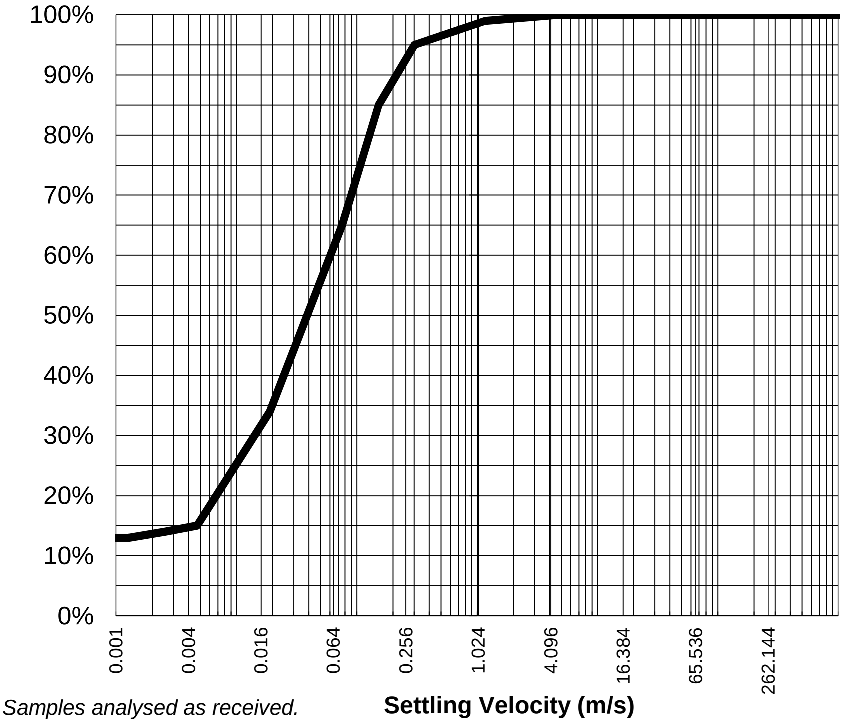
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-036 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	N22CT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
2.36	100%	4.7	3.6E-03
1.18	99%	1.2	1.4E-02
0.600	95%	0.30	5.5E-02
0.425	85%	0.15	1.1E-01
0.300	65%	0.076	2.2E-01
0.150	34%	0.019	8.8E-01
0.075	15%	0.005	3.5E+00
µm			
55	14%	2.6E-03	6.506
39	13%	1.3E-03	13.012
28	13%	6.4E-04	26.025
20	13%	3.2E-04	52.049
10	12%	8.5E-05	195.19
5	12%	2.1E-05	780.74
1	12%	1.8E-06	9368.90

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	0.54
Time for 90% to Settle 100cm	>1440
Settling Rate at 50% settled (m/s)	0.05
Settling Rate at 90% settled (m/s)	<0.0005

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Settling Rates

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Newcastle, NSW

CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

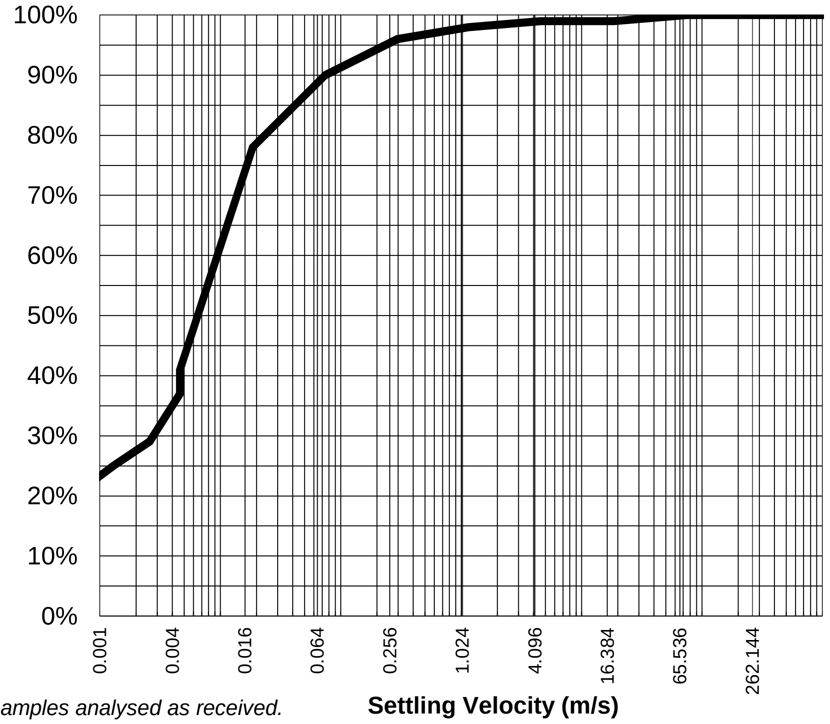
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-037 / SR

PROJECT: WEL SCABS

SAMPLE ID: R4T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	74	2.2E-04
4.75	99%	19	9.0E-04
2.36	99%	4.6	3.6E-03
1.18	98%	1.1	1.5E-02
0.600	96%	0.30	5.6E-02
0.425	93%	0.15	1.1E-01
0.300	90%	0.074	2.2E-01
0.150	78%	0.019	9.0E-01
0.075	41%	0.005	3.6E+00
µm			
56	29%	2.6E-03	6.424
40	25%	1.3E-03	12.849
29	21%	7.0E-04	23.716
21	16%	3.5E-04	47.433
11	12%	9.4E-05	177.87
5	8%	2.3E-05	711.49
2	8%	2.0E-06	8537.86

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.94
Time for 90% to Settle 100cm	355.75
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

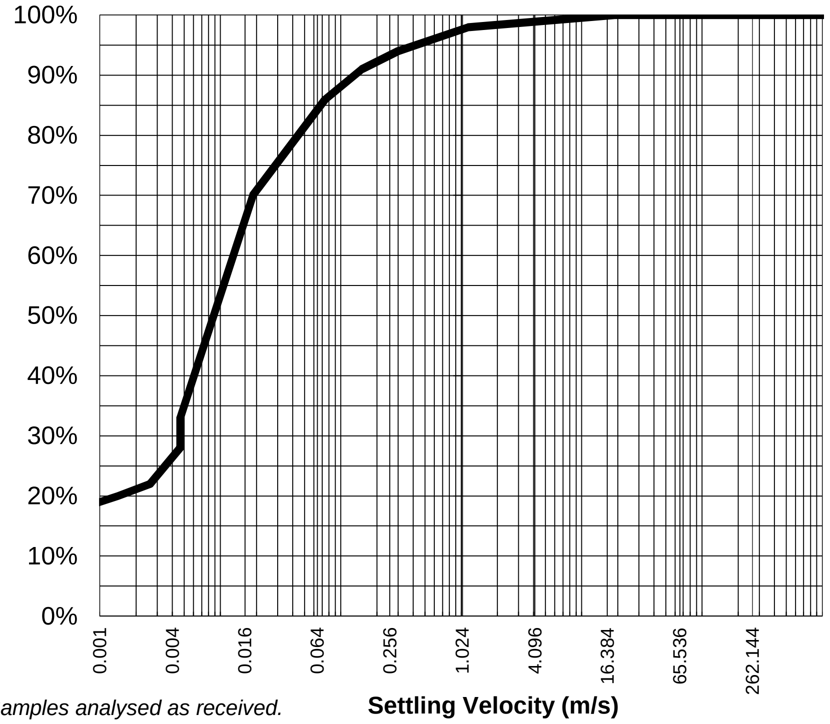
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-038 / SR

PROJECT: WEL SCABS

SAMPLE ID: R4B



Samples analysed as received.

Particle Size mm	Percent Passing %	Settling Velocity m/s	Time to Settle 100cm min
4.75	100%	19	8.9E-04
2.36	99%	4.6	3.6E-03
1.18	98%	1.2	1.4E-02
0.600	94%	0.30	5.6E-02
0.425	91%	0.15	1.1E-01
0.300	86%	0.075	2.2E-01
0.150	70%	0.019	8.9E-01
0.075	33%	0.005	3.6E+00
µm			
56	22%	2.6E-03	6.383
41	20%	1.4E-03	11.782
29	18%	7.1E-04	23.564
21	12%	3.5E-04	47.128
11	8%	9.4E-05	176.73
5	8%	2.4E-05	706.91
2	8%	2.0E-06	8482.95

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.34
Time for 90% to Settle 100cm	132.55
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Settling Rates

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CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

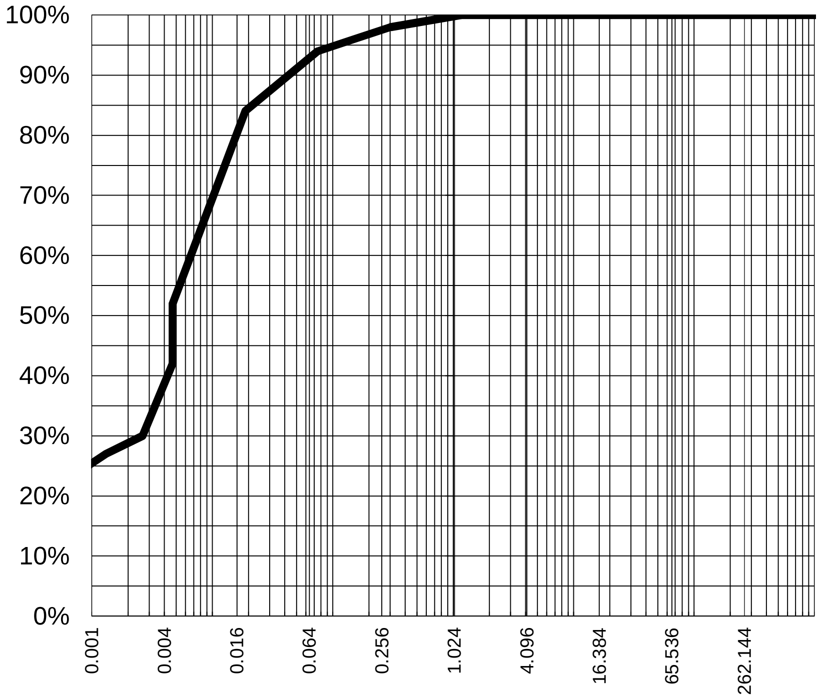
DATE RECEIVED: 13-Dec-2018

ADDRESS:
Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-039 / SR

PROJECT: WEL SCABS

SAMPLE ID: R7AT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
1.18	100%	1.2	1.4E-02
0.600	98%	0.30	5.5E-02
0.425	96%	0.15	1.1E-01
0.300	94%	0.075	2.2E-01
0.150	84%	0.019	8.9E-01
0.075	52%	0.005	3.6E+00
µm			
56	30%	2.6E-03	6.342
40	27%	1.3E-03	12.685
28	23%	6.6E-04	25.369
21	17%	3.6E-04	46.826
11	11%	9.5E-05	175.60
5	9%	2.4E-05	702.40
2	8%	2.0E-06	8428.75

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	3.53
Time for 90% to Settle 100cm	263.40
Settling Rate at 50% settled (m/s)	0.00
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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Certificate of Analysis

Settling Rates

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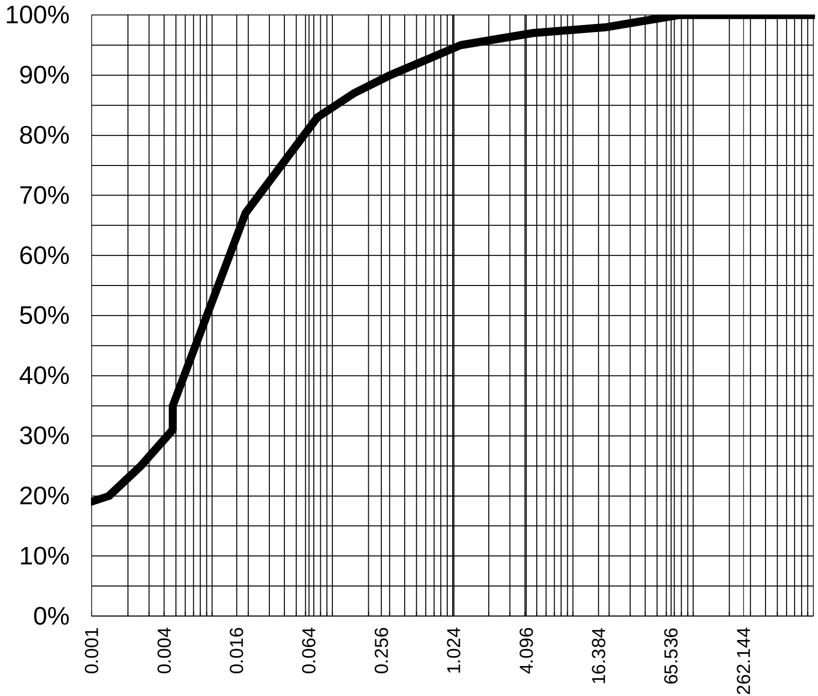
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-040 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7AB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	76	2.2E-04
4.75	98%	19	8.8E-04
2.36	97%	4.7	3.6E-03
1.18	95%	1.2	1.4E-02
0.600	90%	0.30	5.5E-02
0.425	87%	0.15	1.1E-01
0.300	83%	0.076	2.2E-01
0.150	67%	0.019	8.8E-01
0.075	35%	0.005	3.5E+00
µm			
55	25%	2.6E-03	6.506
41	20%	1.4E-03	12.009
29	18%	6.9E-04	24.018
20	16%	3.5E-04	48.037
10	10%	9.3E-05	180.14
5	10%	2.3E-05	720.55
2	8%	1.9E-06	8646.58

Time for 50% to Settle 100cm	2.29
Time for 90% to Settle 100cm	720.55
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
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Certificate of Analysis

Settling Rates

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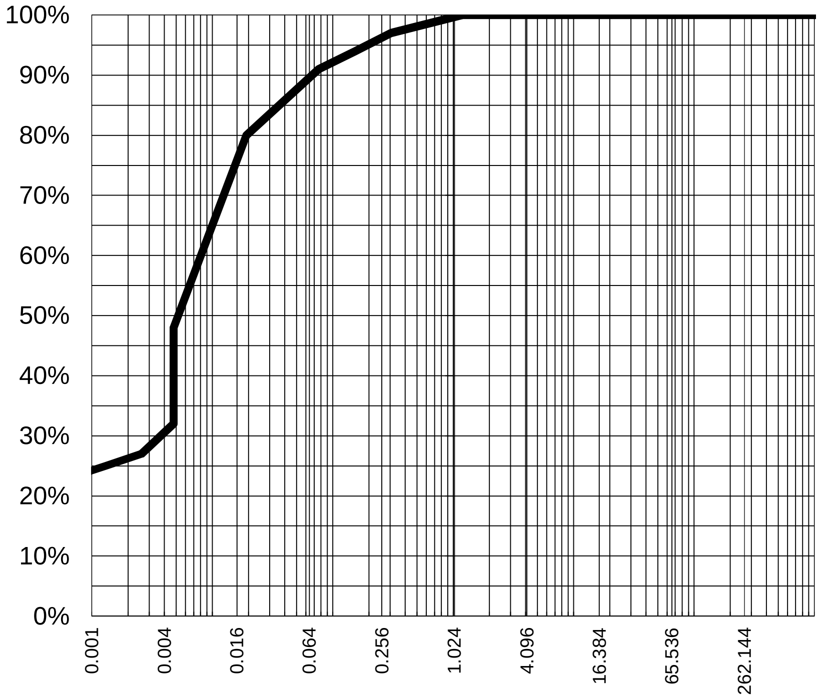
ALS Environmental

Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-041 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7BT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
1.18	100%	1.2	1.4E-02
0.600	97%	0.31	5.4E-02
0.425	94%	0.15	1.1E-01
0.300	91%	0.077	2.2E-01
0.150	80%	0.019	8.7E-01
0.075	48%	0.005	3.5E+00
µm			
55	27%	2.6E-03	6.425
39	25%	1.3E-03	12.849
28	23%	6.5E-04	25.698
20	15%	3.5E-04	47.434
10	8%	9.4E-05	177.88
5	8%	2.3E-05	711.51
2	8%	2.0E-06	8538.16

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	3.32
Time for 90% to Settle 100cm	118.59
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Template Version SRv2-190502

Certificate of Analysis

Settling Rates

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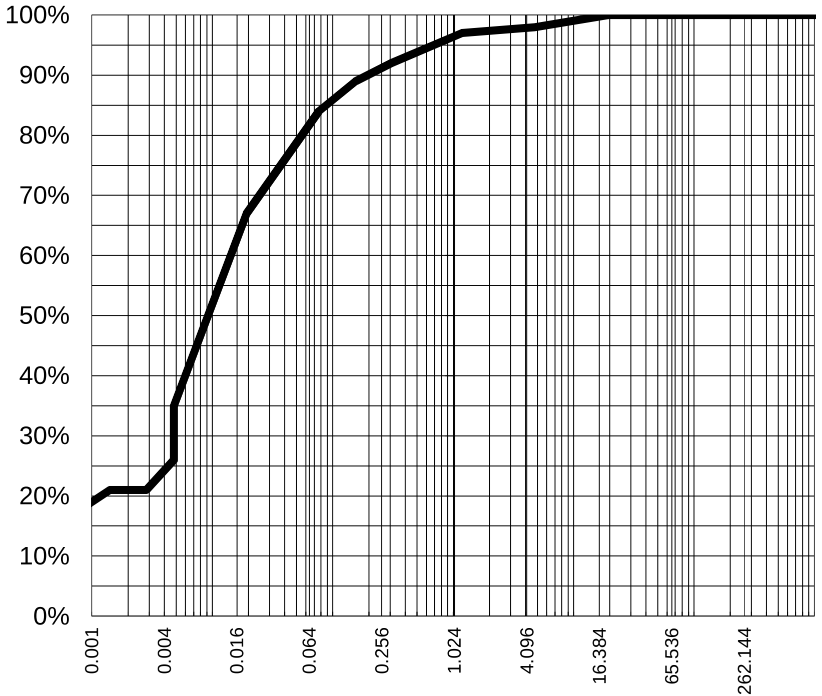
Newcastle, NSW

CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-042 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7BB



Samples analysed as received. **Settling Velocity (m/s)**

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.6E-04
2.36	98%	4.8	3.5E-03
1.18	97%	1.2	1.4E-02
0.600	92%	0.31	5.4E-02
0.425	89%	0.15	1.1E-01
0.300	84%	0.077	2.2E-01
0.150	67%	0.019	8.7E-01
0.075	35%	0.005	3.5E+00
µm			
57	21%	2.8E-03	5.892
41	21%	1.4E-03	11.785
29	17%	7.1E-04	23.569
20	13%	3.5E-04	47.139
10	9%	9.4E-05	176.77
5	9%	2.4E-05	707.08
2	9%	2.0E-06	8484.96

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.25
Time for 90% to Settle 100cm	88.39
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
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Template Version SRv2-190502

Certificate of Analysis

Settling Rates

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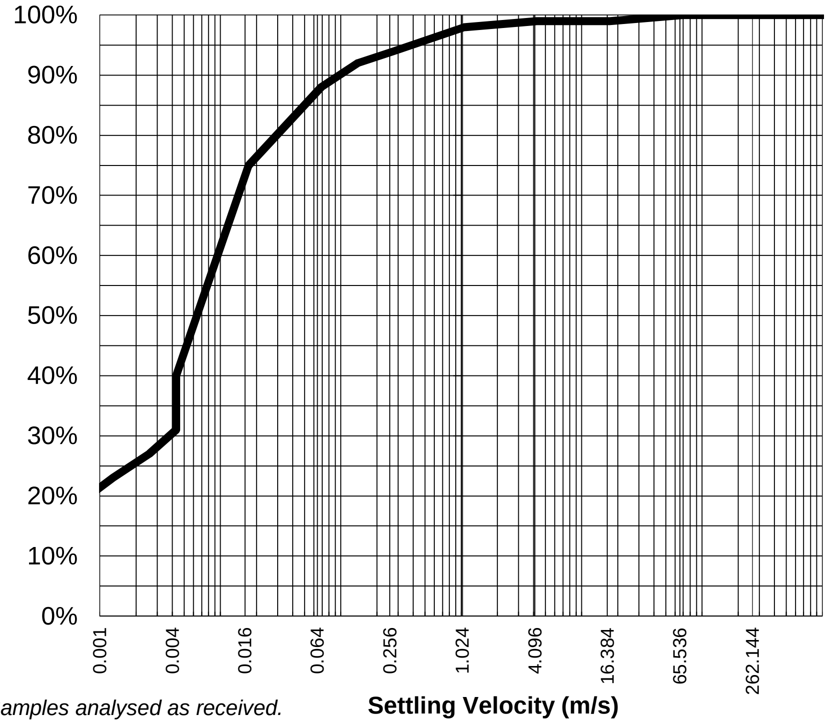
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-043 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7CT



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	69	2.4E-04
4.75	99%	17	9.7E-04
2.36	99%	4.3	3.9E-03
1.18	98%	1.1	1.6E-02
0.600	94%	0.28	6.1E-02
0.425	92%	0.14	1.2E-01
0.300	88%	0.069	2.4E-01
0.150	75%	0.017	9.7E-01
0.075	40%	0.004	3.9E+00
µm			
58	27%	2.6E-03	6.472
41	23%	1.3E-03	12.944
30	19%	7.0E-04	23.892
21	11%	3.5E-04	47.785
11	9%	9.3E-05	179.19
6	8%	2.3E-05	716.77
2	8%	1.9E-06	8601.26

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	3.04
Time for 90% to Settle 100cm	134.40
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
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Settling Rates

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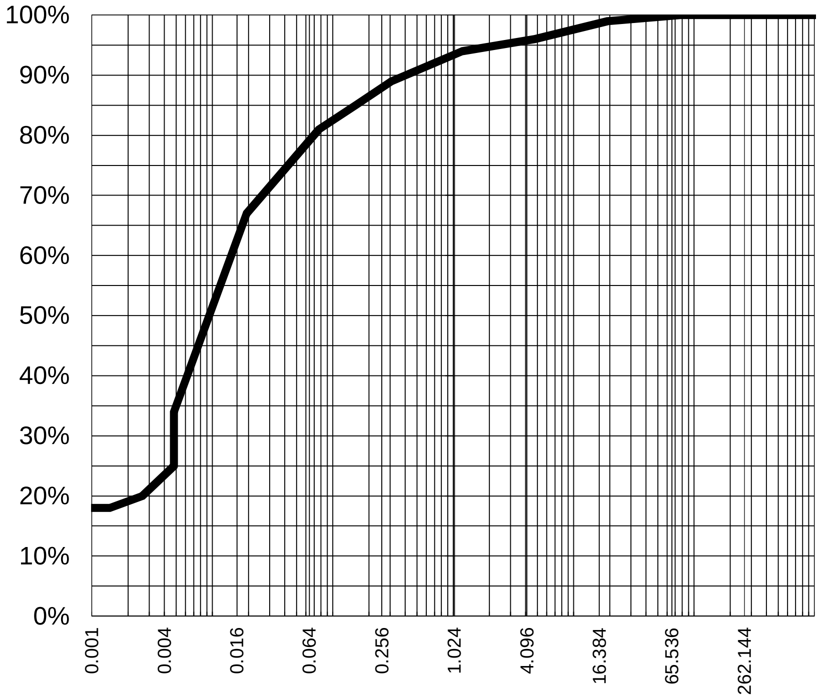
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-044 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R7CB



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.6E-04
2.36	96%	4.8	3.5E-03
1.18	94%	1.2	1.4E-02
0.600	89%	0.31	5.4E-02
0.425	85%	0.15	1.1E-01
0.300	81%	0.077	2.2E-01
0.150	67%	0.019	8.7E-01
0.075	34%	0.005	3.5E+00
µm			
55	20%	2.6E-03	6.385
41	18%	1.4E-03	11.785
29	18%	7.1E-04	23.569
20	14%	3.5E-04	47.139
10	7%	9.4E-05	176.77
5	7%	2.4E-05	707.08
2	7%	2.0E-06	8484.96

Time for 50% to Settle 100cm	2.20
Time for 90% to Settle 100cm	110.48
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Certificate of Analysis

Settling Rates

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5/585 Maitland Road
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fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

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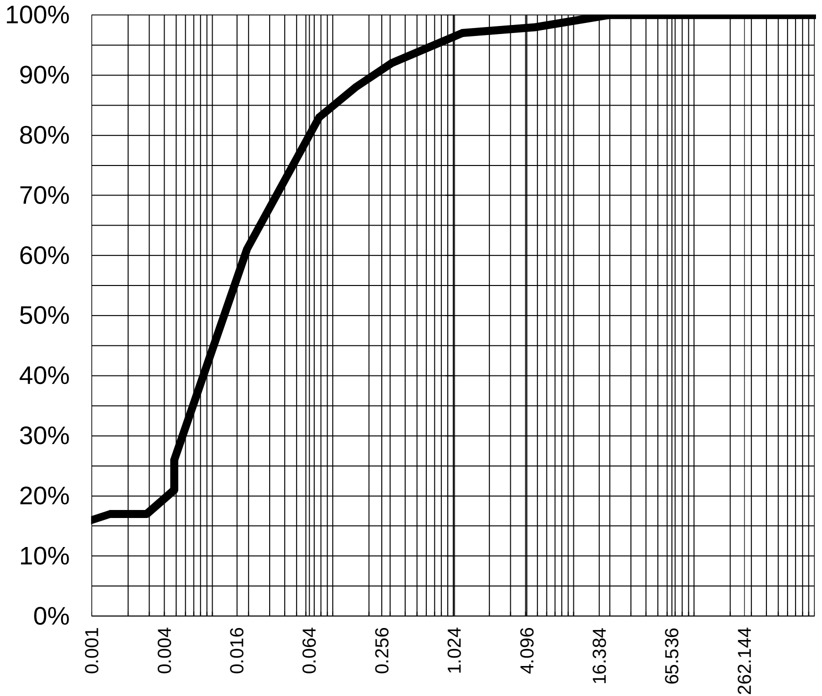
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-045 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R3T



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
4.75	100%	19	8.6E-04
2.36	98%	4.8	3.5E-03
1.18	97%	1.2	1.4E-02
0.600	92%	0.31	5.4E-02
0.425	88%	0.16	1.1E-01
0.300	83%	0.077	2.2E-01
0.150	61%	0.019	8.6E-01
0.075	26%	0.005	3.4E+00
µm			
57	17%	2.8E-03	5.856
41	17%	1.4E-03	11.712
29	15%	7.1E-04	23.423
20	15%	3.6E-04	46.847
10	8%	9.5E-05	175.68
5	7%	2.4E-05	702.70
2	7%	2.0E-06	8432.42

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	1.67
Time for 90% to Settle 100cm	87.84
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	0.00

Sample Description:	FINE, SAND, SHELL		
Test Method:	AS1289.3.6.1/AS1289.3.6.3	**Analysed:**	17-Apr-19
Settling Velocity in:	Typical seawater (density 1.025)	**Dispersion Method**	Shaker
Limit of Reporting:	1%	**Hydrometer Type**	ASTM E100

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Settling Rates

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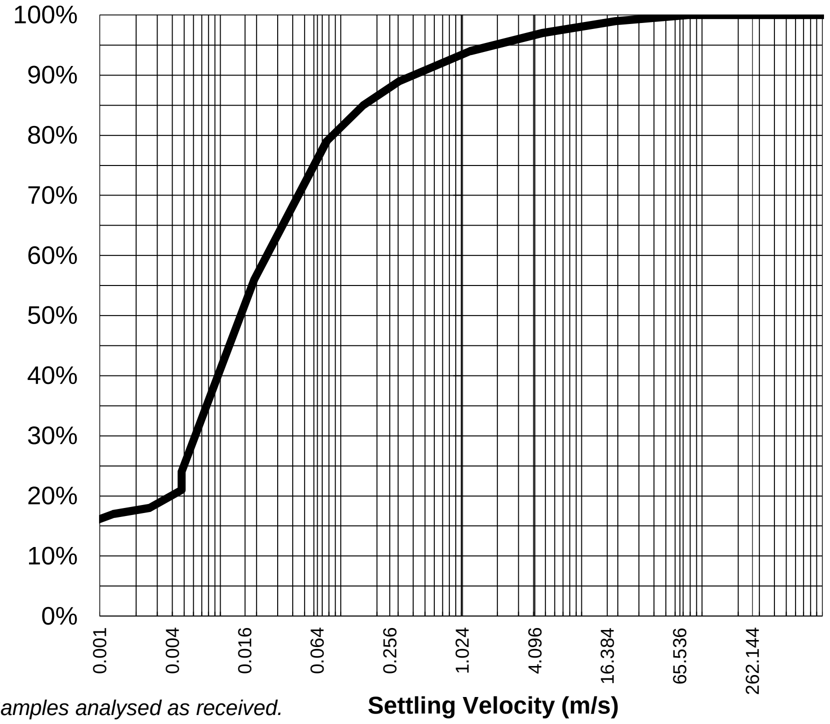
CLIENT:	Paul Nichols	**DATE REPORTED:**	2-May-2019
COMPANY:	WorleyParsons Services Pty Ltd	**DATE RECEIVED:**	13-Dec-2018
ADDRESS:	Level 4, 600 Murray Street West Perth WA, AUSTRALIA	**REPORT NUMBER:**	EP1902982-046 / SR
PROJECT:	WEL SCABS	**SAMPLE ID:**	R3B



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
9.50	100%	77	2.2E-04
4.75	99%	19	8.7E-04
2.36	97%	4.7	3.5E-03
1.18	94%	1.2	1.4E-02
0.600	89%	0.31	5.4E-02
0.425	85%	0.15	1.1E-01
0.300	79%	0.077	2.2E-01
0.150	56%	0.019	8.7E-01
0.075	24%	0.005	3.5E+00
µm			
55	18%	2.6E-03	6.425
39	17%	1.3E-03	12.849
29	15%	7.0E-04	23.717
20	15%	3.5E-04	47.434
10	12%	9.4E-05	177.88
5	12%	2.3E-05	711.51
2	12%	2.0E-06	8538.16

Time for 50% to Settle 100cm	1.36
Time for 90% to Settle 100cm	>1440
Settling Rate at 50% settled (m/s)	0.02
Settling Rate at 90% settled (m/s)	<0.0005

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

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CLIENT: Paul Nichols

DATE REPORTED: 2-May-2019

COMPANY: WorleyParsons Services Pty Ltd

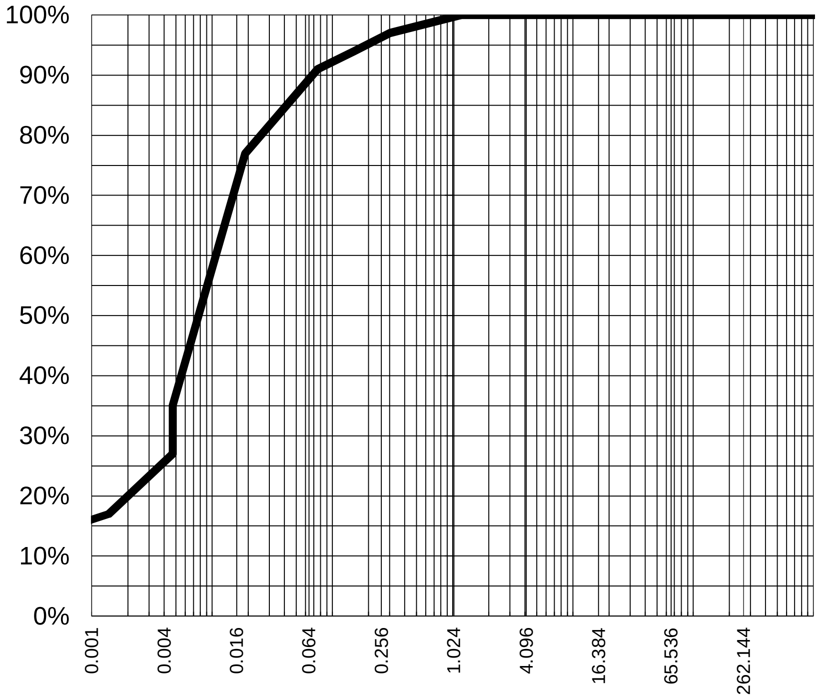
DATE RECEIVED: 13-Dec-2018

ADDRESS: Level 4, 600 Murray Street
West Perth
WA, AUSTRALIA

REPORT NUMBER: EP1902982-047 / SR

PROJECT: WEL SCABS

SAMPLE ID: R4T DUP



Samples analysed as received.

Particle Size	Percent Passing	Settling Velocity	Time to Settle 100cm
mm	**%**	**m/s**	**min**
1.18	100%	1.2	1.4E-02
0.600	97%	0.30	5.5E-02
0.425	94%	0.15	1.1E-01
0.300	91%	0.076	2.2E-01
0.150	77%	0.019	8.8E-01
0.075	35%	0.005	3.5E+00
µm			
55	22%	2.6E-03	6.506
41	17%	1.4E-03	12.009
29	15%	6.9E-04	24.018
20	15%	3.5E-04	48.037
10	13%	9.3E-05	180.14
5	13%	2.3E-05	720.55
2	13%	1.9E-06	8646.58

Analysis Notes

Samples were dispersed in synthetic seawater for hydrometer analysis and particle size results were corrected for differences in salinity. Settling velocities are calculated on the basis of typical seawater salinity.

Time for 50% to Settle 100cm	2.58
Time for 90% to Settle 100cm	>1440
Settling Rate at 50% settled (m/s)	0.01
Settling Rate at 90% settled (m/s)	<0.0005

Sample Description: FINE, SAND, SHELL

Test Method: AS1289.3.6.1/AS1289.3.6.3

Analysed: 17-Apr-19

Settling Velocity in: Typical seawater (density 1.025)

Dispersion Method Shaker

Limit of Reporting: 1%

Hydrometer Type ASTM E100

Peter Keyte
Technical Manager Air
Authorised Signatory

Appendix C

Dampier Archipelago Commonwealth Waters Marine Benthic Habitat Survey

Dampier Archipelago

Commonwealth Waters Marine Benthic Habitat Survey

18 January 2019

Level 4, 600 Murray St
West Perth WA 6005
Australia

401012-02612-EN-REP-0001

www.**advisian**.com

Advisian
WorleyParsons Group

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Project No: SPA-ENG-00-EN-REP-0001 – Dampier Archipelago: Commonwealth Waters Marine Benthic Habitat Survey

Rev	Description	Author	Review	WorleyParsons Approval	Date
A	Issued for Client Review	A Lemmon	H Houridis	P Nichols	18/01/2019
0	Issued for use	A Lemmon	P Raitt	P Nichols	18/04/2019
1	Updated with client comments and issued for use	A Lemmon	P Nichols	P Nichols	13/02/2019
2	Further client comments addressed - issued for use			P Nichols	18/04/2019

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Executive Summary

The Scarborough gas resource is located approximately 375 km west-north-west off the Burrup Peninsula and is part of the Greater Scarborough gas fields which are estimated to hold 9.2 Tcf (2C, 100%) of dry gas. Woodside is proposing to develop the Scarborough gas resource through new offshore facilities connected by an approximately 430 km pipeline onshore. The proposal is to initially develop the Scarborough gas field with wells, tied back to a semi-submersible floating production unit (FPU) moored in 900 m of water close to the Scarborough field. This report has been developed in support of environmental approvals associated with the Scarborough Project.

As part of the trunkline installation, Woodside is assessing the feasibility of using backfill material from a potential borrow ground that has been identified in Commonwealth Waters. The potential borrow ground is located adjacent to the north-western extent of the habitat protection zone of the Dampier Marine Park. A benthic habitat survey of the potential borrow ground and surrounding areas within the Dampier Marine Park was commissioned (this study) to support the environmental impact assessment of the intended activities.

Surveys of marine benthic habitat of the potential borrow ground and nearby areas within the Dampier Marine Park were undertaken between 18th and 20th December 2018. This report presents the methodology and results from the survey.

Bare sandy substrate dominated most of the locations where towed/drop camera transects were conducted. Where biota was observed, it typically consisted of invertebrates such as anemones and crinoids at densities no greater than 10% and typically less than 5% cover. Of the 24 survey locations within the potential borrow ground, sparse invertebrate cover was observed at only two locations. Of the 51 survey locations within the habitat protection zone of the Dampier Marine Park, sparse invertebrate cover was observed at 12 locations.

1 Introduction

1.1 Project Background

Woodside is assessing the feasibility of using backfill material from a potential borrow ground in Commonwealth Waters. The potential borrow ground is adjacent to the north western extent of the Dampier Marine Park (DMP). The area of the DMP that is adjacent to the potential borrow ground is an International Union for Conservation of Nature (IUCN) Protected Area. It has been attributed Category IV status, which has the primary objective to maintain, conserve and restore species and habitats. An understanding of benthic communities at and surrounding the potential borrow ground is required to help inform the impact assessment for the intended activities associated with using the potential borrow ground.

This report presents the methodology and reports the findings of the benthic habitat survey that was undertaken in December 2018 at the potential borrow ground and adjacent areas within the DMP.

1.2 Scope of Work

The primary aim of the Commonwealth Waters survey was to gather information to support an environmental impact assessment of using the proposed borrow ground. The survey was completed to acquire qualitative data on species present, and to report on the presence of sensitive benthic biota or habitat near the proposed borrow ground and the adjacent DMP.

1.3 Survey Location

The potential borrow ground is located directly north of the western extent of the DMP, about 9 km north of the north-western extent of Legendre Island, outside the Dampier Archipelago (Figure 1-1).

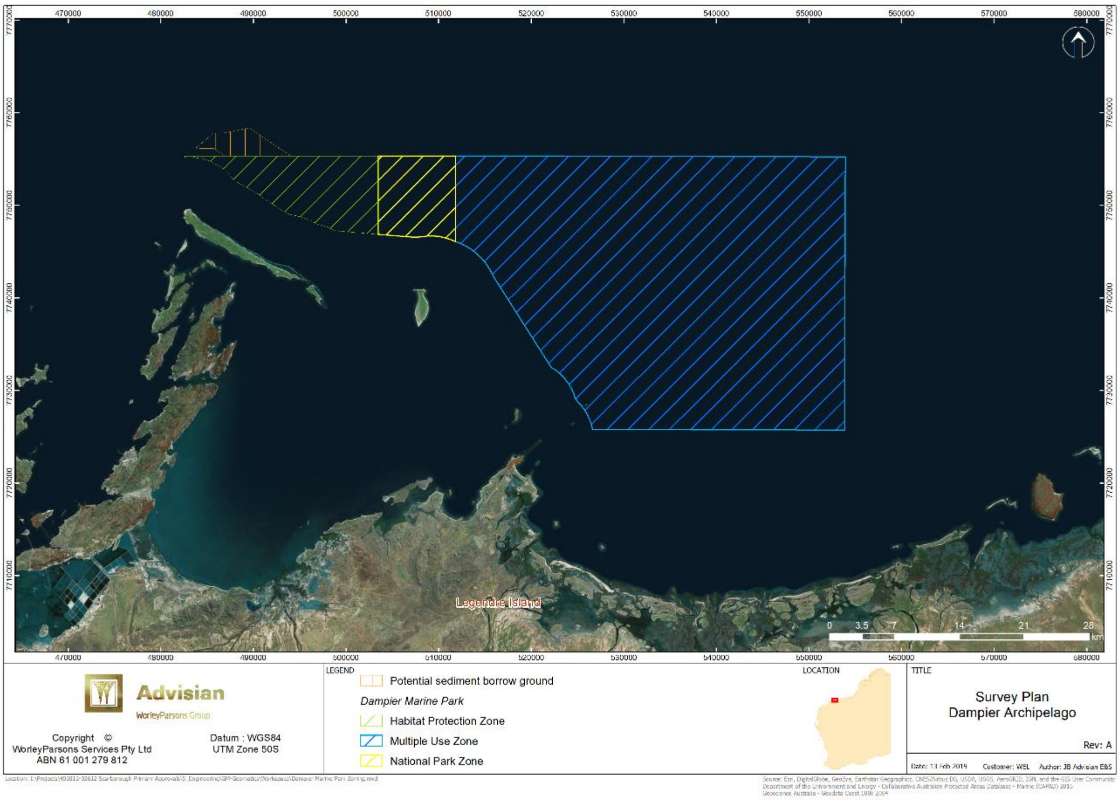


Figure 1-1: Survey location showing potential borrow ground and adjacent section of Dampier Marine Park

1.4 Previous Knowledge

The Marine Park was proclaimed in December 2013, though has been known as Dampier Marine Park since October 2017. DMP is significant because, as a whole, it provides protection for offshore shelf habitats adjacent to the Dampier Archipelago, the area between Dampier and Port Hedland and a seafloor rich with sponges (DNP, 2018). The habitat protection zone adjacent to the potential borrow ground is allocated Category IV Protection as it provides important habitat for benthic communities in the region. Previous knowledge of the benthic habitats and communities of the survey location includes a study by the CSIRO (Pitcher *et al* 2016), which covered an extensive area of the west Pilbara describing benthic habitats and categorizing the assemblages' present. The survey location appears to be on the outer fringes of the CSIRO study. Bathymetric information was limited to nautical charts of the region.

2 Methods

2.1 Survey Design

To optimise the field campaign, survey locations for video and still images were positioned to target the potential borrow ground and surrounding area (Figure 2-1). A 5km buffer was applied to the potential borrow ground to define the survey area in the Dampier Marine Park.

Existing historical data was not available to assist with directing survey effort. To maximise spatial coverage over this area in the available timeframe, a 1 km grid survey pattern was applied. Locations within the potential borrow ground and locations in the DMP closest to the potential borrow ground, were prioritised.

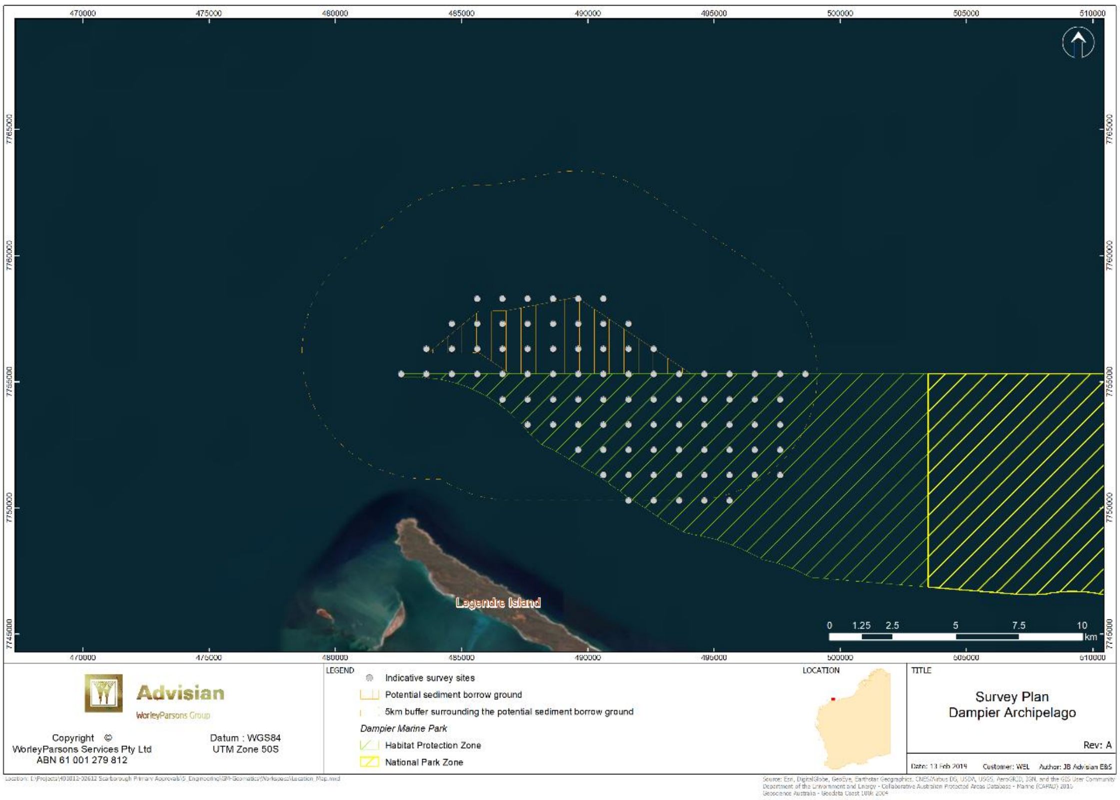


Figure 2-1: Survey sites planned in Commonwealth Waters at the potential borrow ground and Dampier Marine Park

2.2 Field Survey

The field survey was undertaken onboard the vessel *Kaelani*, operated by Bhagwan Marine, between 16th and 20th December 2018. A total of 24 transects were completed within the potential borrow ground and a further 51 transects were completed within the DMP during the survey. Transects varied in length from 30 m to about 230 m, though were typically around 100 m (Figure 2-2). The planned survey locations at the southern extent of the DMP were unable to be surveyed due to time constraints. Habitat data was obtained using a towed/drop camera array including digital recordings of high resolution still photographs and high definition video footage. When possible, real-time standard definition footage was observed by an attending marine scientist on the vessel. Preliminary qualitative habitat information was recorded into log sheets for subsequent review. Information recorded to the log sheet for each transect included:

- transect number (identifier)
- time of transect data collection (start/end) and observed changes of habitat
- dominant benthic habitat (substrate type and biota density)
- approximate depth (as measured by the vessel echo sounder)
- general comments relating to each transect.

Spatial positioning data was acquired using a Garmin GPSMap 62 and a Holux RCV-3000 located onboard the vessel. Two units were used for redundancy. The global positioning system (GPS) units recorded a tracklog for each day of operation and were time-synchronised with the laptops and cameras used to record habitat data.

At each survey location the camera array started recording on the deck of the vessel, where information about the transect and location was recorded before the array was deployed. Once the camera array reached the seabed, the vessel was allowed to drift for two to three minutes, depending on the rate of drift. When real-time viewing was available and more complex habitat was observed, or bathymetry was more variable, the transect/drift was allowed to proceed for a longer period but capped at around five minutes for operational efficacy. The typical drift speed was between 0.5 and 1.7 knots according to the vessel chart plotter.

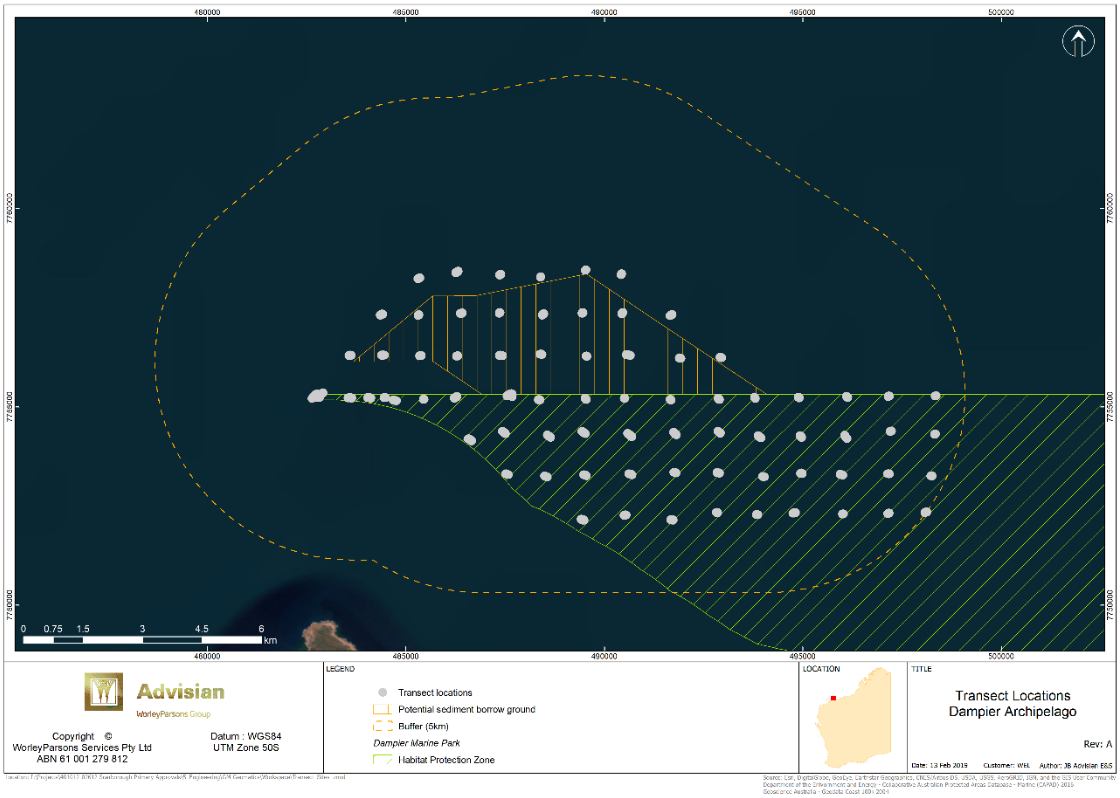


Figure 2-2: Benthic habitat transects conducted in Commonwealth Waters at the potential borrow ground and Dampier Marine Park, December 2018

2.3 Benthic Habitat Characterisation

High level habitat classes were derived from a benthic habitat map of the Dampier Archipelago by MScience (2018). These classes were refined based on habitats and biota observed during the survey (Table 2-1). The video footage and still imagery was reviewed after the field survey was complete, to confirm habitat classifications and to refine spatial data where necessary by improving time logs of habitat boundaries and transect start/end points. Where habitat boundaries or changes in epibenthic density were different to the initial logs, the elapsed time in the video was applied to determine the time and relative spatial position for the particular attribute and a new revision of the log was created.

Habitat information was georeferenced by relating the times recorded on the log sheets with the position logged by the GPS onboard the vessel. Position information was logged by the Holux GPS each second. For each spatial position received, the relative habitat information was attributed to create habitat point data of the areas surveyed.

Habitat point data was imported into ArcMap geographical information systems platform to create Esri shape files and to be displayed with other relevant spatial data for presentation in this report.

Table 2-1: Habitat classification scheme utilised for the survey

Habitat Class	Definition
Coral	Hard coral communities dominate and were present in ≥10% cover. Some minor biota may be present (i.e. ascidians, bryozoans and sponges); however, they are secondary in density and ecological function. No coral was observed along any of the survey transects.
Algae	Macroalgae were the dominant biota (≥10% cover) over a consolidated hard substrate that may contain sparse (≤10%) secondary biota (i.e. solitary corals or seagrasses). No macroalgae or seagrass was observed along any of the survey transects.
Invertebrates	Sessile and mobile benthic invertebrate biota (including crinoids, ascidians, hydroids and sponges) were present (≥3%) on sandy substrate with little or no other biota. Both sessile and mobile invertebrates were observed along survey transects. Example images are supplied in Figure 2-3.
Bare Sediment	Substrate is predominantly bare sand. Biota is very sparse (≤10% cover of macroalgae or coral and ≤3% invertebrates) or entirely absent. Bare sediment was the dominant habitat class in the survey transects. Example images are supplied in Figure 2-4.

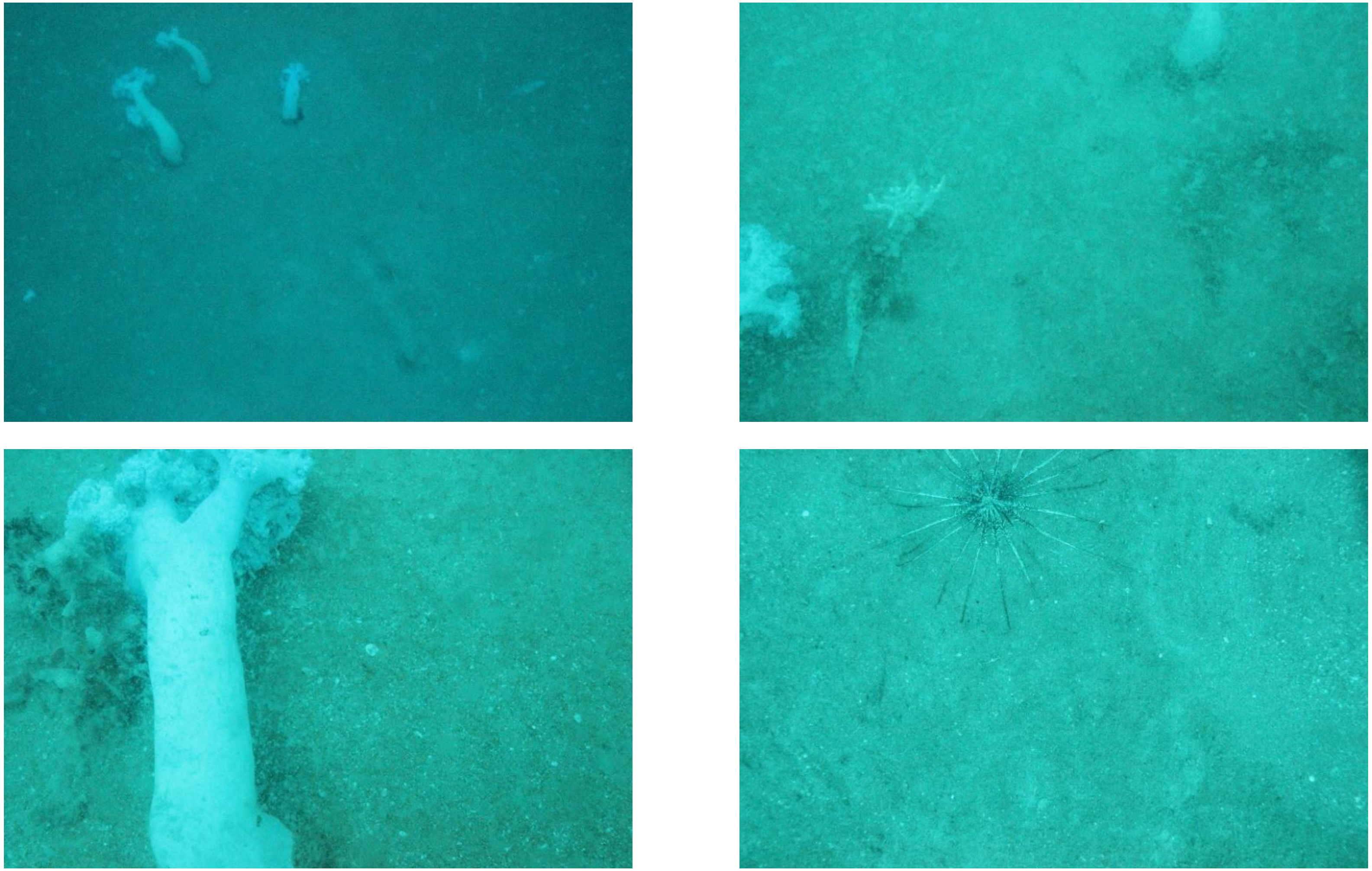


Figure 2-3: Examples of typical habitat classified as Invertebrates

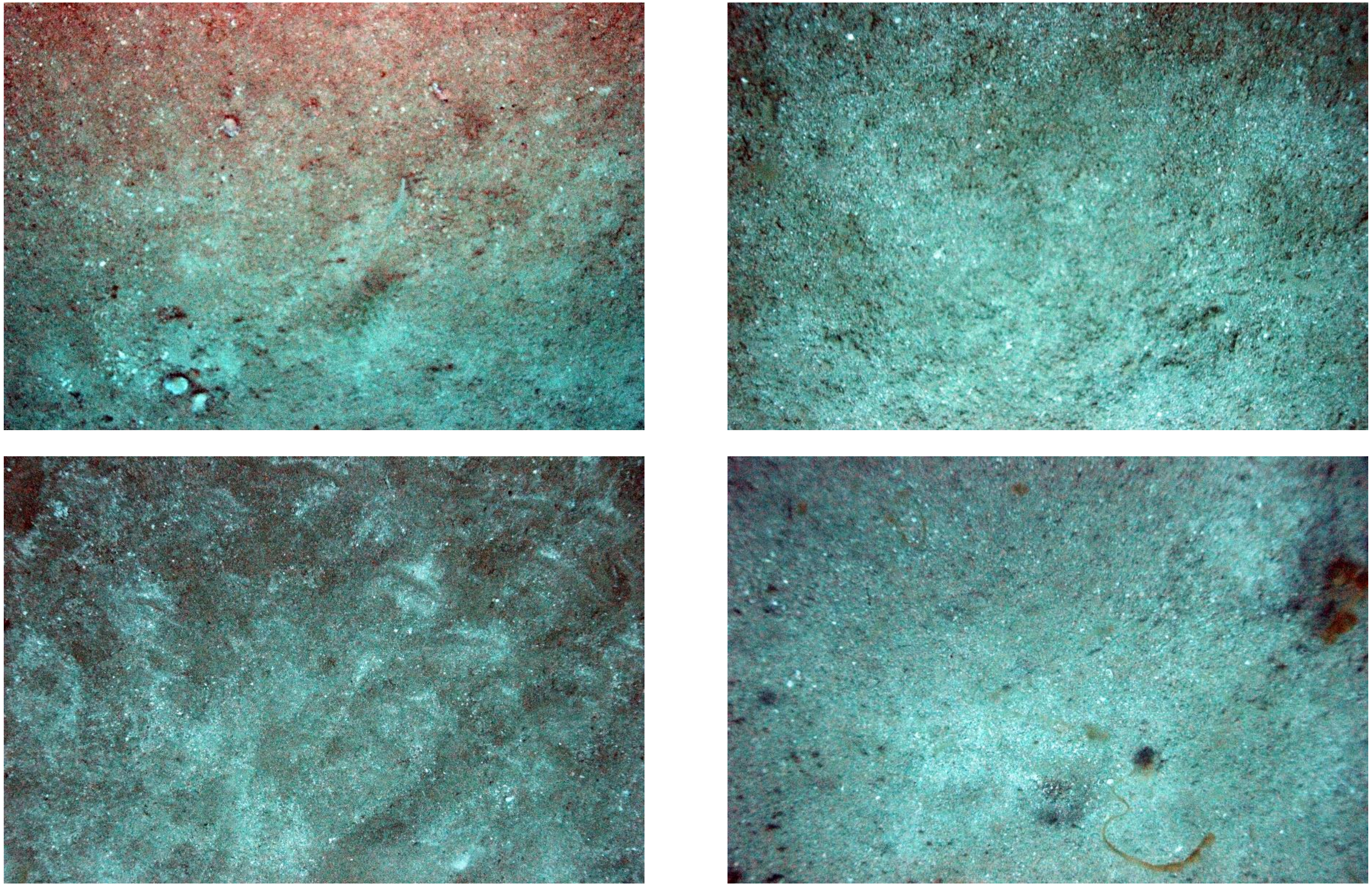


Figure 2-4: Examples of typical habitat classified as Bare Sediment

3 Results

3.1 Benthic Habitat

At the proposed borrow ground bare sandy substrate dominated areas where towed/drop camera transects were conducted. Where biota was observed, it typically consisted of invertebrates such as anemones and crinoids at densities no greater than 10%. Of the 24 survey locations, invertebrates were observed at only two (Figure 3-2 and Figure 3-3). Most transects were conducted in depths between 40 m and 42 m. Four transects were conducted in water depths between 37 and 40 m.

Like the potential borrow ground, bare sandy substrate dominated areas where towed/drop camera transects were conducted in the Dampier Marine Park. Where biota was observed, it typically consisted of invertebrates such as anemones and crinoids at densities no greater than 10%. Of the 51 survey locations, sparse invertebrate cover (3–10%) was observed at 12 of them (Figure 3-4, Figure 3-5 and Figure 3-6). Bathymetry was more variable within the marine park survey area, ranging from 31 m to 43 m. No particular association between habitat and depth is evident based on this data.

Figure 3-1 displays the general location of each the subsequent figures.

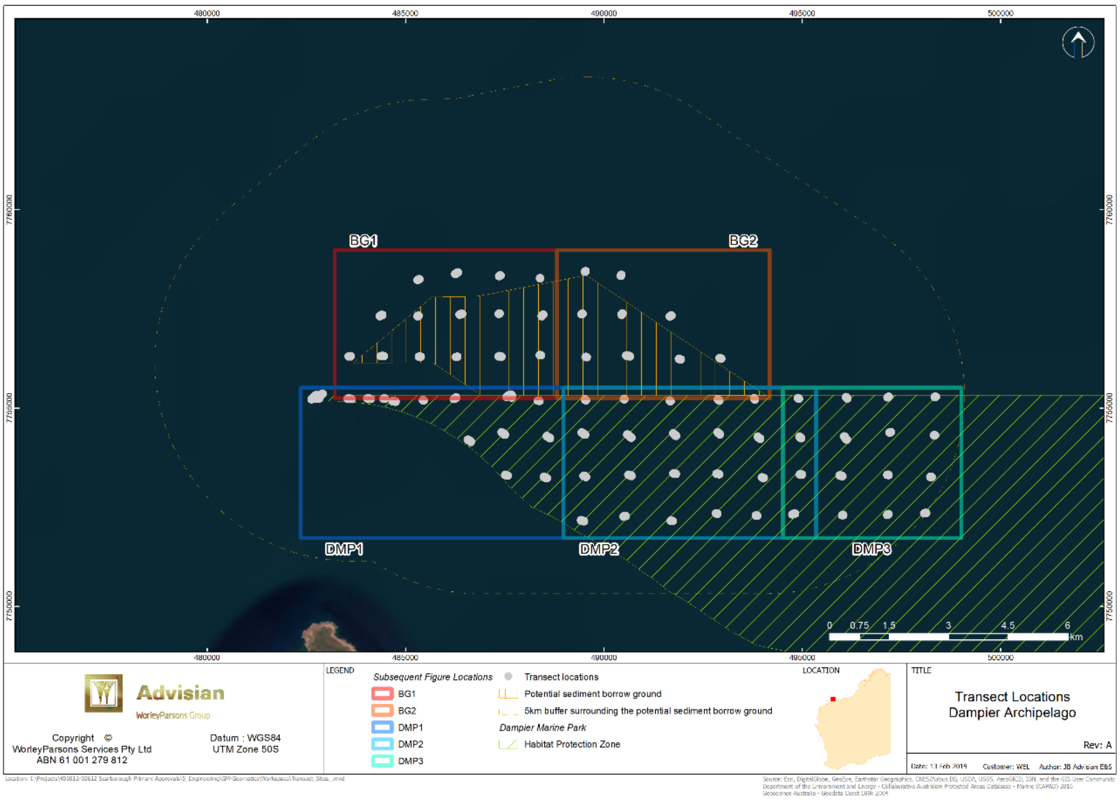
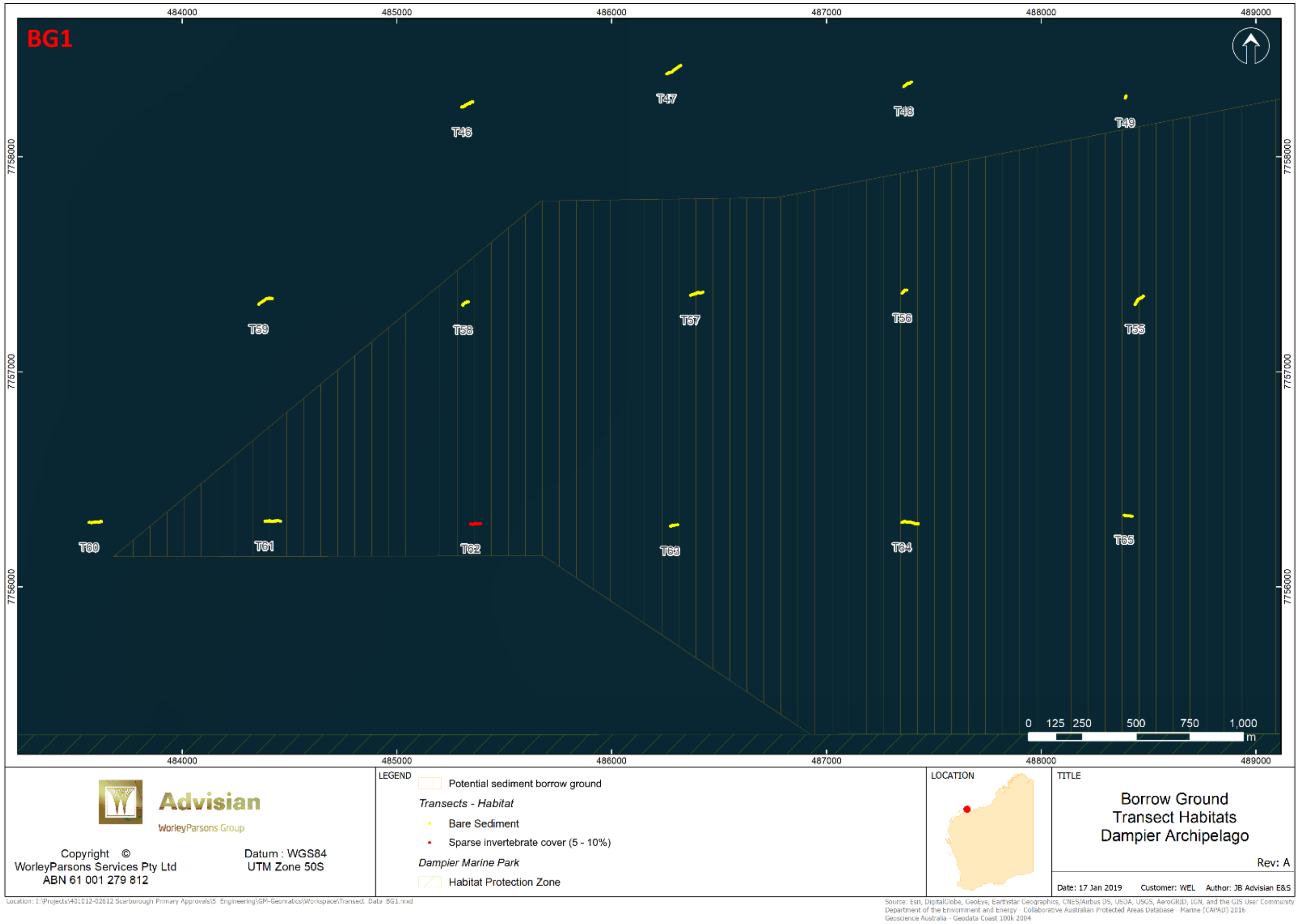


Figure 3-1: Transects with superimposed boxes indicating where subsequent figures presented are located



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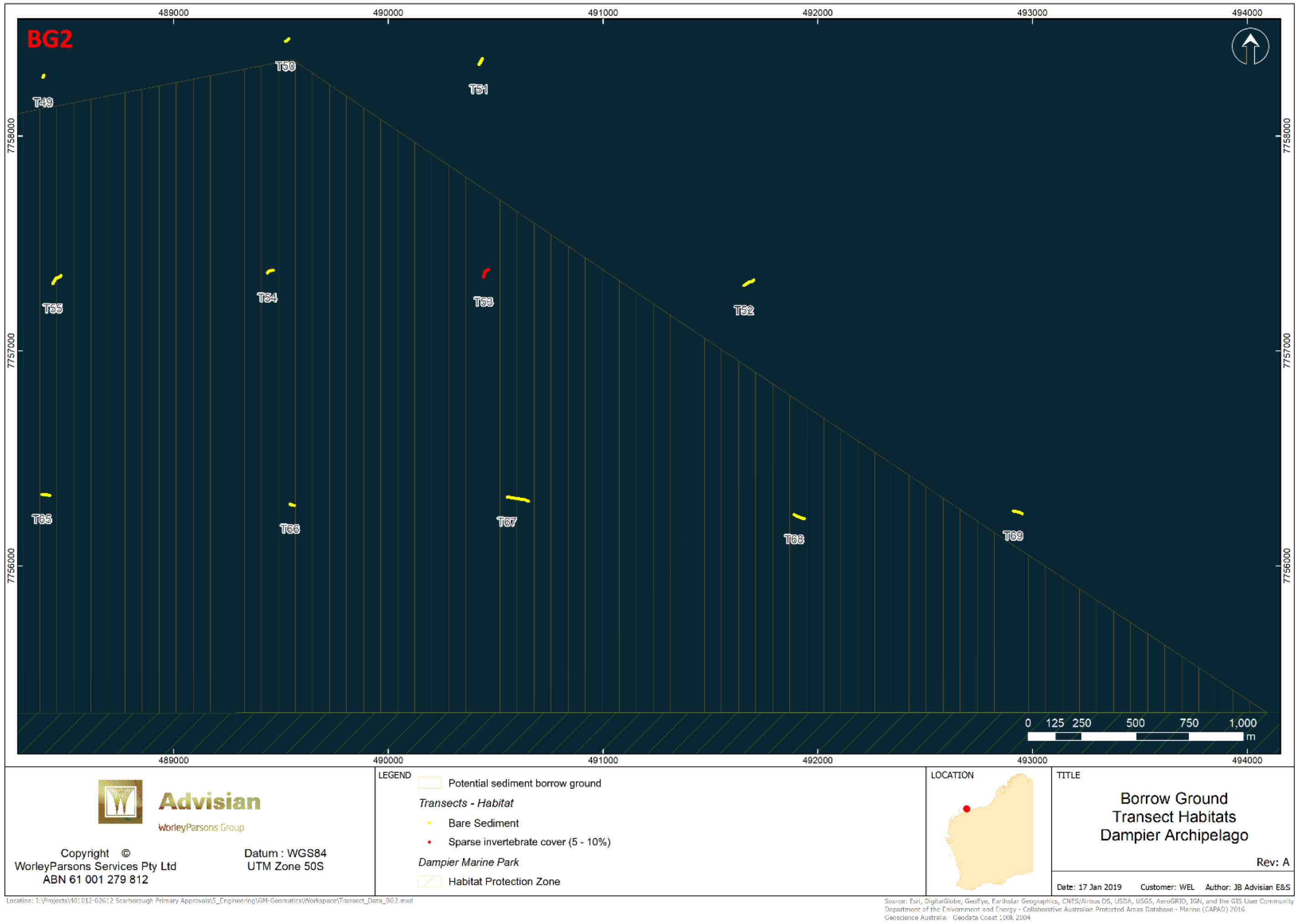
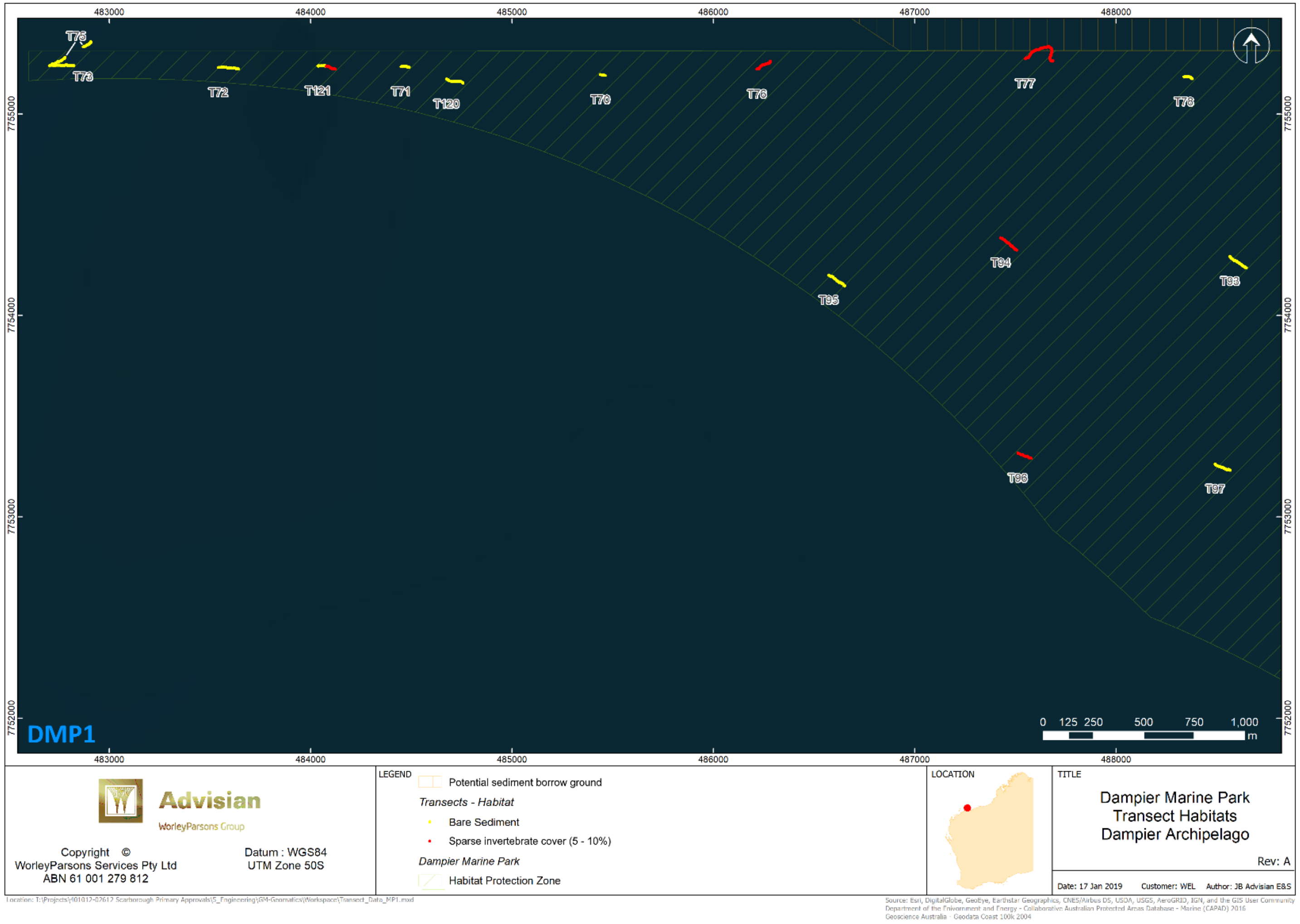
Department of the Environment and Energy - Collaborative Australian Protected Areas Database - Marine (CAPAD) 2016
Geoscience Australia - Geodata Coast 100k 2004

Figure 3-2: Benthic habitat in the western portion of the potential borrow ground



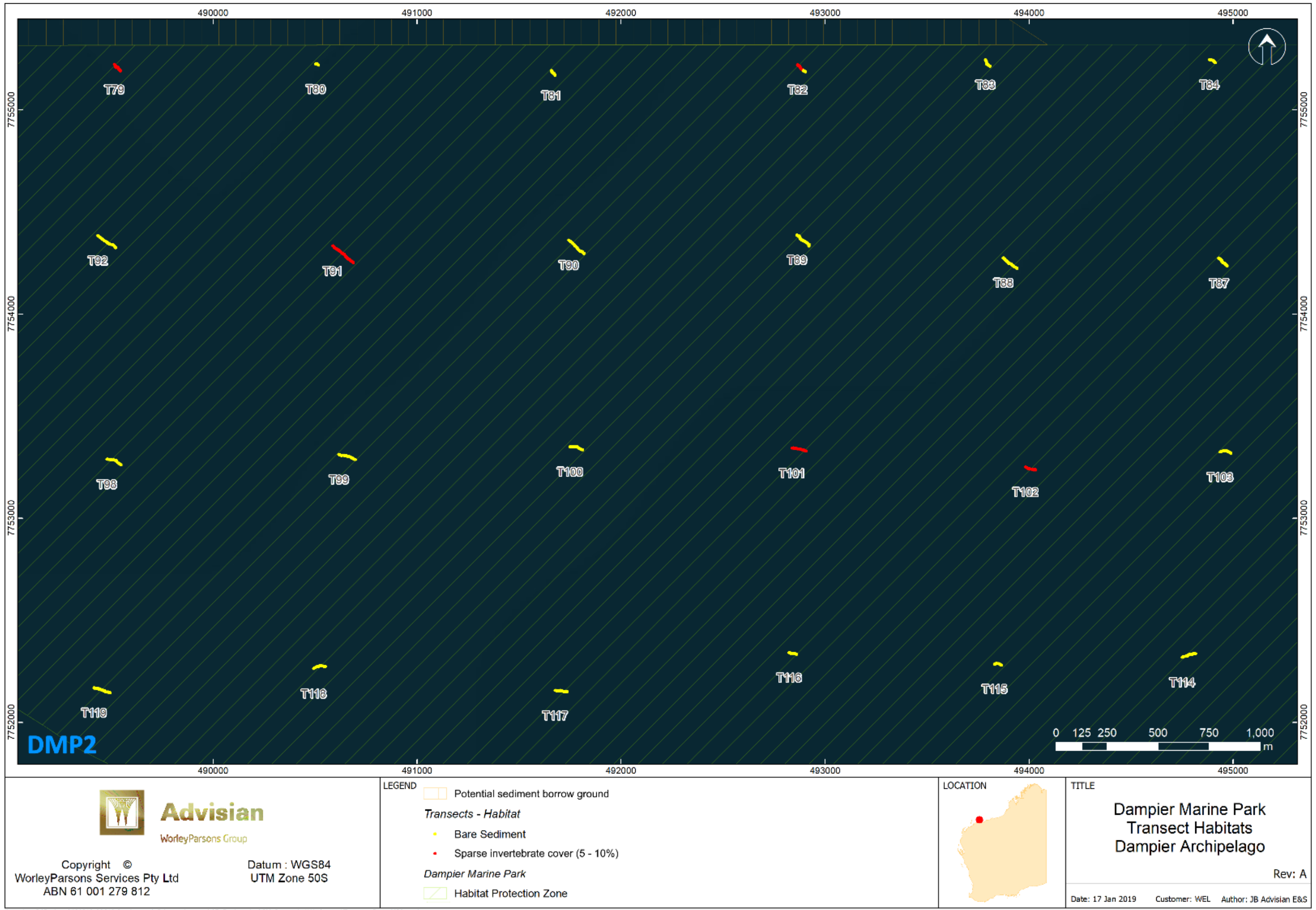
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Department of the Environment and Energy - Collaborative Australian Protected Areas Database - Marine (CAPAD) 2016
Geoscience Australia Geodata Coast 100k 2004

Figure 3-3: Benthic habitat in the eastern portion of the potential borrow ground



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Department of the Enivornment and Energy - Collaborative Australian Protected Areas Database - Marine (CAPAD) 2016
Geoscience Australia - Geodata Coast 100k 2004

Figure 3-4: Benthic habitat in the western portion of the Dampier Marine Park



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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Department of the Environment and Energy - Collaborative Australian Protected Areas Database - Marine (CAPAD) 2016
Geoscience Australia - Geodata Coast 100k 2004

Figure 3-5: Benthic habitat in the middle of the Dampier Marine Park

Location: I:\Projects\401012-02612 Scarborough Primary Approvals\5_Engineering\GM-Geomatics\Workspace\Transect_Data_MP3.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Department of the Environment and Energy - Collaborative Australian Protected Areas Database - Marine (CAPAD) 2016
Geoscience Australia - Geodata Coast 100k 2004

Figure 3-6: Benthic habitat in the eastern portion of the Dampier Marine Park

4 Discussions and Conclusions

Towed video and drop camera survey of both the potential borrow ground and the DMP directly adjacent to the borrow ground confirm that the seabed and its benthic composition are relatively uniform in structure and composition. Both locations are dominated by bare substrate with large areas of seabed that are apparently largely devoid of any epibenthic species. Where epibenthos is present, the percentage cover of species is comparatively low (in the order of 5%), with no transects recording greater than 10% coverage in the species present.

Common species present were alcyonaceans (mainly solitary soft corals), pennatulaceans (sea pens), crinoids (feather stars), asteroids (sea stars), anemones and hydroids. No benthic primary producer habitat in the form of hard corals, macroalgae or seagrass was recorded or observed along any of the survey transects.

The benthic habitat observed during this survey appears to be consistent with a broad scale characterisation of the Pilbara seabed undertaken by UWA and CSIRO (Pitcher *et al* 2016), which categorises this area as "Assemblage 2" and describes it as "typically bare seabed interspersed with moderately high cover of whips (0– 95.6%), median gorgonians (0–12.4%) and median sponges (0–73.4%), some cover of algae (0 25%), and low cover of alcyonarians (0–2.2%), corals (0–6.8%), coral reef (0–5.4%), bioturbation (0– 13.4%) and halimeda (0–0.8%), and ~no cover of seagrass".

The similarity between benthic habitats observed within the potential borrow ground and habitat protection zone of the DMP during this survey, and those described above as Assemblage 2, indicates that the area surveyed is well represented in the regional context as opposed to more spatially discrete habitat features such as submerged coral reefs (Delambre Reef) and shoals (Tessa Shoals).

5 References

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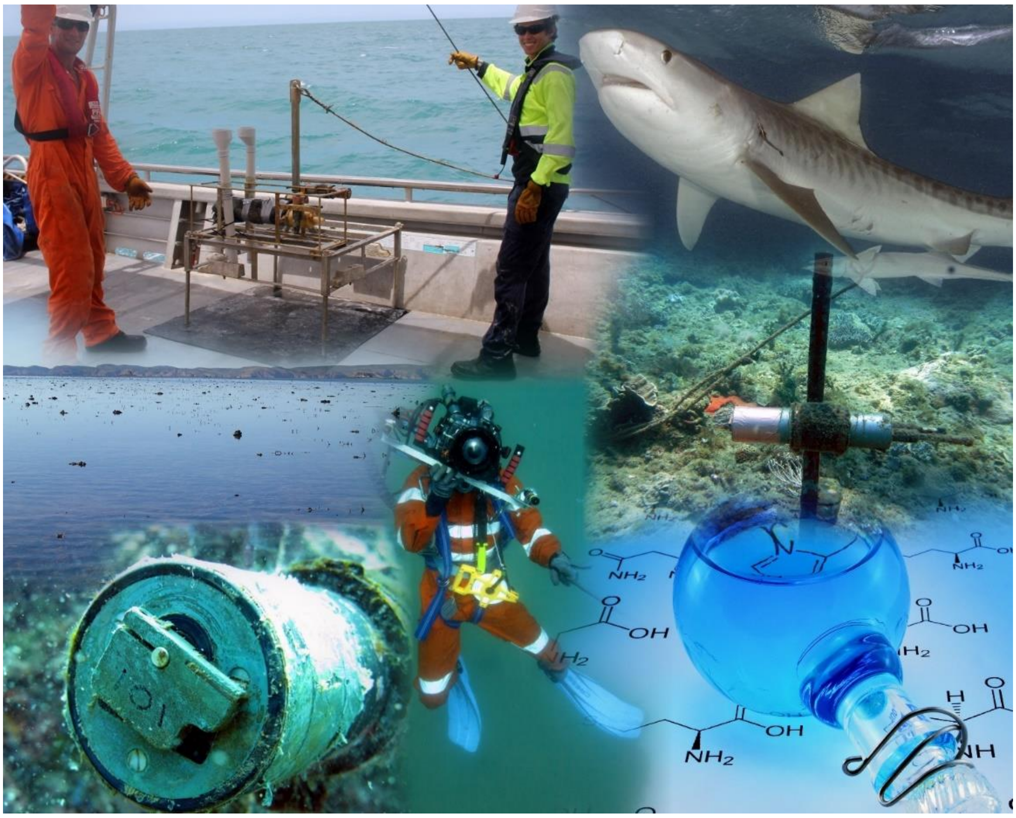
Appendix D

Coral Habitat Assessment

Scarborough Trunkline Marine Environmental Studies



29 May 2019

Pre-Dredging Coral Habitat Assessment

Report to Advisian

From

MScience Pty Ltd
Highgate, Western Australia 6003

Scarborough Trunkline Marine Environmental Studies

Pre-Dredging Coral Habitat Assessment

Document Information

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LIST OF ACRONYMS AND TERMS

ANG2	Angel Island Coral Monitoring Site
BoM	Bureau of Meteorology
BPP	Benthic Primary Producers
COBN	Conzinc Bay North Coral Monitoring Site
CONI	Conzinc Island Coral Monitoring Site
CPCe	Coral Point Count with excel extensions
DMP	Dredging Management Plan
FFP1	Flying Foam Passage Coral Monitoring Site
FPU	Floating Production Unit
GDA94	Geocentric Datum of Australia 1994
GIDI	Gidley Island Coral Monitoring Site
H'	Shannon-Wiener Index
INTI	Intercourse Island Coral Monitoring Site
KGBY	King Bay Coral Monitoring Site
LEGD	Legendre Island Coral Monitoring Site
MAL2	Malus Island Coral Monitoring Site
MIDI	Mid Intercourse Island Coral Monitoring Site
QA/QC	Quality Assurance and Quality Control
SUP2	Supply Base Coral Monitoring Site
Tcf	Trillion cubic feet
WEL	Woodside Energy Limited

1 EXECUTIVE SUMMARY

Scarborough gas resource, located in Commonwealth waters approximately 375 km off the Burrup Peninsula, forms part of the Greater Scarborough gas fields, comprising Scarborough, North Scarborough, Thebe and Jupiter gas fields, of which Woodside Energy Limited (Woodside) is the Operator.

The proposed offshore development, targets commercialising the Scarborough and North Scarborough gas fields, through constructing multiple subsea, high-rate gas wells, tied back to a semi-submersible floating production unit (FPU) moored in approximately 900 m of water close to the Scarborough field. These offshore facilities are proposed to be connected to the mainland through an approximately 430 km trunkline to an onshore facility. Woodside's preferred concept is to process Scarborough gas through a brownfield expansion of the existing Pluto LNG onshore facility (Pluto Train 2).

Advisian are providing assistance to Woodside as part of the environmental assessment and management of Scarborough and have contracted MScience Pty Ltd (MScience) to provide specialist advice on the potential impacts of the project on benthic habitats. One component of that work is to provide a pre-dredging assessment of the status of coral communities within Mermaid Sound, Dampier, Western Australia. While the coral communities of this area have been well studied over the past 20 years, their condition is dynamic and changes in response to both anthropogenic and natural events. A current assessment of the status of coral habitats adjacent to the proposed trunkline route is required to support the prediction of potential impacts from dredging and may form part of a before-after monitoring design in accordance with the tiered management framework for the project.

Sites were selected for survey based on the known distribution of corals, their proximity to the dredging and spoil disposal areas, and their ability act as reference sites. Coral abundance and diversity at each site were assessed using diver-based records of belt transects collected with methods used as standard coral surveys for this area since 2003. Photographic records of transects were then scored quantitatively to the lowest practical taxonomic category to provide estimates of the level of coral cover and species composition at each site.

Coral cover and taxonomic diversity for each site is reported here and compared to previous assessments of these parameters at those sites. Coral cover at the 11 sites ranged from 5.7% (LEGD) to 56.7% (MAL2) and was largely consistent with previous estimates of cover. Sites ANG2, GIDI and SUP2 showed some increases in live coral cover compared to previous surveys, while LEGD showed a decrease in cover compared to previous surveys. Corals examined during the current survey recorded only a small proportion showing bleaching; bleaching was present at most sites at less than 0.5% and predominantly as a small part of a coral colony. There were no signs of coral damage caused by cyclones, and with the exception of a single colony at MIDI, there were no signs of disease. Coral communities were diverse, as assessed by the proportional representation of six major hard coral categories within monitored sites. Community composition varied between sites consistent with the literature and reflective of the different habitats at each monitoring site. Within sites, there was generally good agreement of community composition between surveys (2007-2019). ANG2 site showed a change in community composition compared to previous surveys, most likely due to strong recruitment and growth of *Acropora* species. Detailed descriptions of the corals at each site are presented within the report.

2 INTRODUCTION

2.1 Background

Scarborough gas resource, located in Commonwealth waters approximately 375 km off the Burrup Peninsula, forms part of the Greater Scarborough gas fields, comprising Scarborough, North Scarborough, Thebe and Jupiter gas fields, of which Woodside Energy Limited (Woodside) is the Operator.

The proposed offshore development, targets commercialising the Scarborough and North Scarborough gas fields, through constructing multiple subsea, high-rate gas wells, tied back to a semi-submersible floating production unit (FPU) moored in approximately 900 m of water close to the Scarborough field. These offshore facilities are proposed to be connected to the mainland through an approximately 430 km trunkline to an onshore facility. Woodside's preferred concept is to process Scarborough gas through a brownfield expansion of the existing Pluto LNG onshore facility (Pluto LNG Train 2).

Advisian is conducting environmental surveys to assist Woodside undertake environmental assessment and management of Scarborough. Part of that work includes studies to manage the environmental impacts of dredging to be undertaken for placement of the gas trunkline within Mermaid Sound, Dampier, Western Australia.

MScience Pty Ltd (MScience) was contracted by Advisian to supply a coral specialist to assist with field surveys and to score images of coral habitat returned from surveys to provide an estimate of the cover of hard corals and assign these to a detailed taxonomic basis. MScience has conducted coral surveys previously within this area to support a variety of projects with individual objectives and methods over the period from 2003 onwards. Parts of that data set are presented here for comparative purposes with the results of the current survey.

Structure of this Document

The document lists:

- The background to this study;
- The methods used;
- The study results; and
- A discussion of the results.

The document is current as at the date on the cover page and is referenced as Version 1 (Documents with a lower version number are superseded by this document).

3 METHODS

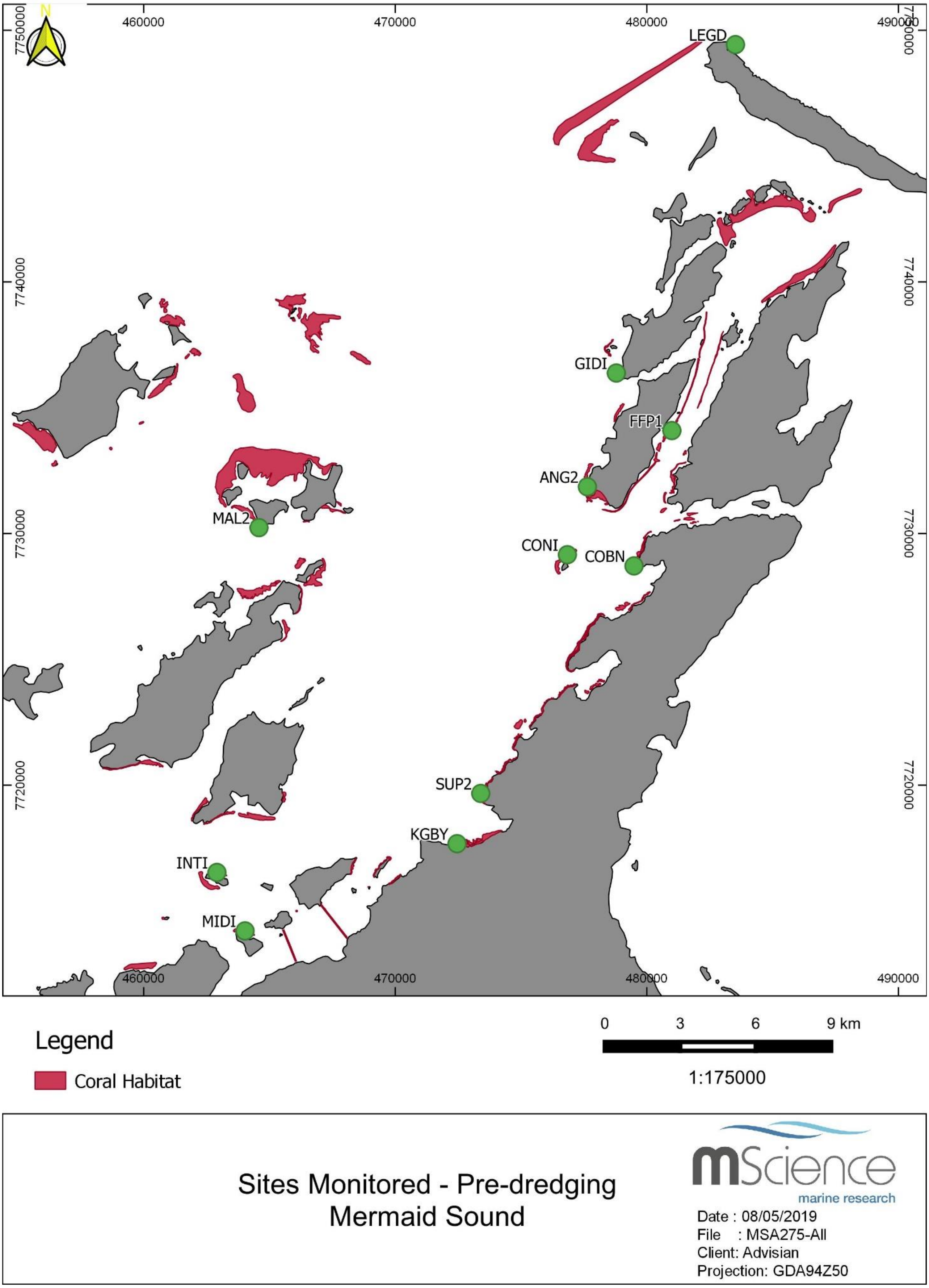
3.1 Sites Surveyed

Sites for survey were selected by Advisian on the basis of the proposed location of the trunkline dredging and previous demonstrations that they contained locally significant coral communities. Sites were chosen to include some close to dredging and disposal sites (potential impact sites) and some as a selection of similar communities outside the potential effects area (reference sites) (Table 3-1, Figure 3-1).

Table 3-1. In situ monitoring sites – location details being the beginning of transect 1.

Site Name - Abbreviation	**Depth*** **(m)**	**Easting** (GDA94-MZ50)	**Northing** (GDA94-MZ50)
Angel Island – ANG2	4.5	477638	7731841
Conzinc Bay North - COBN	4.5	479536	7728650
Conzinc Island - CONI	3-4	476837	7729162
Flying Foam Passage – FFP1	2.5	480996	7734094
Gidley Island - GIDI	4	478812	7736359
Intercourse Island - INTI	3.5	462916	7716559
King Bay - KGBY	2-3	472465	7717710
Legendre Island - LEGD	9	483392	7749414
Malus Island – MAL2	3-4	464581	7730236
Mid Intercourse Island - MIDI	2.5	464025	7714214
Supply Base – SUP2	3	473433	7719666

*Depth is quoted as approximate depth below sea level at the time of survey



Sites Monitored - Pre-dredging
Mermaid Sound

Date : 08/05/2019
File : MSA275-All
Client: Advisian
Projection: GDA94Z50

Figure 3-1. Location of monitoring sites

3.2 Survey methods

Coral habitat was surveyed by divers using surface supplied breathing apparatus (SSBA). All divers were experienced marine scientists. Sites were located using GPS coordinates recorded when the selected sites had been monitored by earlier studies. The survey vessel was placed as close as practical to the GPS points, taking care to anchor in areas of low sensitivity (i.e. away from coral). Divers established five 10 m transects at each site, using re-bar stakes to mark the start, mid-point and end of each transect. Transects were placed within the zone of highest coral cover at each site. This focus on the higher abundance coral areas was consistent with past studies which aimed to record the richer coral communities of the area.

Rope lines were stretched taut along the stakes and coral cover was recorded from a belt along the right-hand side of the rope. Each transect was recorded as a series of 30 slightly overlapping digital still images at a fixed focal distance to provide an image approximately 0.5 x 0.7 m. A video record of the coral community around each transect was also captured.

The location of each transect at a site and comments on the site's coral community are shown in Appendix A.

3.3 Scoring Methods

Coral scoring was conducted using the CPCe software package (Kohler and Gill 2006). Cover was estimated for each transect by scoring a set of 30 points applied in a stratified random design to each of the 30 images recorded. Scoring of images was conducted essentially as described in (Stoddart et al. 2005), but using the categories of Appendix B. Note that corals scored as 'bleached' are assumed to be alive when calculating the presence of live coral cover. Corals (or parts of corals) scored as bleached have a pristine white coloration. While it is not possible to determine from images whether those coral polyps are alive or dead, dead coral is rapidly colonised by algae and takes on a green-brown appearance. As corals may survive without zooxanthellae for some time after initial bleaching (Marshall and Schuttenberg 2006), 'white' coral is more likely to have live than dead polyps.

Output data from the coral cover assessment provides estimates of:

- Total percentage cover of living coral;
- Relative abundance of the 6 taxonomic groupings (see Section 3.4) used for rapid community description;
- The occurrence of other benthic habitat types – e.g. flora and fauna.

Live coral cover is the most commonly used parameter in describing the "health" or "status" of coral reefs (Jokiel et al. 2005). In practice, live coral cover estimated in planar view is a complex measure influenced by many factors including an individual colony's growth form, partial mortality, morphology, angle of the substrate and the presence of surrounding organisms. Where there is a significant component of coral colonies occupying the vertical, this 2-dimensional representation of a 3-dimensional structure may not be fully representative of change in live coral. Nevertheless, coral cover is a practical and informative parameter and was used here to retain consistency with previous studies.

Quality Control

Images were checked following each dive for completeness and quality (clarity, focus, lighting). All images were numbered sequentially. Prior to scoring, image numbers were checked against transects and confirmed at 30 images per transect. Image exposure was enhanced to facilitate scoring using the auto-exposure function of ACDC Pro ® software.

Coral scoring was conducted by a senior marine scientist with 15 years of experience with the taxonomy of Pilbara corals and previous experience in CPCe scoring. A single scorer was used for all scoring and taxonomic identifications to avoid inter-scorer biases. Prior to scoring the current images, the scorer was calibrated against a prior data set for one of the sites (King Bay) which had been scored repeatedly to provide a standardised reference in a prior study. Once a tolerance of <4% was achieved for cover estimates, scoring of the current images was undertaken.

The assignment of taxonomic categories to corals in images was confirmed using:

- The experiences of the observer in 15 years studying corals in this area;
- Taxonomic guides (Kelley and ACRS 2016 and online sources; primarily Veron 2000);
- The MScience reference collection of images of assigned a taxonomic basis (NW Coral Guide).

Statistics

Data derived from scoring of the proportion of the belt transects covered by living coral is expressed as a percentage of the total area within a transect. Coral cover at each site is then expressed as the mean of cover for the five transects (replicate points) surveyed with variance calculated from the between-transect component. The mean and variance of the five transects can then be used as an estimate of the cover of live coral from across the 'site'.

As coral cover is calculated as the percentage of area scored, oversampling of the transect due to image overlapping does not invalidate the abundance estimate. Ensuring that the entire length of the transect is sampled avoids adding to the between-survey variance of estimates as a result of sequential surveys sampling slightly different areas of the transect when images record only parts of a transect.

Coral cover as measured here is a nominal variable expressed as a proportion (Sokal and Rohlf 1995). In approximating proportional data to a normal distribution, the arcsine transformation is commonly applied. However, data points between 30% and 70% are close to the normal before transformation and are little changed by transformation (Snedecor and Cochrane 1967; Sokal and Rohlf 1995). Therefore, data has been presented here untransformed. Should testing be required subsequently against the results of a future survey, data should be tested against normality assumptions to determine if transformation is required.

Variance in the estimates of coral cover at a site within and between times will be derived from:

- The highly patchy distribution of coral (Hughes 1989) at scales of metres (within transects) and at tens of metres (between transects);
- Sampling variance derived from small differences in the placement of the belt transect or the aspect of images recorded from the transect (Ryan and Heyward 2003);
- The variance in scoring coral cover from the recorded images – which may stem from observer factors, uncertainty in discriminating images, and the interaction of water clarity and light availability with those factors (Stoddart et al. 2005).

The use of fixed transects lowers between-sampling variance considerably (Ryan and Heyward 2003), but even with that proviso, belt transects have low statistical power to discriminate effect sizes below 10% when total cover is below 30% (Stoddart et al. 2005): i.e. an effect size of 3% cover.

3.4 Community Composition

While the scoring categories of Appendix B provide as much taxonomic detail as can be confidently scored from images, many of the taxonomic categories are sparsely represented. To allow a common and useful description of sites, the categories of hard coral scored are aggregated into those commonly seen as typifying the area (Blakeway and Radford 2005). Thus, analysis of community composition here uses only six categories: corals assigned to the genera *Acropora*, *Pavona*, Porites and *Turbinaria*, corals in the family Faviidae, and all other scleractinian corals.

Note that after 2014, there has been a substantive change in the family level taxonomy of corals, such that most genera formerly assigned to the family Faviidae are now placed within the family Merulinidae (Huang et al. 2014). To retain consistency with past assessments of the community structure of corals at these sites, we have retained the descriptors 'Faviidae' and favid for corals of those genera formerly assigned to that grouping, sensu Veron (2000). Outside of the nomens for those families, this has little practical implications as future assessments of susceptibility to dredging impacts (should such assessments be required) would be made at a genus level.

An assessment of coral diversity at each of the monitoring sites was also made using these six coral categories. The proportional cover of these coral categories was used to calculate the Shannon-Wiener Index for diversity for each of the sites and surveys. These data were then tabulated for later comparison against coral species diversity if required as per the project tiered management framework.

4 RESULTS

4.1 QA/QC Results

The KGBY site from previous surveys was selected for scorer calibration as part of the QC process discussed in Section 3.3. Calibration scoring of the 2010 data showed the scorer obtained a calibration tolerance of <4%. Having met the calibration criteria, the scorer then moved on to score the images from the current survey.

4.2 Coral cover

Site means of live coral cover ranged from 5.7 % at LEGD to 56.7 % at MAL2. Coral cover from the current survey was generally similar to historic cover levels reported at the monitoring sites, with a few exceptions. Sites ANG2, GIDI and SUP2 showed significantly more coral cover in 2019 than in 2007 and 2010, whereas site LEGD showed significantly less coral cover. A low to moderate level of bleached corals were recorded at all sites, ranging from <0.1% at LEGD to 2.9% at CONI. Bleaching affected several coral taxa, most commonly *Pectinia*, *Galaxea* and *Turbinaria*. Some massive *Porites* and faviid colonies were also bleached, particularly on their upper surfaces.

A few instances of sedimentation on corals were observed, primarily at the inshore sites MIDI and SUP2. The affected corals at these sites were generally encrusting forms, especially *Merulina ampliata*, in lower-lying areas of the reef. Direct sedimentation on corals was rare elsewhere, although virtually all turf-algae covered substrates, including areas of partial mortality on living corals, exhibited a light coating of fine sediment.

There were no obvious signs of recent cyclone damage; i.e. no extensive deposits of recently broken or overturned coral colonies. Nor were any disease outbreaks observed, only a single incidence of apparent black-band disease on a *Podabacia* colony at MIDI.

The data on cover of major benthic habitat classes by transect is provided below in Tables 4-1 to 4-11, while figures showing the current level of live coral cover against data collected in late 2007 and mid 2010 are shown in Figures 4-1 to 4-11.

Angel Island Site 2 – ANG2

Mean live coral cover at ANG2 was 46.1%, with only a small proportion (0.5%) of bleaching. Cover was consistent between all five transects, ranging from 42.1 – 50.7 % (Table 4-1). Live coral cover at ANG2 has increased since previous surveys (Figure 4-1) and this appears to be due to extensive growth of *Acropora spp.* between the 2010 and 2019 surveys.

Table 4-1. Benthic cover (%) at ANG2.

	Live coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	43.8	0.0	3.2	38.2	14.8
Transect 2	44.7	1.1	2.4	41.3	10.4
Transect 3	47.5	0.7	6.5	32.8	12.5
Transect 4	41.7	0.4	2.6	47.6	7.8
Transect 5	50.2	0.5	2.4	36.6	10.4
Site Mean **(S.E.)**	45.6 (1.5)	0.5 (0.2)	3.4 (0.8)	39.3 (2.5)	11.2 (1.2)

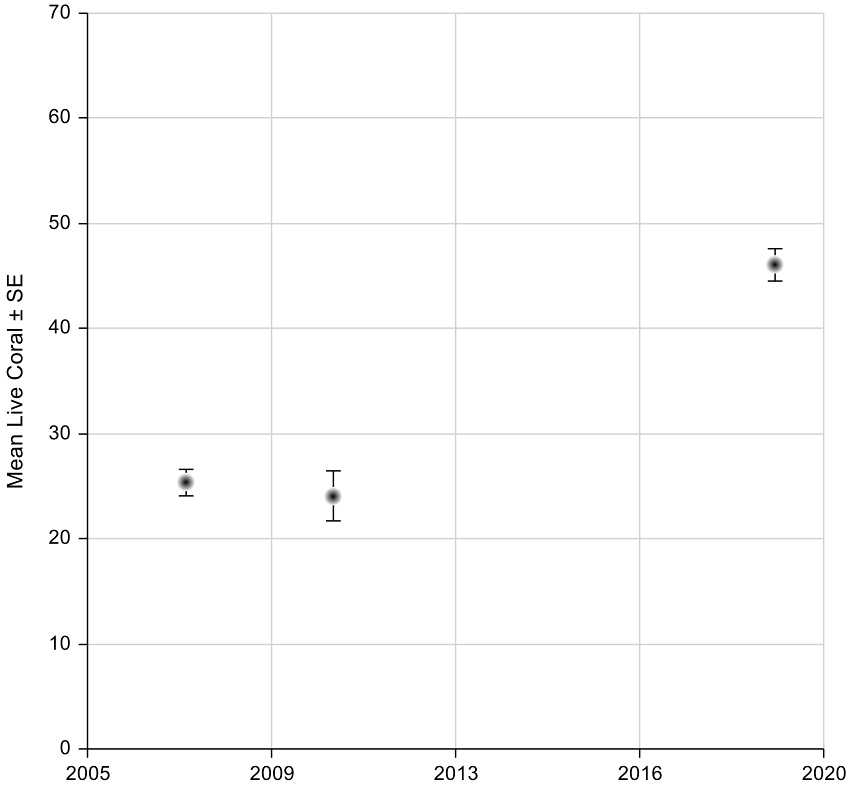


Figure 4-1. Cover of live hard coral at site ANG2

Conzinc Bay North – COBN

Mean live coral cover at COBN was 31.9%, with a very small proportion (0.1%) of bleaching. Cover was ranged from 23.2 - 27.4% for four transects, with Transect 4 cover at 55% with a high proportion of *Porites* (Table 4-2). Despite the high variance between transects, live coral cover at COBN remains similar, though slightly lower, to that of previous surveys (Figure 4-2).

Table 4-2. Benthic cover (%) at COBN.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	26.5	0.0	12.7	54.6	6.2
Transect 2	27.4	0.0	5.0	44.5	23.1
Transect 3	23.1	0.2	7.6	56.1	12.9
Transect 4	54.7	0.0	8.0	36.8	0.5
Transect 5	27.3	0.1	13.4	56.9	2.2
Site Mean **(S.E.)**	31.8 (5.8)	0.1 (0.0)	9.4 (1.6)	49.8 (3.9)	9.0 (4.1)

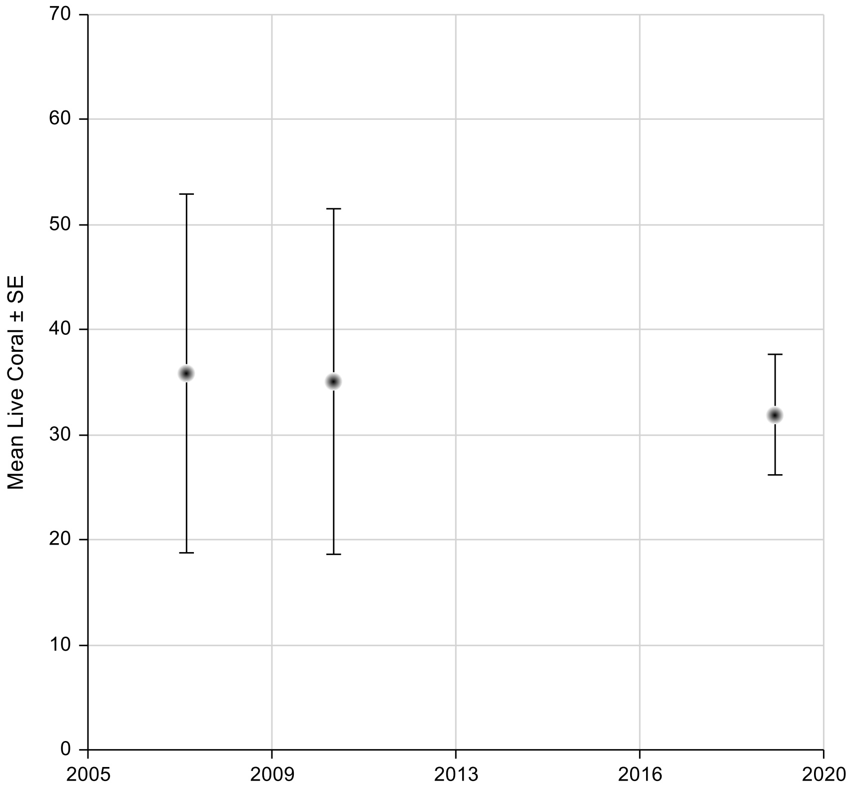


Figure 4-2. Cover of live hard coral at site COBN

Conzinc Island – CONI

Mean live coral cover at CONI was measured at 49%, with 2.9% bleaching. Cover was relatively variable across transects, ranging from 37.2 – 56.1%, with higher levels of bleaching recorded in Transects 1 and 2 (Table 4-3). Despite the variance between transects, live coral cover at CONI remains similar to that recorded in previous surveys (Figure 4-3).

Table 4-3. Benthic cover (%) at CONI.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	47.8	8.2	6.5	23.1	14.4
Transect 2	52.0	4.1	6.6	27.6	9.8
Transect 3	48.9	0.3	2.1	29.9	18.8
Transect 4	44.6	1.7	1.6	32.2	20.0
Transect 5	36.9	0.2	5.6	23.8	33.4
Site Mean **(S.E.)**	46.1 (2.6)	2.9 (1.5)	4.5 (1.1)	27.3 (1.7)	19.3 (4.0)

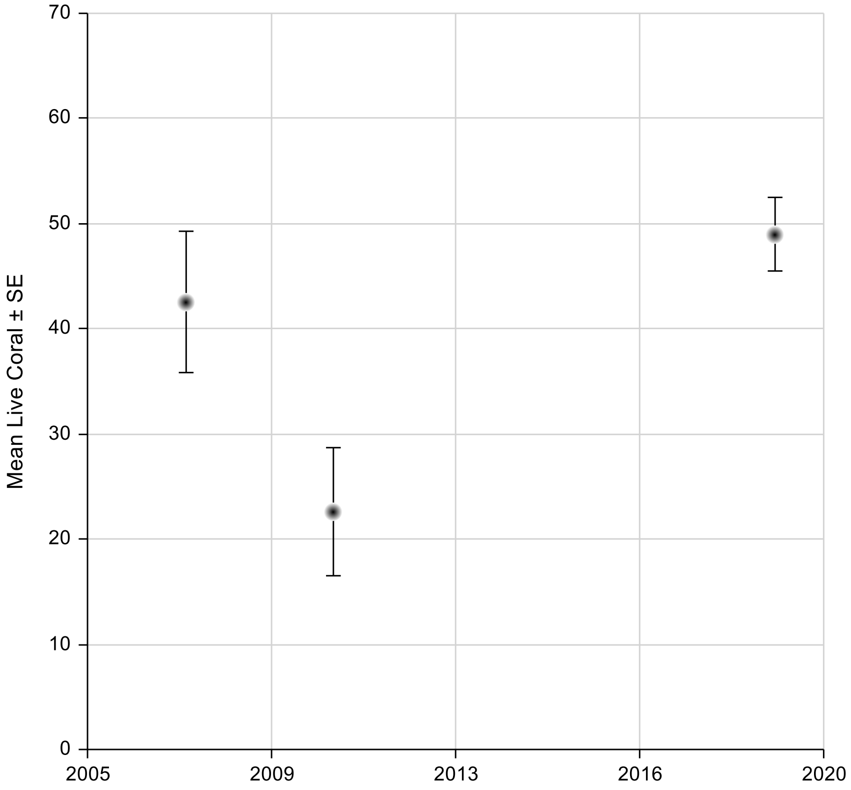


Figure 4-3. Cover of live hard coral at site CONI

Flying Foam Passage 1 – FFP1

Mean live coral cover at FFP1 with cover of live coral measured at 32.4%, with 0.5% bleaching. Cover was relatively consistent across all transects, ranging from 28.7 – 37.5% (Table 4-4). Live coral cover at FFP1 remains similar to that recorded in previous surveys (Figure 4-4).

Table 4-4. Benthic cover (%) at FFP1.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	**Bleached**			
Transect 1	37.2	0.3	4.1	46.0	12.3
Transect 2	27.7	1.0	3.2	55.3	12.8
Transect 3	36.5	0.7	16.6	39.9	6.3
Transect 4	28.4	0.0	1.9	56.1	13.6
Transect 5	29.6	0.4	1.2	56.4	12.4
Site Mean **(S.E.)**	31.9 (2.1)	0.5 (0.2)	5.4 (2.8)	50.8 (3.3)	11.5 (1.3)

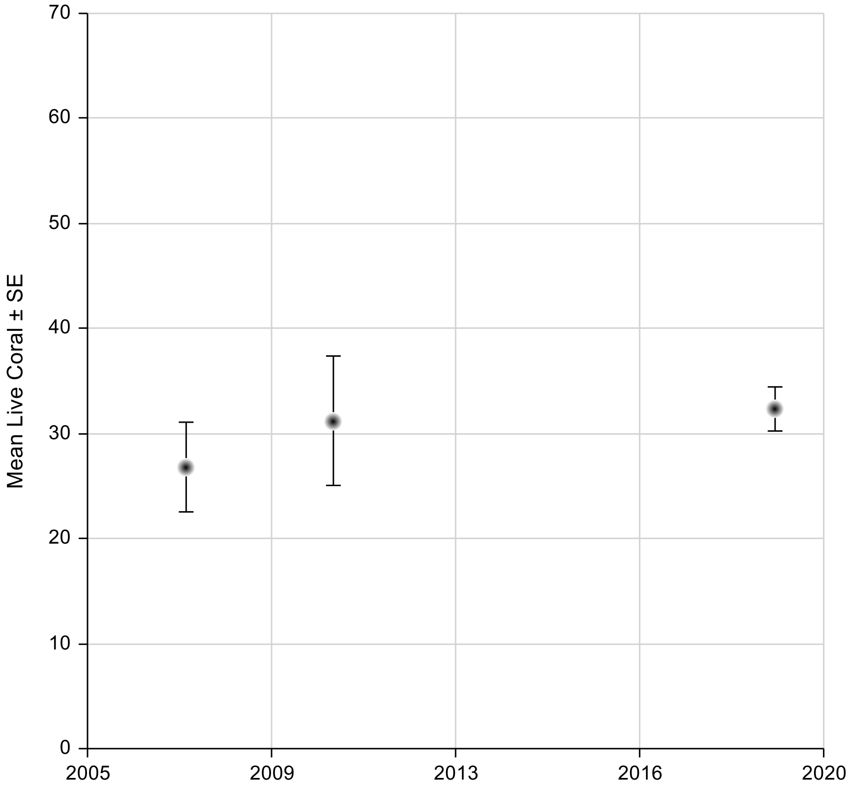


Figure 4-4. Cover of live hard coral at site FFP1

Gidley Island – GIDI

Mean live coral cover at GIDI with cover of live coral measured at 47.6%, with 0.6% bleaching. Cover was relatively consistent across all transects, ranging from 42.9 – 52.5% (Table 4-5). Live coral cover recorded during the current survey is significantly higher than cover recorded in the 2007 and 2010 surveys (Figure 4-5). Although there are only data points from three surveys, the data appears to show a trend for increasing coral cover between 2007 and 2019.

Table 4-5. Benthic cover (%) at GIDI.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	48.6	1.0	5.6	35.0	9.8
Transect 2	51.9	0.6	3.2	42.4	1.9
Transect 3	41.3	0.6	4.3	40.4	13.4
Transect 4	50.9	0.2	5.2	36.7	7.0
Transect 5	42.2	0.7	7.9	43.3	5.9
Site Mean **(S.E.)**	47.0 (2.2)	0.6 (0.1)	5.2 (0.8)	39.6 (1.6)	7.6 (1.9)

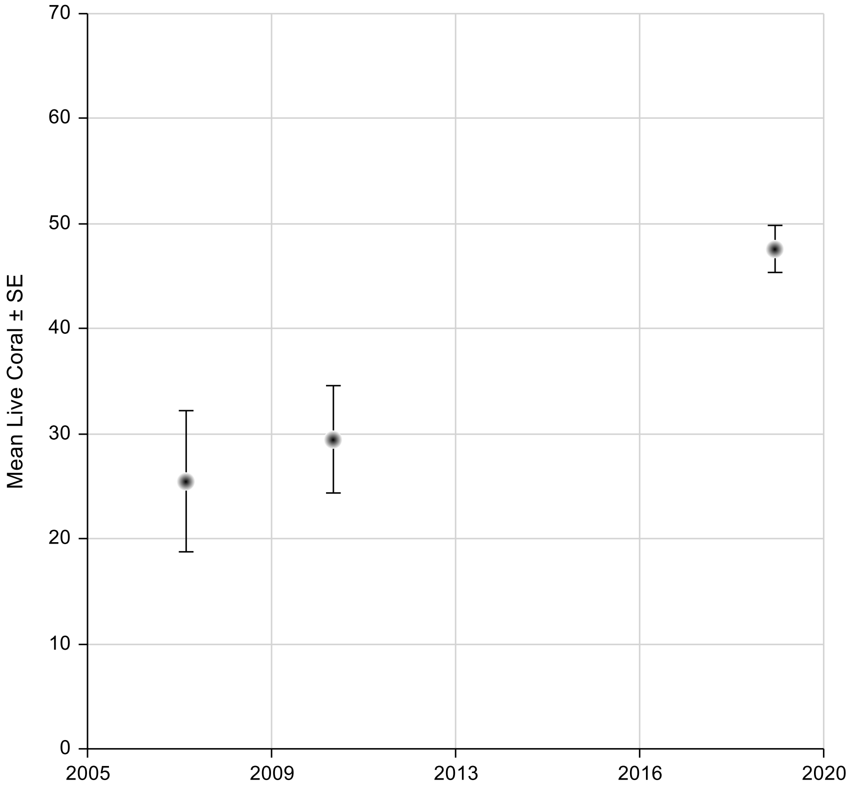


Figure 4-5. Cover of live hard coral at site GIDI

Intercourse Island – INTI

Mean live coral cover at INTI was 39.3%, with 2.1% bleaching. Cover was quite variable across transects, ranging from 25.7 – 48.9%, with high levels of bleaching recorded in Transect 1 and low levels of bleaching recorded along Transect 3 (Table 4-6). Despite the variance between transects, live coral cover at INTI remains similar to that recorded in previous surveys (Figure 4-6).

Table 4-6. Benthic cover (%) at INTI.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	36.9	5.7	6.6	41.0	9.7
Transect 2	47.3	1.6	0.9	31.5	18.6
Transect 3	25.5	0.2	0.3	33.5	40.3
Transect 4	29.4	1.1	0.7	24.8	44.0
Transect 5	46.7	1.8	3.7	28.2	19.6
Site Mean **(S.E.)**	37.2 (4.4)	2.1 (0.9)	2.4 (1.2)	31.8 (2.7)	26.5 (6.7)

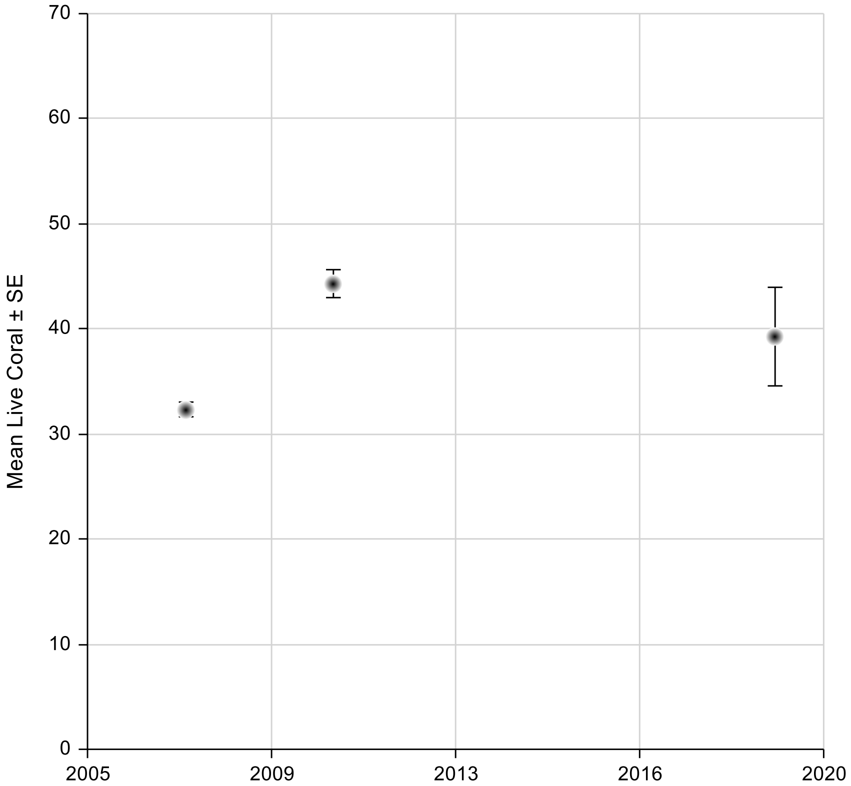


Figure 4-6. Cover of live hard coral at site INTI

King Bay – KGBY

Mean live coral cover at KGBY was 30%, with 0.7% bleaching. Cover was highly variable across transects, ranging from 19.0 – 53.1 % (Table 4-7). Despite the large variance in live coral cover across the KGBY site in the 2019 survey, total live coral cover between surveys shows good agreement with current coral cover between the levels observed in the 2007 and 2010 surveys (Figure 4-7).

Table 4-7. Benthic cover (%) at KGBY.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	52.5	0.6	3.0	39.2	4.7
Transect 2	23.8	0.2	0.7	36.5	38.8
Transect 3	17.7	1.3	1.4	43.8	35.7
Transect 4	29.2	1.0	1.8	29.3	38.8
Transect 5	23.4	0.4	1.5	30.5	44.1
Site Mean **(S.E.)**	29.3 (6.1)	0.7 (0.2)	1.7 (0.4)	35.9 (2.7)	32.4 (7.1)

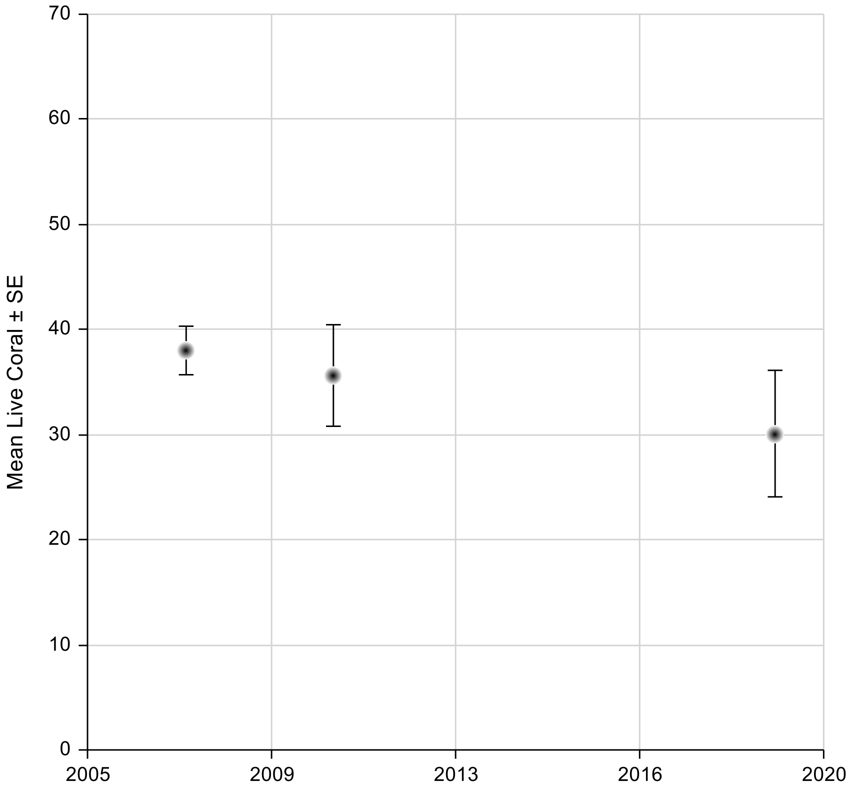


Figure 4-7. Cover of live hard coral at site KGBY

Legendre Island – LEGD

Mean live coral cover at LEGD was only 5.7%. Bleaching was rare, recorded at low levels in only two transects (Table 4-8). Individual transects varied in cover between 3.8 – 9.0%. Comparison of the current cover with cover observed at previous surveys, shows while coral cover has been historically low at LEGD, the 2019 survey has shown a reduction in cover compared to previous surveys (Figure 4-8).

Table 4-8. Benthic cover (%) at LEGD.

	Live		Other Fauna	Flora	Abiotic
	Hard Coral	**Bleached**			
Transect 1	5.5	0.0	44.6	49.5	0.4
Transect 2	4.1	0.1	48.8	45.9	1.0
Transect 3	3.8	0.0	43.4	52.3	0.5
Transect 4	8.9	0.1	24.0	65.8	1.2
Transect 5	6.1	0.0	50.8	42.5	0.7
Site Mean **(S.E.)**	5.7 (0.9)	0.0 (0.0)	42.3 (4.8)	51.2 (4.0)	0.8 (0.2)

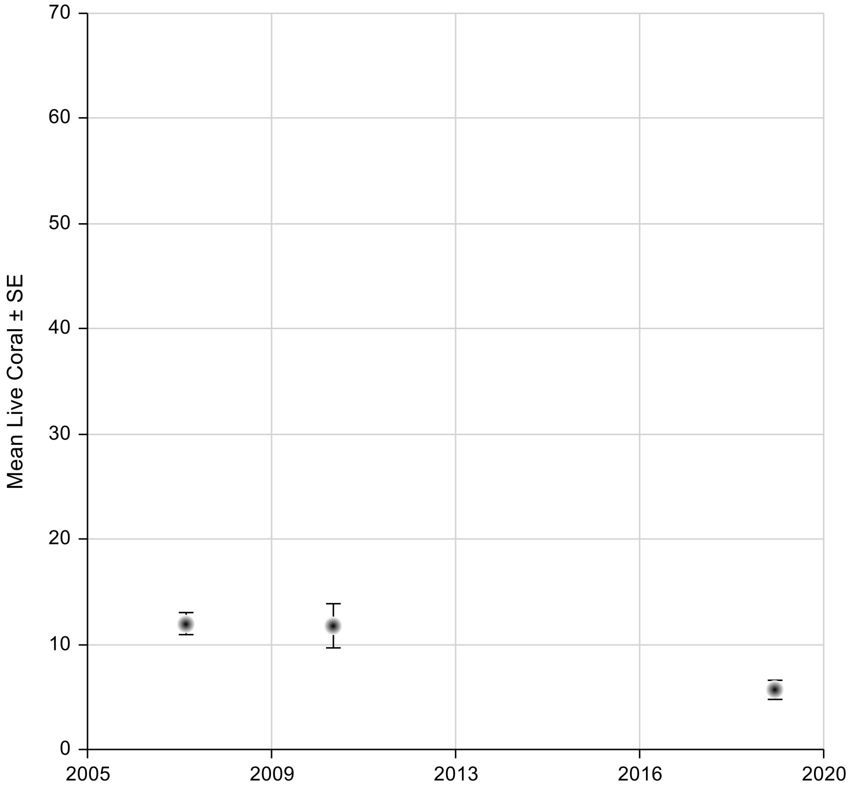


Figure 4-8. Cover of live hard coral at site LEGD

Malus Island Site 2 – MAL2

MAL2 had the highest mean live coral cover of all sites (56.7%), with 0.2% bleaching. Cover was relatively consistent across all transects, ranging from 48.5 – 60.5% (Table 4-9), with the 48.5% cover along transect 5 being a low 'outlier'. Live coral cover at MAL2 remains very similar to that recorded in previous surveys (Figure 4-9).

Table 4-9. Benthic cover (%) at MAL2.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	59.9	0.6	6.4	33.1	0.1
Transect 2	59.0	0.3	6.0	30.4	4.2
Transect 3	55.3	0.0	7.3	30.6	6.8
Transect 4	59.7	0.1	5.6	23.0	11.6
Transect 5	48.5	0.0	4.6	39.9	7.0
Site Mean **(S.E.)**	56.5 (2.2)	0.2 (0.1)	6.0 (0.4)	31.4 (2.7)	5.9 (1.9)

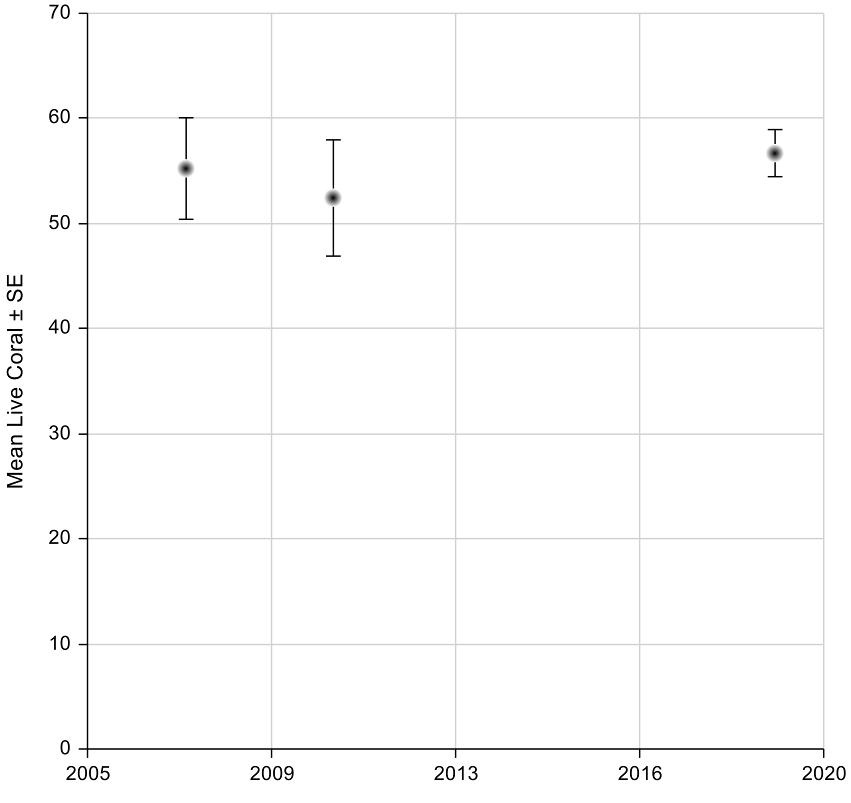


Figure 4-9. Cover of live hard coral at site MAL2

Mid Intercourse Island – MIDI

Mean live coral cover at MIDI was 20.4%, with 0.6% bleaching. Cover was relatively consistent across all transects, ranging from 16.0 – 22.8%. Levels of bleaching across transects showed more variability (Table 4-10). While coral cover in the current survey is slightly higher than in previous surveys, coral cover at this site appears relatively stable over time (Figure 4-10).

Table 4-10. Benthic cover (%) at MIDI.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	**Bleached**			
Transect 1	22.6	0.2	2.2	62.8	12.1
Transect 2	18.7	1.7	0.9	57.7	21.0
Transect 3	22.7	0.1	2.1	60.4	14.7
Transect 4	14.9	1.1	1.2	67.2	15.6
Transect 5	20.3	0.0	0.6	57.8	21.3
Site Mean **(S.E.)**	19.8 (1.5)	0.6 (0.3)	1.4 (0.3)	61.2 (1.8)	16.9 (1.8)

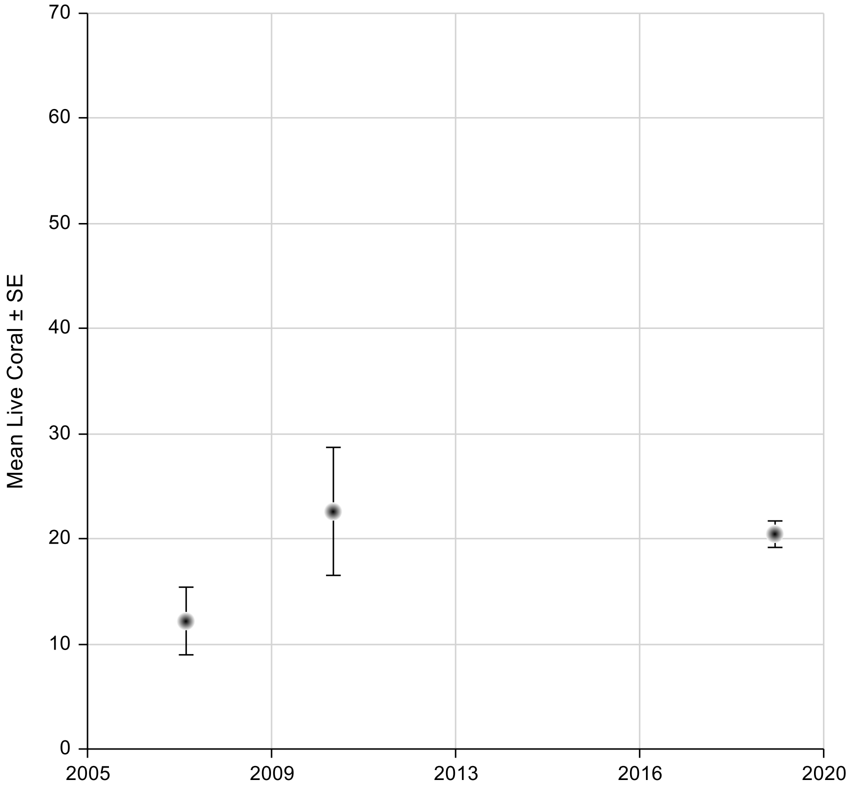


Figure 4-10. Cover of live hard coral at site MIDI

Supply Base Site 2 – SUP2

Mean live coral cover at SUP2 was 36.4%, with 1.1% bleaching. Cover was quite variable across transects, ranging from 24.4 – 49.4%, with lower levels of bleaching recorded in Transect 2, and to a lesser extent, Transect 3 (Table 4-11). Live coral cover at INTI recorded during the current survey was much higher than coral cover reported during the 2007 and 2010 surveys (Figure 4-11).

Table 4-11. Benthic cover (%) at SUP2.

	Live Coral		Other Fauna	Flora	Abiotic
	Hard Coral	Bleached			
Transect 1	22.3	2.1	4.2	42.3	29.2
Transect 2	44.1	0.3	2.6	41.4	11.5
Transect 3	33.4	0.8	2.3	45.2	18.3
Transect 4	28.3	1.1	1.6	37.7	31.3
Transect 5	48.1	1.3	1.2	35.6	13.9
Site Mean **(S.E.)**	35.3 (4.8)	1.1 (0.3)	2.4 (0.5)	40.4 (1.7)	20.8 (4.0)

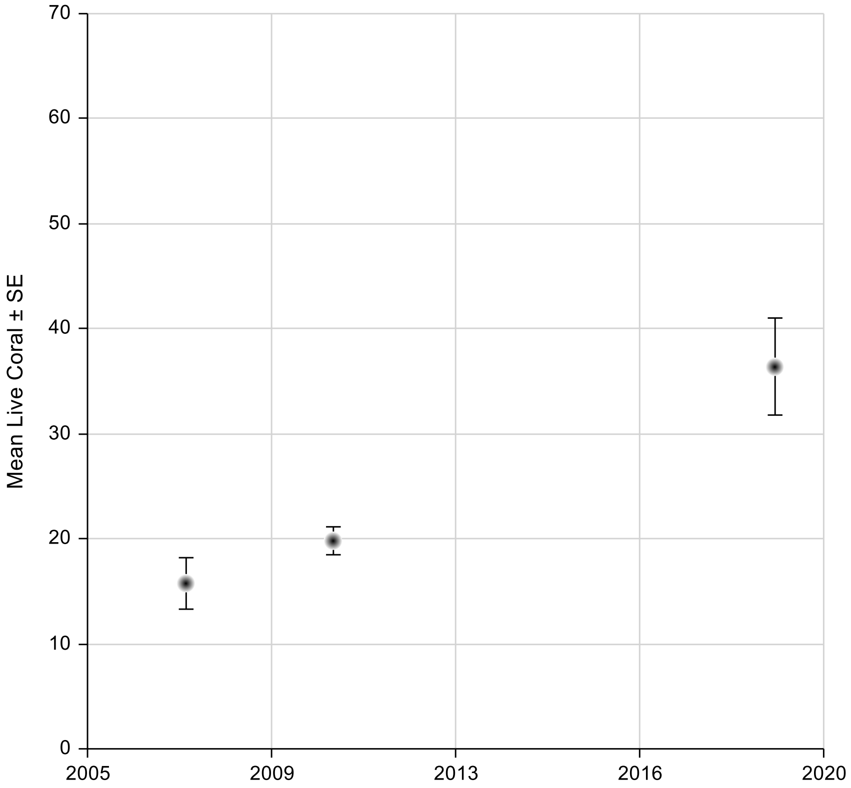


Figure 4-11. Cover of live hard coral at site SUP2

4.3 Community composition

Data using the full taxonomic breakdown has been supplied to Advisian in electronic form for each site. That data will be available should it be required as per the project tiered management framework. The following section uses the 6-category classification of hard corals set out in Section 3.4.

Angel Island Site 2 – ANG2

All six categories of hard corals were present at the ANG2 site, though at very different proportions (Figure 4-12). There are very few *Turbinaria* corals present at this site, which is now dominated by Acropora corals. Live coral cover at ANG2 has significantly increased in the current survey compared to the 2007 and 2010 coverage. The increase in cover observed in the current survey was largely due to an increase in Acropora coral, and to a lesser extent, *Porites* coral.

There was an apparent reduction in the proportion of Faviid corals, but this was considered to be due to the methods for calculating proportions when factoring in the large growth in *Acropora*, rather than a real loss of Faviid corals at this site.

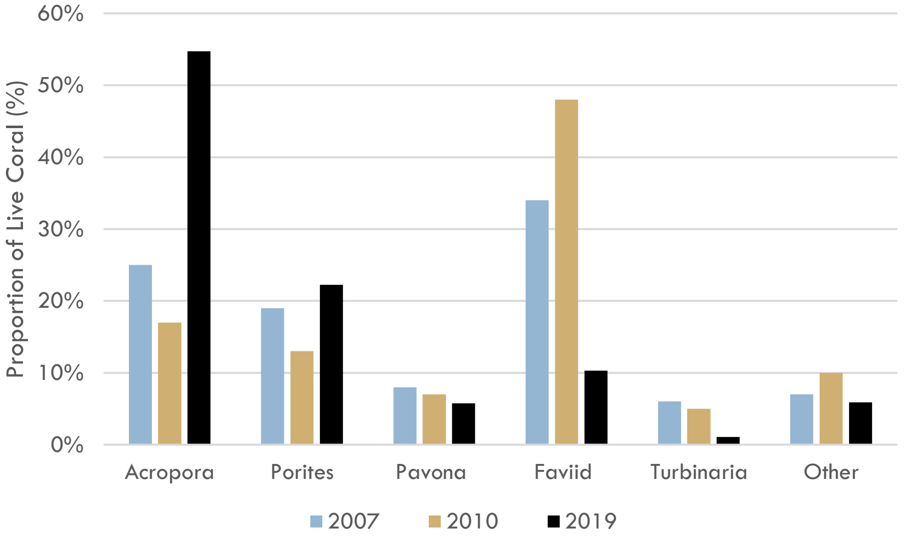


Figure 4-12. Community composition of live hard corals at site ANG2

Conzinc Bay North – COBN

Live coral cover at COBN has remained stable between surveys 2007 – 2019, with slightly less coral cover reported in the 2019. There was good species diversity at this site with all six hard coral categories represented at COBN (Figure 4-13). While the proportions of coral categories show some variance between surveys a consistent feature at this site has been the low representation of *Pavona* corals. The current survey shows a small proportion of *Acropora* and *Pavona*, with more abundant *Turbinaria* and *Porites*. Diversity within the current survey is most consistent with the community composition identified in the 2007 survey.

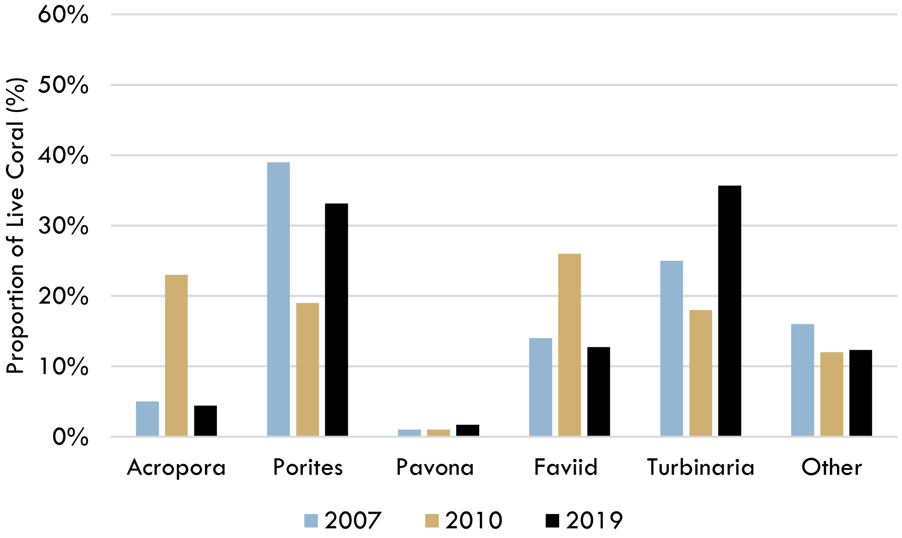


Figure 4-13. Community composition of live hard corals at site COBN

Conzinc Island – CONI

Total live coral cover at CONI is relatively high at 45-50% and cover was reasonably stable across surveys between 2007 – 2019. In terms of diversity, all six hard coral categories were present at this site, with community composition showing good agreement between surveys (Figure 4-14). Whilst community composition at this site appears to be stable over time, the community is dominated by *Porites* coral, with very few *Acropora* and *Turbinaria* corals. The dominance of the *Porites* category reduces the diversity at this site.

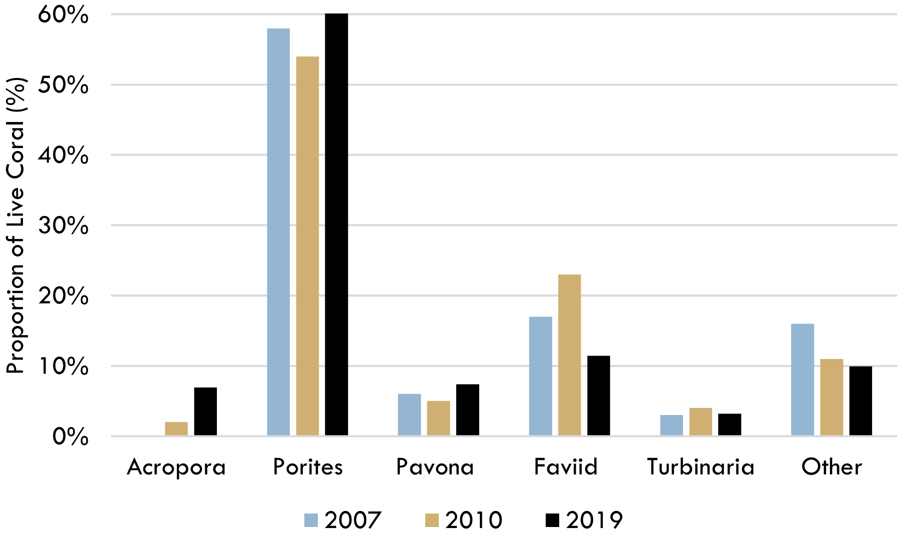


Figure 4-14. Community composition of live hard corals at site CONI

Flying Foam Passage 1 – FFP1

Total live cover was recorded at approximately 32% in the current survey and coral cover at the FFP1 site showed good agreement with previous surveys. The coral community present showed good species diversity with all six hard coral categories represented (Figure 4-15). While most categories showed similar proportional representation, there were slightly lower proportions of *Acropora* and *Pavona* corals. Community composition in the current survey comprised slightly more *Porites* and less *Turbinaria* than in previous surveys. While there does not appear to be a dominant hard coral category, corals species form the "other" category are consistently occurring in the highest proportions at this site.

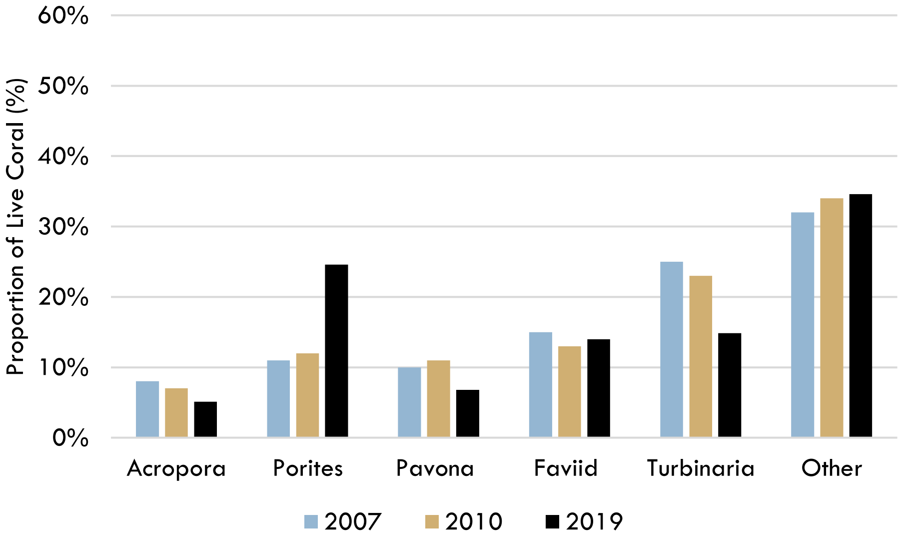


Figure 4-15. Community composition of live hard corals at site FFP1

Gidley Island – GIDI

Live coral cover at GIDI increased from 20-30% in 2007 and 2010 surveys to nearly 50% coral cover in the 2019 survey. All six hard coral categories were represented in this community and community composition appears stable over time (Figure 4-16). While there was no dominant category, proportions of Pavona corals were low at this site. The similarity of community composition in this survey compared with previous surveys, suggest that the large increase in coral cover in the 2019 survey was not due to the growth of any particular species or category, rather a general increase in coral cover across all species. There was some evidence to suggest that abundance of *Acropora* corals at this site can vary. Acroporids are susceptible to bleaching and cyclone events, but also show rapid colonisation and good growth rates, so it is not surprising that this category shows some variability between surveys.

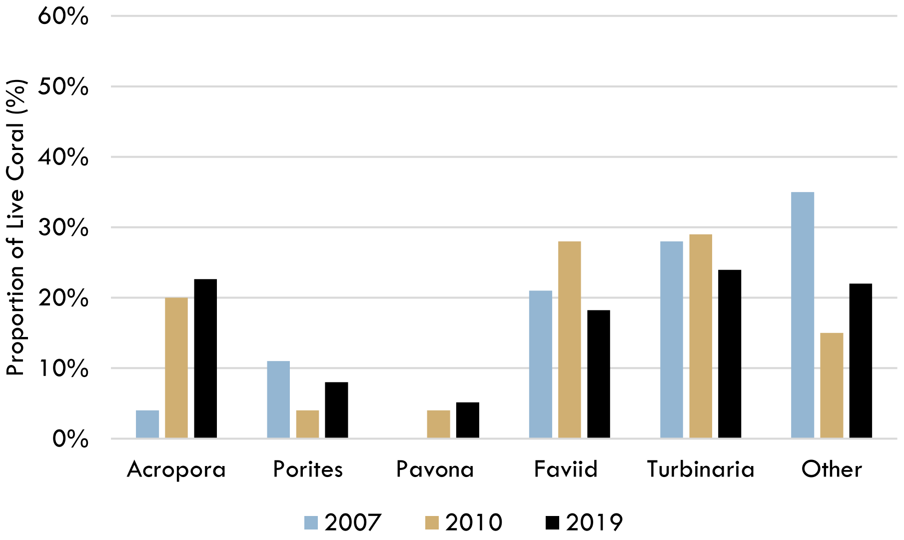


Figure 4-16. Community composition of live hard corals at site GIDI

Intercourse Island – INTI

Live coral cover at INTI shows stable coral cover of around 40%. This community is represented by all six hard coral categories, though *Turbinaria* and *Acropora* corals are only present in small proportions (Figure 4-17). Small changes in community composition over time appear to be present in the 'Other' and *Pavona* categories, and to a lesser extent, Faviid corals.

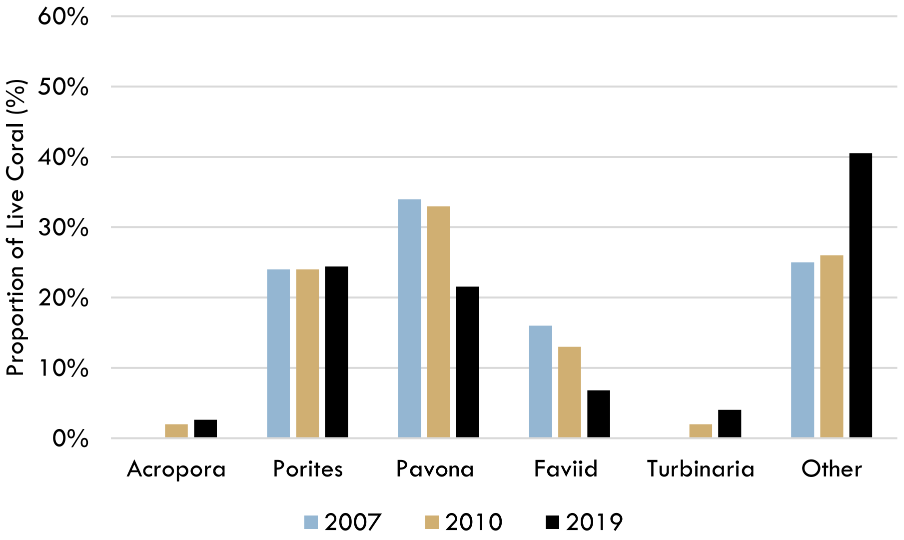


Figure 4-17. Community composition of live hard corals at site INTI

King Bay – KGBY

Live coral cover at KGBY was reported at 30% in the current survey, slightly less than 2010 survey, but similar to coverage observed during the 2007 survey. Community composition at KGBY appears to be different from the other monitoring sites, with no *Acropora* corals present in any of the surveys and the community is dominated by Faviid corals (Figure 4-18). Proportions of *Porites* and *Pavona* corals have also been consistently low across all surveys. The current survey identified slightly more *Turbinaria* and slightly less Faviids than previous surveys, though since these proportions are not independent measurements, the magnitude of change is unlikely to represent any changes to abundance or composition.

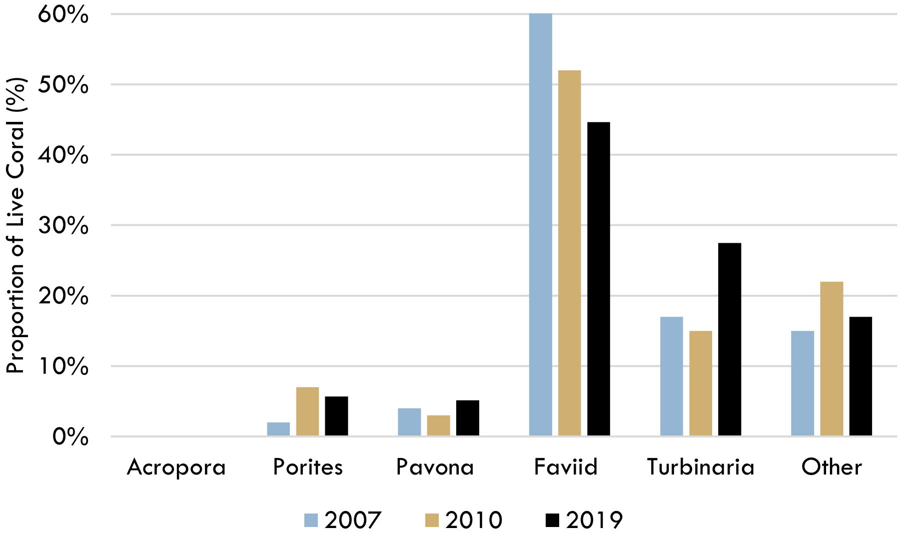


Figure 4-18. Community composition of live hard corals at site KGBY

Legendre Island – LEGD

Live coral cover at LEGD has been historically low relative to the other coral monitoring sites in the Dampier Archipelago. The current survey reported a lower coverage than previous surveys with cover estimates around 5%. While all hard coral categories were represented at this site in the current survey, there was almost no *Pavona* identified in 2019, with this category also absent from previous surveys (Figure 4-19). The remaining categories showed similar proportional coverage between surveys, though the current survey reported a slight increase in *Porites* that was offset by a slight decrease in the Other corals category when compared to previous surveys.

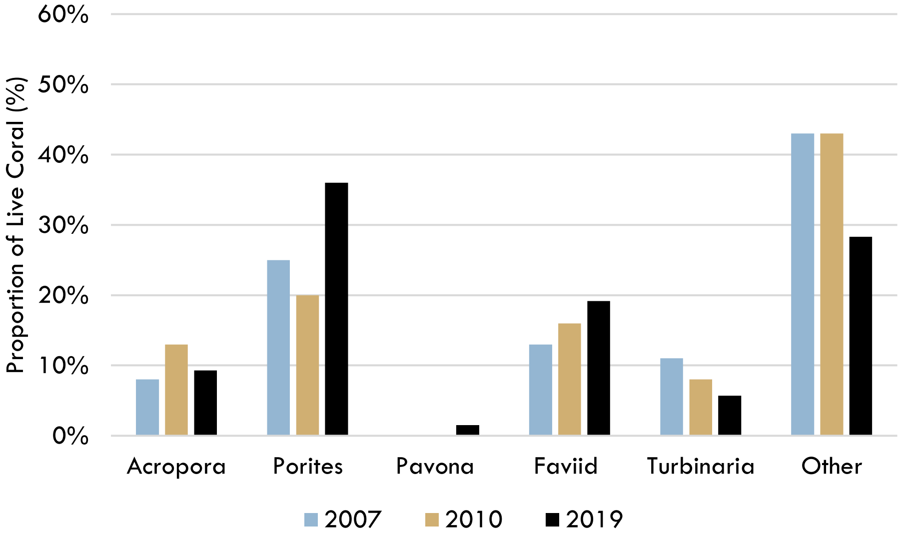


Figure 4-19. Community composition of live hard corals at site LEGD

Malus Island Site 2 – MAL2

Live coral cover at MAL2 was very stable between surveys reporting coverage estimates of approximately 56% cover in the 2019 survey. Community composition shows good agreement between surveys, with the community dominated by *Porites*, with almost no *Turbinaria* present (Figure 4-20). *Turbinaria* were identified at <0.1% in the current survey.

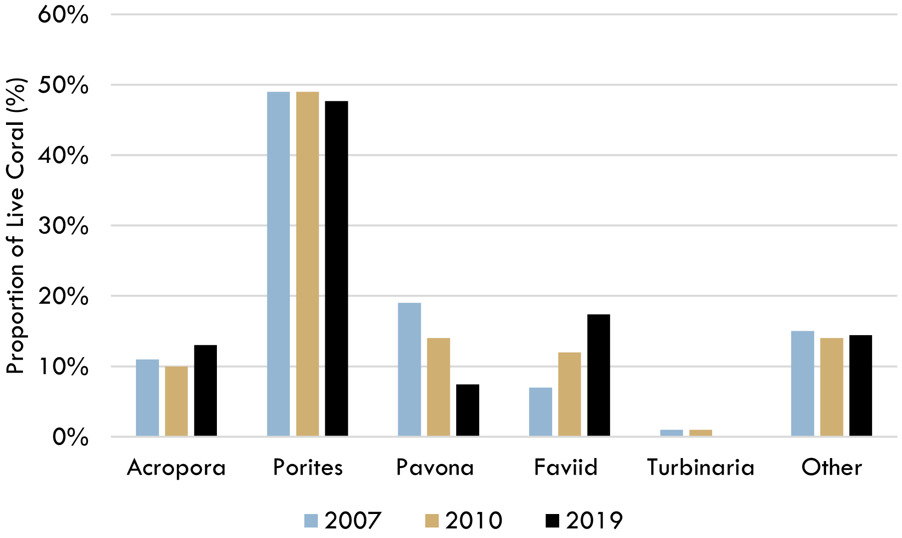


Figure 4-20. Community composition of live hard corals at site MAL2

Mid Intercourse Island – MIDI

There was a slight increase in total live coral cover at MIDI identified in this survey, with coverage estimates at around 20%. While all six hard coral categories were present in the community, there were clearly categories showing better representation that others (Figure 4-21). The community was dominated by corals from the Other category, with good proportional representation from *Pavona* and Faviid corals. *Porites*, *Acropora* and *Turbinaria* categories were poorly represented in this community. The low abundance of these categories led to significant variability in proportions of these categories when compared between surveys.

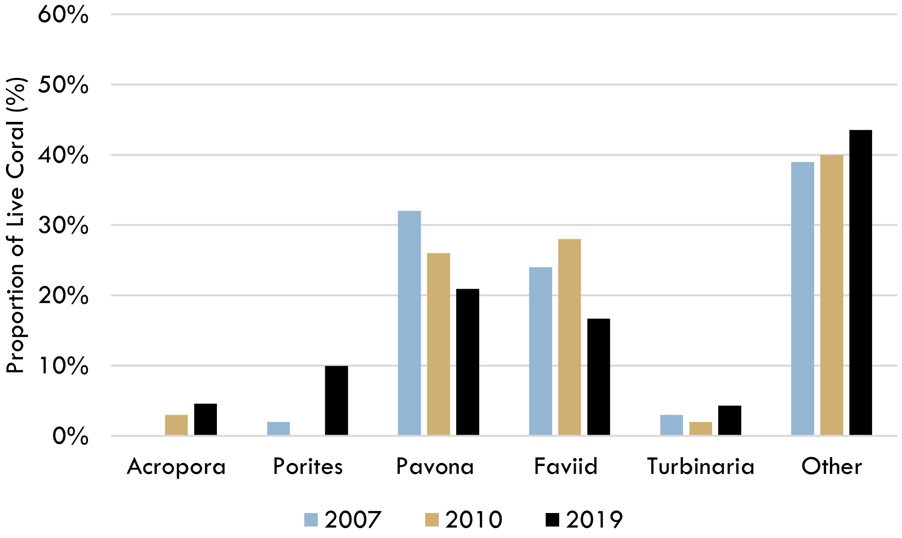


Figure 4-21. Community composition of live hard corals at site MIDI

Supply Base Site 2 – SUP2

Live coral cover at SUP2 was higher in the 2019 survey than in the 2007 and 2010 surveys, with live coral cover currently reported at approximately 36%. With the exception of *Acropora* corals, all hard coral categories are represented in similar proportions at SUP2 (Figure 4-22). There was a slight increase in the proportions of *Pavona* identified and a concomitant decrease in the proportions of *Porites* when compared to the previous surveys. No *Acropora* corals were identified in previous surveys, and only small proportion of *Acropora* (1.6%) was reported in the current survey. This site does not appear to be a good habitat to support *Acropora* species.

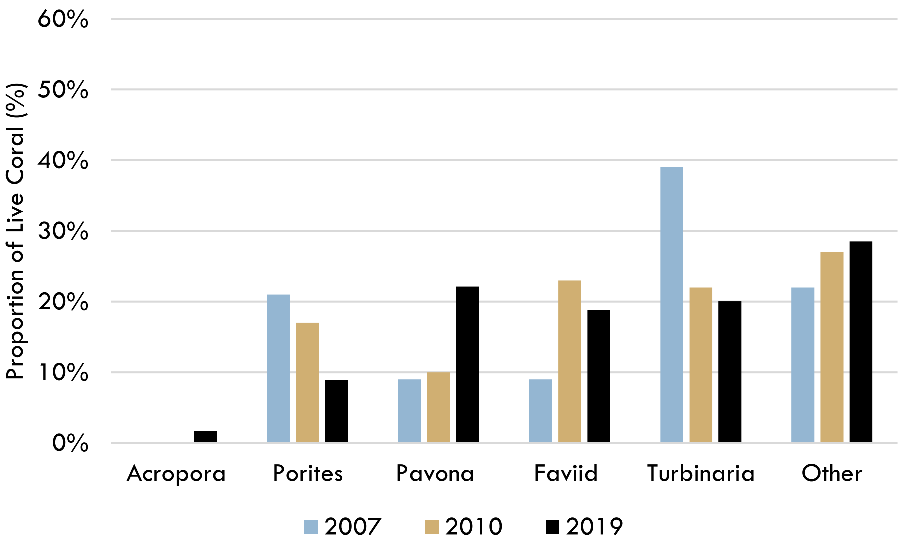


Figure 4-22. Community composition of live hard corals at site SUP2

To further investigate community composition and biodiversity of coral species present at each monitoring site, the Shannon-Weiner Index (H') was calculated for each site to provide a measure of diversity for comparison against previous surveys (Table 4-12). The Shannon-Wiener index increases as both the richness and the evenness of the community increase. Thus low values represent sites dominated by one type of coral, while higher values show sites with a mixture of species (or major groups, as used here).

Table 4-12. Shannon-Wiener Index of diversity based on coral cover at each site

H'	**2007**	**2010**	**2019**
ANG2	1.59	1.48	1.28
COBN	1.48	1.61	1.46
CONI	1.18	1.27	1.27
FFP1	1.67	1.65	1.61
GIDI	1.42	1.58	1.68
INTI	1.35	1.48	1.45
KGBY	1.09	1.25	1.33
LEGD	1.42	1.45	1.49
MAL2	1.42	1.43	1.40
MIDI	1.26	1.26	1.49
SUP2	1.46	1.56	1.61

5 DISCUSSION

Coral communities within Mermaid Sound and the surrounding Dampier Archipelago have been studied since the 1970s, initially by scientists from the Western Australian Museum as part of assessments of impacts of Crown of Thorns starfish (Johnson and Stoddart 1988; Veron and Marsh 1988) and integrated ecological assessments of the local marine environment (Simpson 1988). Since the early 1980s, quantitative studies of coral abundance, reproduction and recruitment have been conducted as part of numerous environmental assessment and monitoring studies (See Moustaka et al. 2019 for some of those studies).

The coral communities of Mermaid Sound occur most commonly as narrow linear features fringing the shorelines of islands and the Burrup Peninsula, typically between -2 m and -10 m mean lower low water (Blakeway and Radford 2005; Jones 2004). These fringing reefs are generally relatively thin structures overlying pre-existing hard substratum (Jones 2004; Semeniuk et al. 1982; WorleyParsons 2009).

Surveys conducted in and around Mermaid Sound and the Dampier Archipelago identified 229 species of hard coral from 57 genera (Griffith 2004) with the wide range of habitats existing in the area being listed as a key factor in supporting that level of diversity. The distribution of coral communities shows a strong gradient in which nearshore or inner harbour reefs are dominated by sediment tolerant species that shift to wave tolerant clear water species further offshore in the outer port (Moustaka et al. 2019; Simpson 1988) A detailed study of the Dampier Port inner harbour area found that of the 229 known Dampier coral species, 120 species from 40 genera occur in the inner harbour (Blakeway and Radford 2005). These inner harbour communities are typically dominated by faviids, *Turbinaria* and *Pavona* (Blakeway and Radford 2005; WorleyParsons 2009a) while outer harbour communities shift towards *Acropora* and *Pocillopora* dominated communities (Blakeway and Radford 2005; MScience 2007).

The composition, density and extent of coral communities in this area responds to a variety of environmental factors including cyclones, thermal bleaching, coral diseases and coral predators (Moustaka et al. 2019; MScience 2010). In addition, anthropogenic factors such as industrial development surrounding the Sound, occasional capital and maintenance dredging projects for port infrastructure and a very high volume of ship and tug movements (PPA 2019) may cause changes to benthic habitats.

5.1 Coral cover

Coral cover from the current survey was very similar to historic cover levels reported at the majority of monitoring sites. Although most sites reported similar coral coverage estimates between surveys, there were a few exceptions. Sites ANG2 (Figure 4-1), GIDI (Figure 4-5) and SUP2 (Figure 4-11) showed significantly more coral cover in the 2019 survey when compared to the 2007 and 2010 surveys. Coral cover increases at ANG2 appear to be driven by the abundance of corymbose and tabular *Acropora* colonies relative to previous surveys (Figure 4-12). Increases at GIDI (Figure 4-16) and SUP2 (Figure 4-22) do not appear to be due to any species-specific changes, rather a general increase in cover of all corals across the monitoring site; although there was some evidence to suggest a disproportionate increase in *Pavona* coral species at SUP2.

The only site to show a significant reduction in coral cover in the current survey was LEGD (Figure 4-8). While this site has shown historically low cover relative to the other monitoring sites, cover in the current survey has shown further reductions from the historic coverage estimates of ~10% down to approximately 6% coral cover. The reduction in coral cover appeared to occur across all coral species present on the reef. It is unclear as to what has caused this decrease in coral cover, though the offshore location of the monitoring site suggest it was unlikely to be due to anthropogenic effects arising from activities in the Dampier Harbour.

Levels of bleaching in the current survey were relatively low; 1-3% at SUP2, INTI and CONI, and <0.5% at the remaining sites. This is consistent with mid-year surveys previously conducted in the Pilbara, when the thermal bleaching effects of high summer water temperatures have usually resolved, either in recovery or mortality (Depczynski et al. 2013). The low proportion of recently-dead standing coral observed in the current survey suggested that mortality due to thermal bleaching over the 2018-2019 summer was minimal.

5.2 Community composition

For the present study, community composition has been assessed using a reduced taxonomic classification based on previous descriptions of the common taxa of Mermaid Sound. That classification provides an insight into susceptibility to dredging based on community type (for instance by using the predictions of Gilmour et al. 2006) and aligns with historic descriptions of community composition (MScience 2007). Morphology of the coral colonies at a site may be a more important factor in predicting the susceptibility of corals to the impacts of dredging (Gilmour et al. 2006; Jones et al. 2015), and that data could be derived from the more detailed taxonomic classification found in the raw scoring data.

Diversity of corals at monitoring sites evaluated using the six hard coral categories (see Section 3.4) showed proportional representation of each category to be relatively consistent over time, indicative of a relatively stable community structure. Whilst there was a relatively consistent proportional representation of categories over time within a site, there were some obvious differences in the community composition between sites. Acroporid corals were nearly absent from inshore sites KGBY (Figure 4-18) and SUP2 (Figure 4-22), while outer harbour communities at MAL2 (Figure 4-20), ANG2 (Figure 4-12) and GIDI (Figure 4-16) showed higher proportional representation of *Acropora*, consistent with previous reports at Dampier (Blakeway and Radford 2005; MScience 2007). MAL2 (Figure 4-20), CONI (Figure 4-14) and COBN (Figure 4-13) sites showed a high proportion of *Porites*, while KGBY (Figure 4-18) was unique in its very high proportion of favid corals.

Community composition between surveys has remained stable at most sites, although some changes were apparent between the current and earlier surveys at a few sites. The interpretation of changes requires that community composition based on relative abundance (proportions) be related to absolute abundance (cover) and an understanding of coral life histories, as an increasing proportion of one coral type could be due to more of that type or less of another type. An example of the former was noted at ANG2 (Figure 4-12), where an increase in the proportion of the *Acropora* group was accompanied by an increase in overall cover. *Acropora* is known to rapidly colonise substrates through abundant settlement and fast growth rates (Harriott 1999; Simpson 1988) and is often the dominant group in recovering communities. In the case of LEGD, which showed a clear decrease in coral cover in the current survey, the increase in the proportion of *Porites* coral was more likely due to loss of other coral species and good survivorship of *Porites* resulting in a proportional increase of that category within the community. Once established, Porites colonies are long lived and tend to be very stable components of turbid water communities (Done et al. 2007).

Within the spatially patchy and relatively small coral communities of Mermaid Sound, slight changes in the placement of transects between surveys can have an equivalent or larger effect on changes in the estimates of cover and composition than population dynamics. In the present case, it is considered that small changes in the placement of transects has contributed the majority of the between-survey variance recorded for many of the sites in coral cover and, to a lesser degree, community composition.

Overall, the changes in coral communities seen within the present set of sites are less than those reported elsewhere in the coastal Pilbara (Depczynski et al. 2013; Moore et al. 2012; Moustaka et al. 2019; Ridgway et al. 2016), suggesting that the coral communities within Mermaid Sound have avoided some of the depredations of thermal bleaching events and cyclones occurring here over the last decade.

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APPENDIX A – SITE DETAILS

Date	29/04/2019
Site	ANG2
Transect 1	
Compass bearing (start to end)	345°
Orientation to next transect	Right – 1m
Transect 2	
Compass bearing (start to end)	5°
Orientation to next transect	Left 1m
Transect 3	
Compass bearing (start to end)	15
Orientation to next transect	Right 1.5m
Transect 4	
Compass bearing (start to end)	345
Orientation to next transect	Right 1.5m
Transect 5	
Compass bearing (start to end)	30
General site description / notes: Some small amount of bleaching to tops of Porites and Faviids. Pickets did not seat particularly well, some loose – due to refusal Depth ~4.5 m Start point (WGS 84 Z50): Easting – 0477638 Northing – 7731841	

Date	1/05/2019
Site	COBN
Transect 1	
Compass bearing (start to end)	60°
Orientation to next transect	Right – 0.5m 150°
Transect 2	
Compass bearing (start to end)	20°
Orientation to next transect	Left 0.2m 0
Transect 3	
Compass bearing (start to end)	30
Orientation to next transect	Right 1 m 140
Transect 4	
Compass bearing (start to end)	40
Orientation to next transect	Left 0.5m 310
Transect 5	
Compass bearing (start to end)	40
General site description / notes: Some sediment on colonies Mucous present on Porites Lots of juveniles on rock Old transect stakes still present & cross new transects – look for difference in wear of stakes Depth varies but average @ 1320 ~4-5m Start point (WGS 84 Z50): Easting – 0479536 Northing – 7728650	

Date	2/05/2019
Site	CONI
Transect 1	
Compass bearing (start to end)	30°
Orientation to next transect	Right – 1m 00°
Transect 2	
Compass bearing (start to end)	45°
Orientation to next transect	Left 1m 270
Transect 3	
Compass bearing (start to end)	40
Orientation to next transect	Right 1 m 90
Transect 4	
Compass bearing (start to end)	50
Orientation to next transect	Left 1.5m 320
Transect 5	
Compass bearing (start to end)	30
General site description / notes: Porites Dominated, large colonies. High diversity of other species. Some Faviids and a few Porites bleached on top. Most of the Pavona have some partial mortality but this looks to be old. Depth @1200 ~ 3 – 4m Start point (WGS 84 Z50): Easting – 0476844 Northing – 7729163	

Date	1/05/2019
Site	FFP1
Transect 1	
Compass bearing (start to end)	220°
Orientation to next transect	Right – 1m 270°
Transect 2	
Compass bearing (start to end)	210°
Orientation to next transect	Left 1m 110
Transect 3	
Compass bearing (start to end)	220
Orientation to next transect	Right 0.2 m 280
Transect 4	
Compass bearing (start to end)	220
Orientation to next transect	Left 0.2m 150
Transect 5	
Compass bearing (start to end)	210

General site description / notes:

Coral rubble is the dominant substrate.
Overturned colonies and physical damage to large colonies, much of these colonies are still alive.
New recruits and coral colonies have settles on existing dead and damaged colonies – still unsecure (unconsolidated substrate).
Existing transect stakes observed on some sections of the new transect (near start and end)

Strong current – need to plan at slack water. Tides are ~1hour ahead of King Bay times.

Depth @ 1430 ~2.5m

Start point (WGS 84 Z50):
Easting – 0480996
Northing – 7734094

Date	2/05/2019
Site	GIDI
Transect 1	
Compass bearing (start to end)	0°
Orientation to next transect	Right – 1m 90°
Transect 2	
Compass bearing (start to end)	350°
Orientation to next transect	Left 1.5m 270
Transect 3	
Compass bearing (start to end)	0
Orientation to next transect	Right 1 m 60
Transect 4	
Compass bearing (start to end)	0
Orientation to next transect	Left 2.5m 300
Transect 5	
Compass bearing (start to end)	0

General site description / notes:
Partial and complete mortality to tabular *Acropora*.
Partial bleaching to Faviids, upper surfaces (tops) also *Galaxia, Podabacia*.

Depth @1000 ~ 4m

Start point (WGS 84 Z50):
Easting – 0478812
Northing – 7736359

Date	30/04/2019
Site	INTI
Transect 1	
Compass bearing (start to end)	320°
Orientation to next transect	Right – 1m 40°
Transect 2	
Compass bearing (start to end)	310°
Orientation to next transect	Left 1m 250
Transect 3	
Compass bearing (start to end)	280
Orientation to next transect	Right 0.5m 0
Transect 4	
Compass bearing (start to end)	260
Orientation to next transect	Left 0.5m 240
Transect 5	
Compass bearing (start to end)	300
General site description / notes: Some discolouration & partial bleaching evident in *Pectinia*, Faviids, Mussids, Fungids Site predominantly *Porites* and *Pavona* although diverse assemblage. Transects zig-zag along edge of a shallow reef shelf Depth ~2 – 3.5 m Start point (WGS 84 Z50): Easting – 0462916 Northing – 7716559	

Date	28/04/2019
Site	KGBY
Transect 1	
Compass bearing (start to end)	300°
Orientation to next transect	Right – 1m 180°
Transect 2	
Compass bearing (start to end)	300°
Orientation to next transect	Left 1m 30
Transect 3	
Compass bearing (start to end)	300
Orientation to next transect	Right 1 m 0
Transect 4	
Compass bearing (start to end)	300
Orientation to next transect	Left 1m 270
Transect 5	
Compass bearing (start to end)	290 - 300
General site description / notes: Some partial bleaching widespread Pink parasites on *Porites* corals Evidence of recent mortality Start point (WGS 84 Z50): Easting – 0472465 Northing – 7717710	

Date	29/04/2019
Site	LEGD
Transect 1	
Compass bearing (start to end)	180°
Orientation to next transect	Right – 0.5m 310°
Transect 2	
Compass bearing (start to end)	180°
Orientation to next transect	Left 0.5m 150
Transect 3	
Compass bearing (start to end)	180
Orientation to next transect	Right 1 m 200
Transect 4	
Compass bearing (start to end)	200
Orientation to next transect	Left 1m 150
Transect 5	
Compass bearing (start to end)	240

General site description / notes:
Sinularia soft coral dominant
Lots of juvenile hard corals
Small *Galaxea* colony damaged by rope on T3

Start point (WGS 84 Z50):
Easting – 0483392
Northing – 7749414

Date	27/04/2019
Site	MAL2
Transect 1	
Compass bearing (start to end)	330
Orientation to next transect	Right – 1.5m 30°
Transect 2	
Compass bearing (start to end)	330°
Orientation to next transect	Left 1m 250
Transect 3	
Compass bearing (start to end)	330
Orientation to next transect	Right 1 m 10
Transect 4	
Compass bearing (start to end)	330
Orientation to next transect	Left 0.5m 300
Transect 5	
Compass bearing (start to end)	340
General site description / notes: Some partial mortality of *Acropora*, minor. *Diadema* common. Some overturned *Acropora* colonies (dislodged) Start point (WGS 84 Z50): Easting – 0464581 Northing – 7730236	

Date	30/04/2019
Site	MIDI
Transcect 1	
Compass bearing (start to end)	300°
Orientation to next transect	Right – 0.5m 360°
Transect 2	
Compass bearing (start to end)	300°
Orientation to next transect	Left 1m 210
Transect 3	
Compass bearing (start to end)	280
Orientation to next transect	Left 1 m 120
Transect 4	
Compass bearing (start to end)	280
Orientation to next transect	Left 1m 210
Transect 5	
Compass bearing (start to end)	290
General site description / notes: Sargassum common Some colonies overgrown by macroalgae Sediment burial in lower lying areas Black band disease observed over *Podobacia* Small amounts of bleaching/discolouration in Faviids and *Pectinia* Depth @ 1140 ~2.5m Start point (WGS 84 Z50): Easting – 0464025 Northing – 7714214	

Date	30/04/2019
Site	SUP2
Transect 1	
Compass bearing (start to end)	225°
Orientation to next transect	Right – 1m 310°
Transect 2	
Compass bearing (start to end)	200°
Orientation to next transect	Left 1m 130
Transect 3	
Compass bearing (start to end)	200
Orientation to next transect	Right 0.5 m 100
Transect 4	
Compass bearing (start to end)	190
Orientation to next transect	Left 1m 300
Transect 5	
Compass bearing (start to end)	190
General site description / notes: Bleached/discoloured *Turbinaria* occasionally. Pink parasites in *Porites* Sandy sediments smothering lower lying corals Depth @ 1430 ~3m Start point (WGS 84 Z50): Easting – 0473433 Northing – 7719666	

APPENDIX B: SCORING CATEGORIES USED IN ANALYSIS (CPCE).

Group	CATEGORIES	Code	Comment
	Unknown		
U	Blurred (Blur)	Blur	unresolvable image
U	Unknown (Unk)	Unk	anything not in category below
	Bare Substratum		
A	Rock (R)	R	includes coralline algae
	Sediment		
A	Rubble (Ru)	Ru	includes coralline algae
A	Sand (S)	S	white sand
A	Sand on Hard Coral (SHc)	SHc	sand layer on what appears to be living coral
A	Sand on Soft Coral (SSc)	SSc	sand layer on what appears to be living coral
A	Sand on Sponge (SSp)	SSp	sand layer on what appears to be living coral
A	Shell grit (Sh)	Sh	large particles with edges
A	Silt (Silt)	Silt	dark coloured fine sediments
	Macroalgae		
Ma	Algae	Alg	large & small
	Seagrass		
Sg	General seagrass	USG	species unidentified or not Halophila
Sg	Halophila ovalis	Ho	all oval leafed Halophila
Sg	Halophila spinulosa	Hs	Christmas tree halophila - white stalk
	Turf Algae		
	Turf algae (Tu)	Tu	fine turf
	Dead Standing Coral		
Dc	Dead Standing Coral (DSC)	DSC	white coral with no sign of living tissue - starting to discolour

Group	CATEGORIES	Code	Comment
	CORAL		
Hc	Acropora branching	ACB	As per MScience NW coral guide
Hc	Acropora tabular	ACT	As per MScience NW coral guide
Hc	Astreopora encrusting	AstE	As per MScience NW coral guide
Hc	Astreopora massive	AstM	As per MScience NW coral guide
Hc	Branching Unknown	UNKBra	As per MScience NW coral guide
Hc	Echinophyllia encrusting	EchE	As per MScience NW coral guide
Hc	Encrusting Unknown	UNKEnc	As per MScience NW coral guide
Hc	Favid encrusting	FavE	As per MScience NW coral guide
Hc	Favid foliose	FavF	As per MScience NW coral guide
Hc	Favid massive	FavM	As per MScience NW coral guide
Hc	Foliose Unknown	UNKFol	As per MScience NW coral guide
Hc	Fungid	Fung	As per MScience NW coral guide
Hc	Galaxea	Galax	As per MScience NW coral guide
Hc	Goniopora	Gon	As per MScience NW coral guide
Hc	Hydnophora encrusting	HydE	As per MScience NW coral guide
Hc	Hydnophorasubmassive	HydSub	As per MScience NW coral guide
Hc	Lobophyllia	LoboM	As per MScience NW coral guide
Hc	Massive unknown	UNKMas	As per MScience NW coral guide
Hc	Merulina	Mer	As per MScience NW coral guide
Hc	Montipora	Mon	As per MScience NW coral guide
Hc	Mycedium encrusting	MycE	As per MScience NW coral guide
Hc	Pachyseris	Pach	As per MScience NW coral guide
Hc	Pavona	Pav	As per MScience NW coral guide
Hc	Pocilloporid	Poc	As per MScience NW coral guide
Hc	Porites branching	PorB	As per MScience NW coral guide
Hc	Porites encrusting	PorE	As per MScience NW coral guide
Hc	Porites massive	PorM	As per MScience NW coral guide
Hc	Seriatopora	Ser	As per MScience NW coral guide
Hc	Submassive unknown	UNKSub	As per MScience NW coral guide

Group	CATEGORIES	Code	Comment
Hc	Symphyllia	Sym	As per MScience NW coral guide
Hc	Turbinaria encrusting	TurbE	As per MScience NW coral guide
Hc	Turbinaria foliose	TurbF	As per MScience NW coral guide
	Bleached Coral		
Bc	Acropora branching	BLACB	Bleached - but alive
Bc	Acropora tabular	BLACT	Bleached - but alive
Bc	Astreopora encrusting	BLAstE	Bleached - but alive
Bc	Astreopora massive	BLAstM	Bleached - but alive
Bc	Branching Unknown	BLUNKBra	Bleached - but alive
Bc	Echinophyllia encrusting	BLEchE	Bleached - but alive
Bc	Encrusting Unknown	BLUNKEnc	Bleached - but alive
Bc	Favid encrusting	BLFavE	Bleached - but alive
Bc	Favid foliose	BLFavF	Bleached - but alive
Bc	Favid massive	BLFavM	Bleached - but alive
Bc	Foliose Unknown	BLUNKFol	Bleached - but alive
Bc	Fungid	BLFung	Bleached - but alive
Bc	Galaxea	BLGalax	Bleached - but alive
Bc	Goniopora	BLGon	Bleached - but alive
Bc	Hydnophora encrusting	BLHydE	Bleached - but alive
Bc	Hydnophorasubmassive	BLHydSub	Bleached - but alive
Bc	Lobophyllia	BLLoboM	Bleached - but alive
Bc	Massive unknown	BLUNKMas	Bleached - but alive
Bc	Merulina	BLMer	Bleached - but alive
Bc	Montipora	BLMon	Bleached - but alive
Bc	Mycedium encrusting	BLMycE	Bleached - but alive
Bc	Pachyseris	BLPach	Bleached - but alive
Bc	Pavona	BLPav	Bleached - but alive
Bc	Pocillopora	BLPoc	Bleached - but alive
Bc	Porites branching	BLPorB	Bleached - but alive
Bc	Porites encrusting	BLPorE	Bleached - but alive

Group	CATEGORIES	Code	Comment
Bc	Porites massive	BLPorM	Bleached - but alive
Bc	Submassive unknown	BLUNKSub	Bleached - but alive
Bc	Symphyllia	BLSym	Bleached - but alive
Bc	Turbinaria encrusting	BLTurbE	Bleached - but alive
Bc	Turbinaria foliose	BLTurbF	Bleached - but alive
	Filter Feeders		
FF	Gorgonians		rigid soft corals
FF	Soft Coral spp.		all octocorals except gorgonians
FF	Ascidian		members of Class Ascidia
FF	Clam- and other molluscs		All intact molluscs (not shell fragments)
FF	Crinoid		brittle stars
FF	Hydroid		feathery branching hydroids
FF	Sponge spp.		all sponge species
	Other fauna		
Of	Other invertebrate		mobile & bryozoans
Of	COT		Crown of Thorns starfish
Of	Drupella		rugose shelled molluscs with Drupella shape
Of	Zoanthid		zoanthid or palythoan
	TAPE WAND SHADOW		
TWS	Shadow		poorly lit section of image
TWS	Tape		any measuring equipment
TWS	Wand		any measuring equipment

N.B. TWS – is excluded from analyses when calculating % cover

Appendix E

Dredge Sediment Dispersion Modelling Report

SCARBOROUGH DEVELOPMENT DREDGED SEDIMENT DISPERSION MODELLING

Report

MAW0753J.002
Scarborough Development
Dredged Sediment
Dispersion Modelling
Rev 3
22 March 2022

www.rpsgroup.com/mst

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1 INTRODUCTION

1.1 Background

RPS was commissioned by Woodside Energy Ltd (Woodside) to undertake sediment dispersion modelling of dredging, disposal and backfill operations associated with the development of Scarborough, in support of the State and Commonwealth referrals and an Offshore Project Proposal to NOPSEMA. The Scarborough gas field is located within offshore permit WA-1-R.

Dredging, disposal and backfill operations along the Scarborough pipeline route, from the mainland of the Burrup Peninsula outwards to a chainage of KP50, are proposed as part of the project (Figure 1.1).

RPS has conducted sediment dispersion modelling to quantify the potential magnitude, intensity and spatial distribution of suspended sediment concentrations (SSC) and sedimentation that would be expected for the dredging, disposal and backfill operations proposed for the development of Scarborough. The predicted outcomes are to be used to inform the assessment of the potential for influence or impact upon water quality and benthic habitats in the region.

This technical report contains a summary of the sediment fate model inputs, methodologies and assumptions, and the model outcomes following analysis of specified threshold criteria.

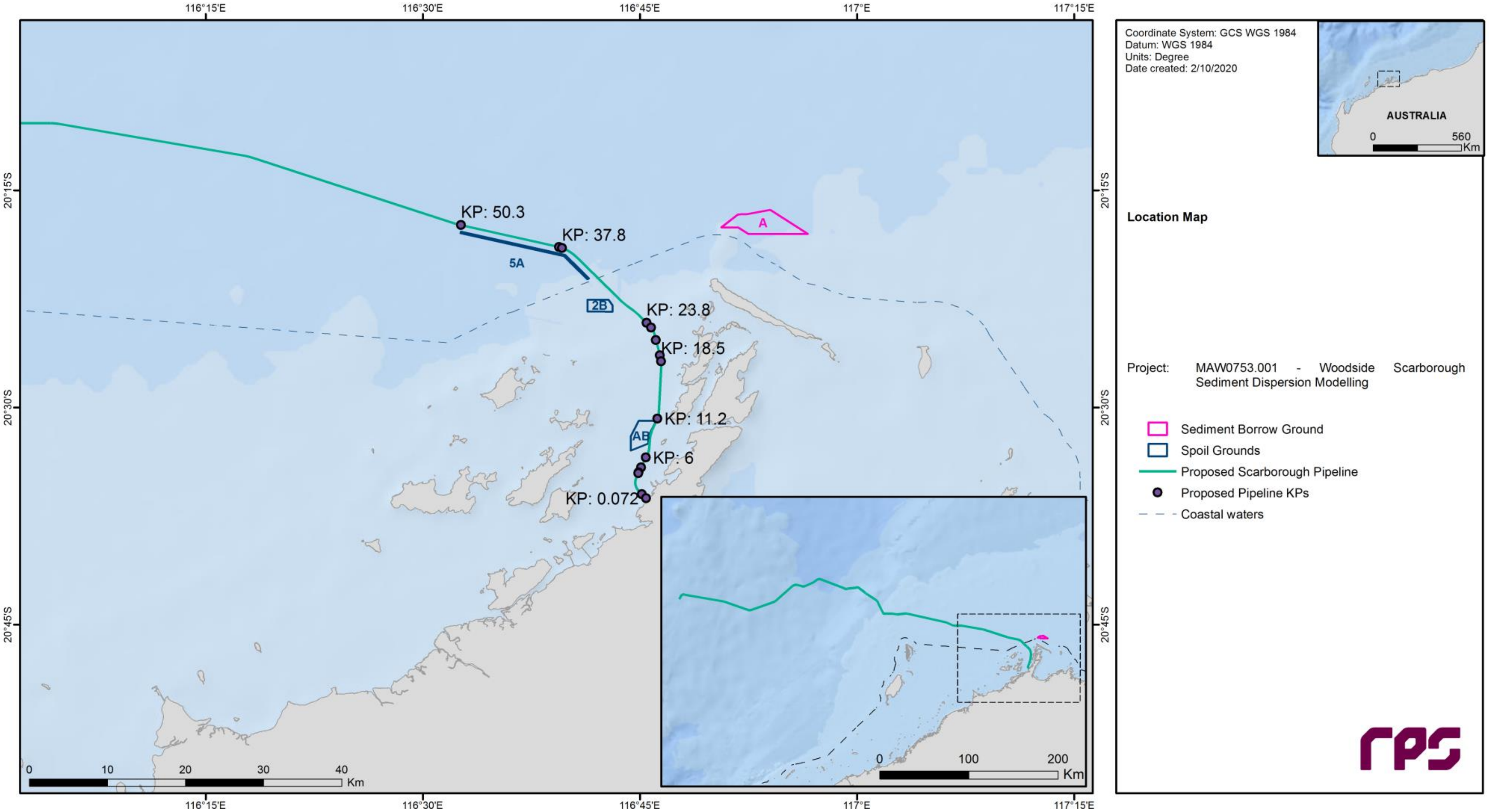

Figure 1.1 Route of the inner sections (KP0 to KP50) of the proposed Scarborough pipeline on the North West Shelf of Australia, and locations of the existing spoil grounds (AB, 2B and 5A) and sediment borrow ground A that will be utilised during disposal and backfill activities.

1.2 Modelling Scope

RPS was commissioned to conduct sediment dispersion modelling for the following activities:

- Dredging of sediment along the pipeline route and disposal of dredged sediment at three nominated spoil grounds.
- Dredging of the borrow ground and backfill and stabilisation of the pipeline.

The scope of work required to complete the sediment dispersion modelling included:

1. Hydrodynamic Modelling.
    a. An initial assessment of the existing D-FLOW hydrodynamic model framework in the Mermaid Sound region determined that refinements were necessary to suit the requirements of this scope of work. Reconfiguration of the model was conducted, followed by re-validation of the model predictions against available measurements of water levels and currents for the same validation period as utilised previously.
    b. Two years (2016-2017) of hydrodynamic simulation data was produced for use as input to the sediment dispersion model.
2. Wave Modelling.
    a. An initial assessment of the existing D-WAVE wave model framework in the Mermaid Sound region determined that refinements were necessary to suit the requirements of this scope of work. Reconfiguration of the model was conducted, followed by re-validation of the model predictions against available predictions from an operational RPS model for the same validation period as utilised previously.
    b. Two years (2016-2017) of wave simulation data was produced for use as input to the sediment dispersion model.
3. Sediment Dispersion Modelling.
    a. Inputs for the dredging program were prepared for the DREDGEMAP model, accounting for all potential concurrent sources of sediment characterised by location, intensity, particle size distribution, vertical distribution in the water column, and levels of cohesivity.
    b. Two dredging, disposal and backfill scenarios were simulated: (i) dredging commencing in winter; and (ii) dredging commencing in summer.
    c. Simulation outputs from each separate dredging, disposal and backfill activity were post-processed, combined and analysed to determine outcomes including zones of impact and influence for each scenario based on specified threshold criteria.
    d. Key model outcomes were provided as spatial datasets in GIS shapefile format.
4. Reporting. A technical report detailing the sediment fate model inputs, methodologies, assumptions and model outcomes following analysis of specified threshold criteria was provided.

1.3 Definitions of Relevant Terms and Abbreviations

BHD:

Backhoe Dredge. A pontoon equipped with a hydraulic excavator. The pontoon is stabilised and secured by three spuds. The excavator uses a large arm fitted with a bucket to excavate material from the seabed and discharge it into (typically) a split hopper barge moored alongside. BHDs are mainly used for dredging or breaking up the sedimentary rock below a layer of unconsolidated sediments, or for dredging in areas inaccessible to larger self-propelled vessels.

Dewatering:

Draining of excess water from a split hopper barge using its drainage system.

Overflow:

Excess water and suspended solids that leave a TSHD hopper and are discharged to the water column via a weir and discharge pipe located at the base of the vessel.

Resuspension:

Removal of deposited material from the seabed to the water column as a result of natural or artificial agitation.

Sedimentation rate:

Rate of sediment accumulation on the seabed following deposition of SSC from the water column.

Side-dump vessel:

Self-propelled vessel that is capable of transporting and installing a variety of different sizes of rock. Large cranes of fall pipes are used to dump rocks from the vessels to the seabed.

Split hopper barge:

Vessel with a large open hold used to load and transport dredged material. The unloading is performed by splitting the two halves of the hull to release the material towards the seabed.

SSC:

Suspended Solids Concentration (or Suspended Sediment Concentration). The concentration of sediment material in the water column following natural or artificial resuspension from the seabed.

TSHD:

Trailer Suction Hopper Dredge. A self-propelled vessel with one or two suction tubes/arms, equipped with drag-heads that are lowered to the seabed and trailed over the bottom. The vessel has a powerful pump system that sucks up a mixture of sediment and water and discharges it in the hopper (hold) of the vessel. TSHDs are mainly used for dredging loose and soft soils such as sand, gravel, silt or clay.

2 HYDRODYNAMIC AND WAVE MODELLING

2.1 Overview

Modelling of the potential sediment dispersion from the dredging, disposal and backfill activities associated with the development of Scarborough required temporal and spatial representation of the hydrodynamic and wave conditions within the project area. A hydrodynamic and wave model framework for the Mermaid Sound area was constructed, calibrated and validated for a past marine modelling study of dredge spoil stability and navigation for Woodside (RPS, 2016). This model framework has been refined for the Scarborough scope of work and is described in the following sections.

The hydrodynamic and wave modelling for the project was conducted using the Delft3D suite of software. The Delft3D suite is a fully integrated computer software package composed of several modules (e.g. flow, waves, sediment, water quality, and ecology) grouped around a common interface. This software suite has been developed to carry out studies with a multi-disciplinary approach and multi-dimensional calculations (e.g. 2-D and 3-D) for a range of systems, such as oceanic, coastal, estuarine and river environments. It can simulate the interaction of flows, waves, sediment transport, morphological developments, water quality and aquatic ecology. Specific modules of the Delft3D suite are referenced in this report, following the convention of the software developers, with the suffix D- (e.g. D-FLOW for the Delft3D Hydrodynamics module and D-WAVE for the Delft3D Spectral Wave module).

The Delft3D suite has been developed by Deltares, an independent institute for applied research on water with over 30 years of experience in modelling aquatic systems (http://www.deltares.nl/en). The Delft3D suite of models adheres to the International Association for Hydro-Environment Engineering and Research guidelines for documenting the validity of computational modelling software, closely replicating an array of analytical, laboratory, schematic and real-world data.

The configuration of the current and wave models is in line with recommendations of best practice for sediment dispersion modelling in Western Australia as outlined by WAMSI Dredging Science Node guidance (Sun *et al.*, 2016). Inclusion of mesoscale ocean currents is recommended, as these currents have a significant influence on the net drift of suspended material over the time scales of dredging operations (days to weeks) and are therefore important to predictions of sediment transport. The use of three-dimensional current modelling with a series of interconnected grids of progressively finer resolution is also recommended, as are coupling of the current and wave models and validation of current predictions against measured data.

2.2 Hydrodynamic Model (D-FLOW)

2.2.1 Model Description

To simulate the hydrodynamics within Mermaid Sound and the surrounding area, a three-dimensional model with accurate representations of the bathymetry, bottom roughness and spatially-varying wind stress was utilised for the region. The model framework was developed through the combination of a large-scale regional model with smaller refined regions, or sub-domains.

The D-FLOW model is ideally suited to represent the hydrodynamics of complex coastal waters, including regions where the tidal range creates large intertidal zones and where buoyancy processes are important. RPS has applied the model for numerous studies in the region.

D-FLOW is a multi-dimensional (2-D or 3-D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport phenomena that result from tidal, meteorological and baroclinic forcing on a rectilinear or a curvilinear, boundary-fitted grid. In three-dimensional simulations, the vertical grid can be defined following the sigma-coordinate approach, where the local water depth is divided into a series of layers with thickness at a set proportion of the depth.

D-FLOW allows for the establishment of a series of interconnected (two-way, dynamically-nested) curvilinear grids of varying resolution; a technique referred to as “domain decomposition”. This allows for the generation of a series of grids with progressively increasing spatial resolution, down to an appropriate scale for accurate resolution of the hydrodynamics associated with features such as dredged channels. The main advantage of domain decomposition over traditional one-way, or static, nesting systems is that the model domains interact seamlessly, allowing transport and feedback between the regions of different scales. The ability to dynamically couple multiple model domains offers a flexible framework for hydrodynamic model development. This modelling method was applied in this study.

Inputs to the model, as discussed in the following sections, included:

- Bathymetry of the study area, including shipping channels, islands, and adjacent features. The wetting and drying of the intertidal zones was simulated in applicable areas.
- Boundary elevation forcing data.
- Spatially-varying surface wind and pressure data.

2.2.2 Bathymetry and Domain Definition

The hydrodynamic model was established over the domain shown in Figure 2.1. Accurate bathymetry is a significant factor in development of a model framework required to resolve highly variable wave and current conditions. The bathymetry was developed using data provided by Woodside and supplemented with data from Geoscience Australia and the C-MAP electronic chart database where relevant and required.

The composite bathymetric data was interpolated onto the D-FLOW Cartesian grid. The resultant bathymetry is shown in Figure 2.2. The extent and shape of the model coastline will change as water levels rise and fall with tidal movements due to the inclusion of wetting and drying within the model system.

The vertical grid of the model comprised five layers of varying thickness, depending on location, throughout the domain. Five layers was found to be enough to resolve the circulation and provide suitable bed level currents, without overly compromising model performance. As the model was set up as a proportional sigma-grid in the vertical dimension, these layers therefore represented a terrain-following arrangement with a layer thickness of 20% of the total local water depth.

To offset the computational effort required for a large, multi-layered model domain, and to achieve adequate horizontal and temporal resolution, a multiple-grid (domain-decomposition) strategy was applied using three sub-domains of varying horizontal grid cell size (Figure 2.1 and Figure 2.2). Horizontal resolutions within each sub-domain were 250 m for the Mermaid Sound region from Enderby Island to Legendre Island (sub-grid 2), 500 m for the intermediate region (sub-grid 1) and 2 km for the outer domain (sub-grid 0).

Each sub-domain is an individual hydrodynamic model simulated in parallel with the others, with dynamic coupling at the shared boundaries between sub-domains. The outermost sub-domain captured large-scale oceanographic phenomena which progressively fed into the finer-resolution domains representing the area of interest. The resolution of the innermost sub-domain was specified after assessment of the requirement to adequately resolve the variation in current fields, and in turn the sediment dynamics.

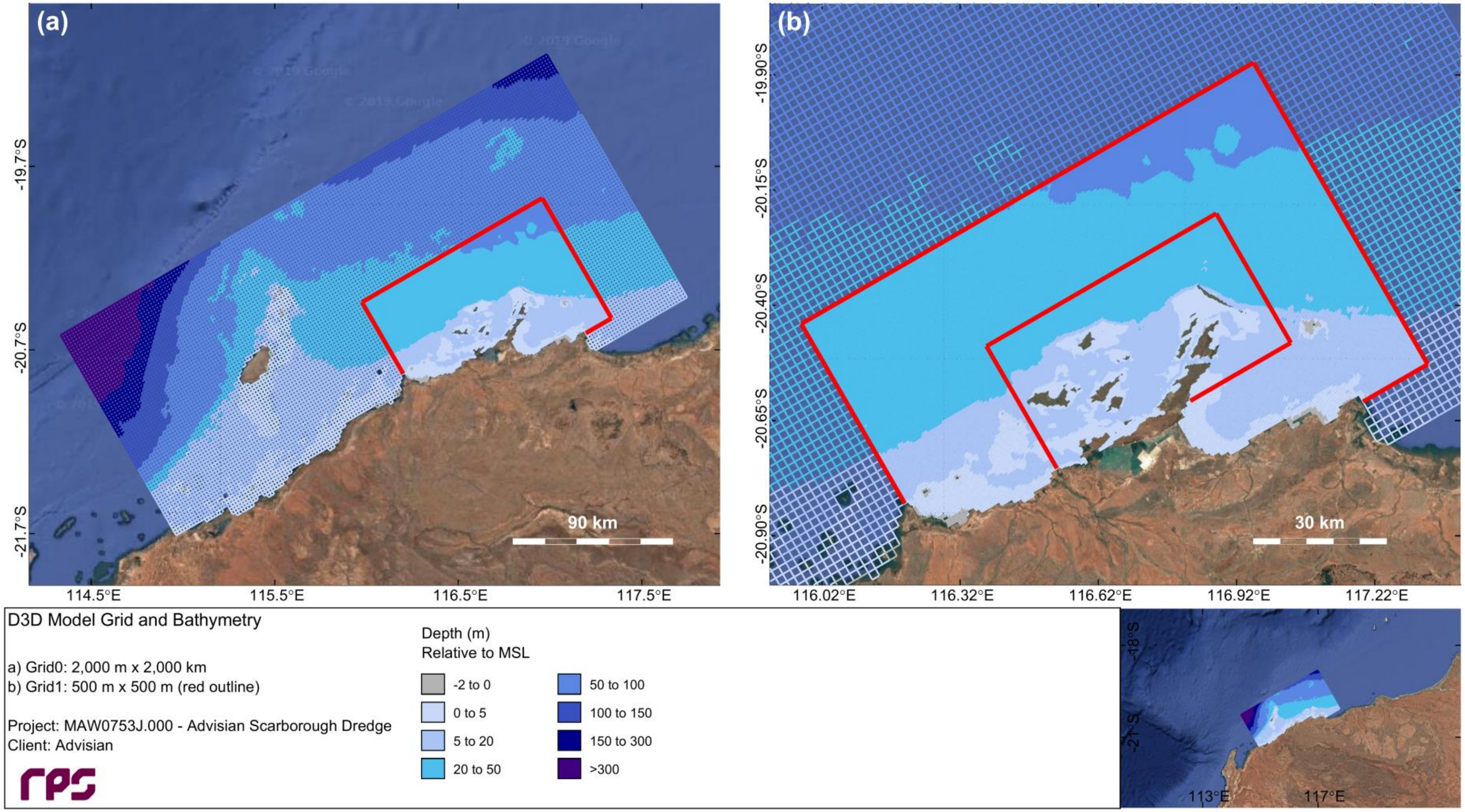

Figure 2.1 Model grid setup showing the domain-decomposition scheme applied, highlighting the two outermost grids.

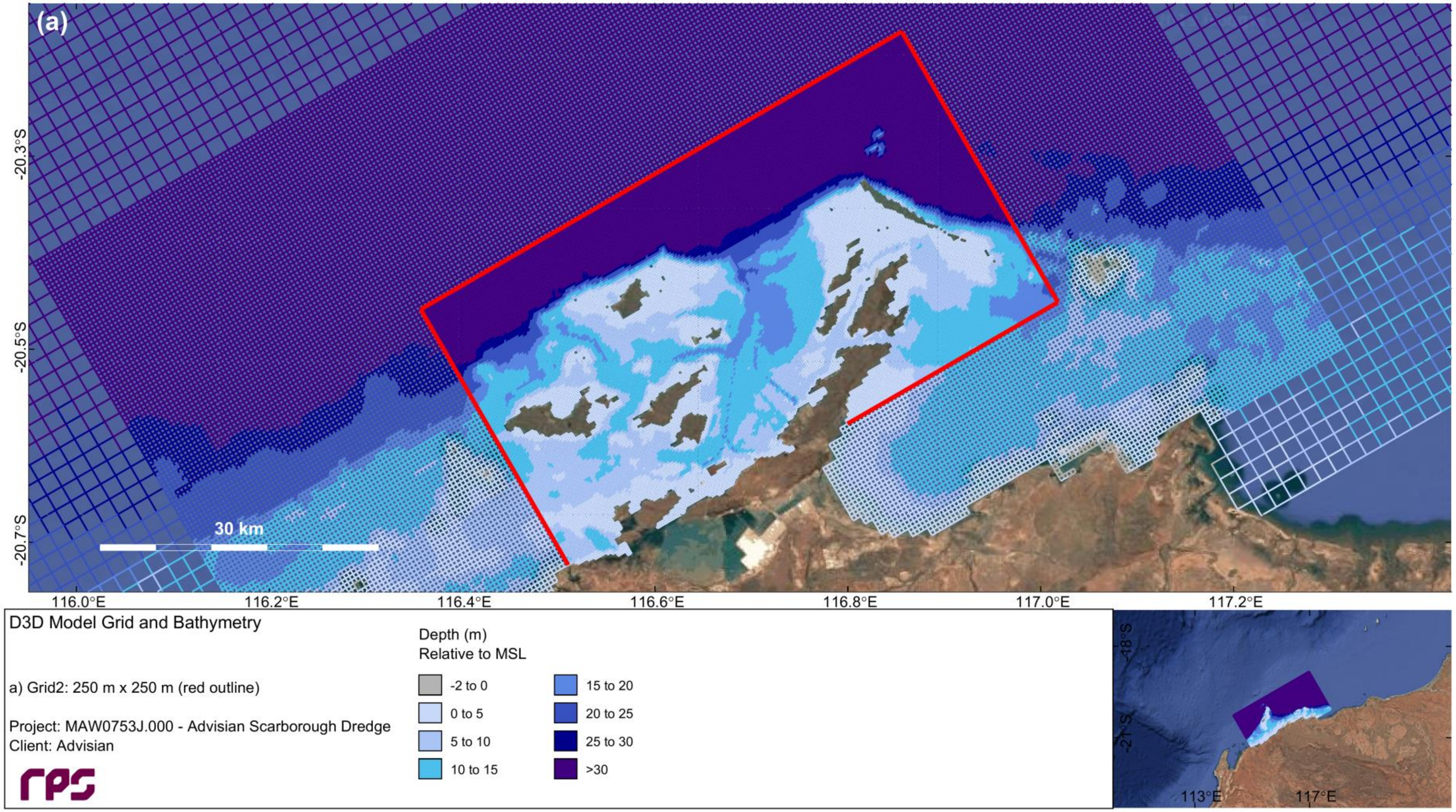

Figure 2.2 Model grid setup showing the domain-decomposition scheme applied, highlighting the innermost grid.

2.2.3 Boundary and Initial Conditions

2.2.3.1 Overview

As the hydrodynamics in the study area are controlled primarily by tidal flows and wind forcing, these processes were explicitly included in the developed model.

The model was forced on the open boundaries of the outer sub-domain with time series of water elevation obtained for the chosen simulation period. Spatially-varying wind speed and wind direction data was used to force the model across the entire domain.

2.2.3.2 Water Elevation

Water elevations at hourly intervals were obtained from the TPXO8.0 database, which is the most recent iteration of a global model of ocean tides derived from measurements of sea-surface topography by the TOPEX/Poseidon satellite-borne radar altimeters. Tides are provided as complex amplitudes of earth-relative sea-surface elevation for eight primary (M_2, S_2, N_2, K_2, K_1, O_1, P_1, Q_1), two long-period (M_f, M_m) and three non-linear (M_4, MS_4, MN_4) harmonic constituents at a spatial resolution of 0.25°.

The tidal sea level data was augmented with non-tidal sea level elevation data from the global Hybrid Coordinate Ocean Model (HYCOM; Bleck, 2002; Chassignet *et al.*, 2003; Halliwell, 2004), created by the USA's National Ocean Partnership Program (NOPP) as part of the Global Ocean Data Assimilation Experiment (GODAE). The HYCOM model is a three-dimensional model that assimilates observations of sea surface temperature, sea surface salinity and surface height, obtained by satellite instrumentation, along with atmospheric forcing conditions from atmospheric models to predict drift currents generated by such forces as wind shear, density, sea height variations and the rotation of the Earth.

The HYCOM model is configured to combine the three vertical coordinate types currently in use in ocean models: depth (z-levels), density (isopycnal layers), and terrain-following (σ-levels). HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas. Thus, this hybrid coordinate system allows for the extension of the geographic range of applicability to shallow coastal seas and unstratified parts of the world ocean. It maintains the significant advantages of an isopycnal model in stratified regions while allowing more vertical resolution near the surface and in shallow coastal areas, hence providing a better representation of the upper ocean physics than non-hybrid models. The model has global coverage with a horizontal resolution of 1/12th of a degree (~7 km at mid-latitudes) and a temporal resolution of 24 hours.

2.2.3.3 Wind Forcing

Spatially-variable wind data was sourced from the Global Data Assimilation System (GDAS), which is used by the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) model to place observations into a gridded model space for the purpose of starting, or initializing, weather forecasts with observed data. The GFS Forecasts model variant used has a horizontal resolution of 1/12th of a degree and a temporal resolution of 6 hours (NCEP, 2016).

2.2.4 Model Validation

2.2.4.1 Comparison of Modelled and Measured Water Elevation

Validation of the water level changes predicted by the D-FLOW hydrodynamic model configuration was provided through comparisons to independent predictions from the XTide tidal constituent database (Flater, 1998). Comparison of model tidal amplitudes with the XTide database showed strong agreement (Figure 2.3), with slight overprediction of tidal amplitudes at some stations. Time series comparisons for two tide stations situated at locations that are relevant to this study also showed good agreement (Figure 2.4).

In general, a consistent match is observed between water elevations calculated by the D-FLOW model and those predicted by XTide (Figure 2.4). Both the amplitude and phase of the semidiurnal tidal signal are clearly reproduced at each station, as is the timing of the spring-neap cycle. The D-FLOW model slightly overpredicts high tides and underpredicts low tides, which indicates there was a small difference between the datums used to compare these different data sets rather than actual amplitude differences.

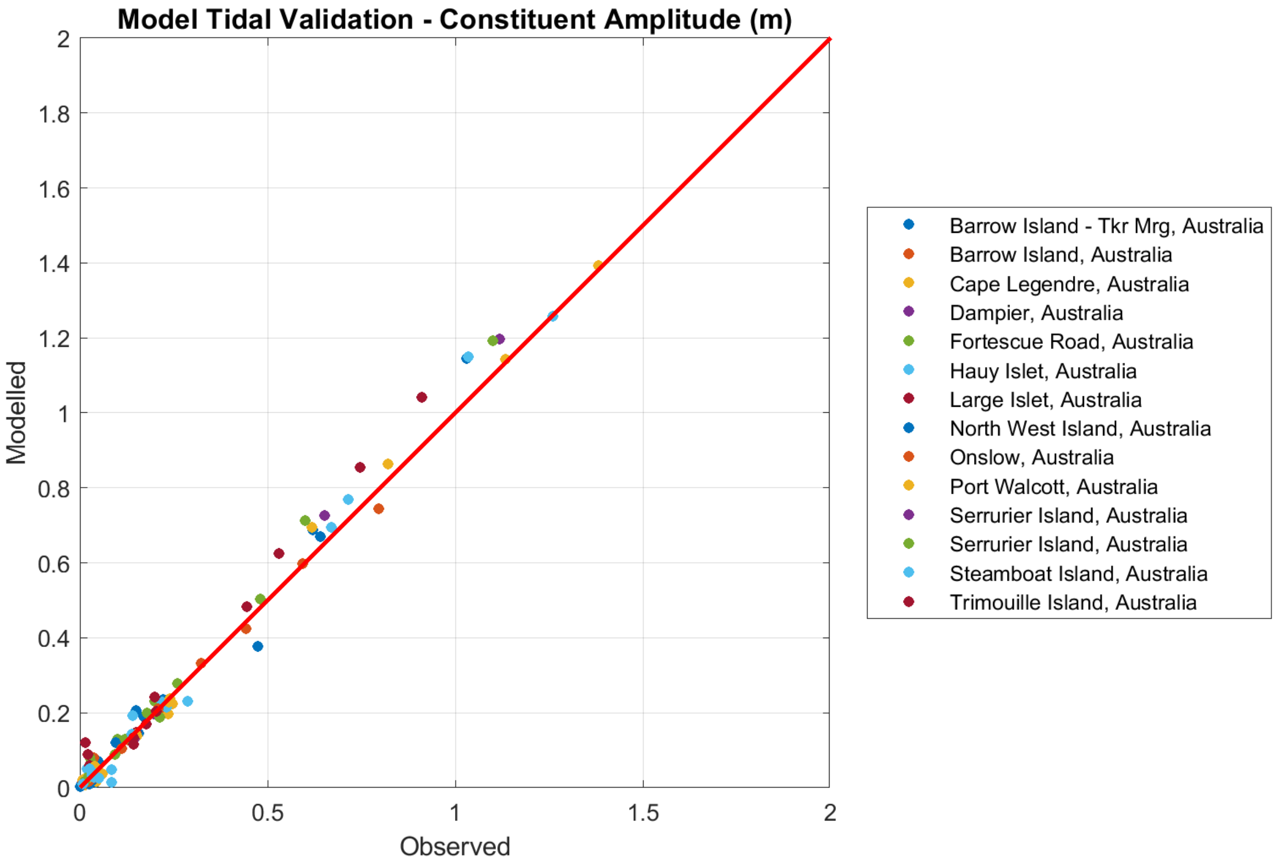

Figure 2.3 Comparison of tidal amplitudes from the D-FLOW hydrodynamic model (y-axis) with those from the XTide database (x-axis) at 14 stations located within the model domain.

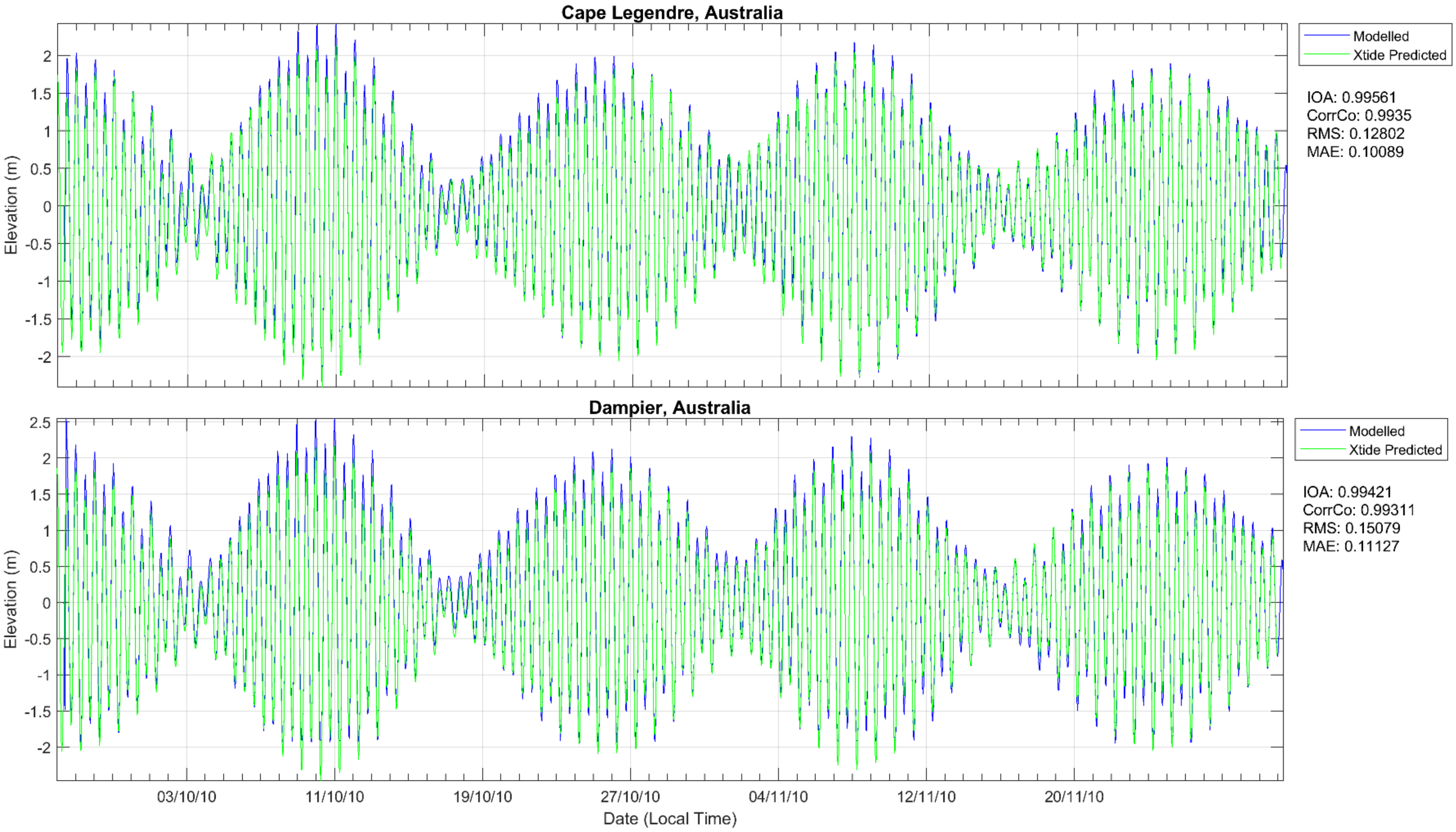

Figure 2.4 **Comparisons of water elevations predicted by the D-FLOW hydrodynamic model (blue line) with those predicted by the XTide database (green line) over the validation period of October-November 2010 at two selected station locations.**

2.2.4.2 Comparison of Modelled and Measured Currents

Validation of the model-predicted currents was conducted for a spring/neap tide period during October and November 2010 by comparing the model results to measured data from the Woodside LNG Channel AWAC that was located within Mermaid Sound (116.738° E, 20.561° S) in water depth of approximately 12 m. Comparisons of current speed and direction at a depth interval representative of the mid-water column are provided in Figure 2.5.

Overall, the comparison indicates that the model provides a good prediction of tidal currents at the comparison site. There was a minor mismatch in the phase of the tidal oscillations, with a slight lag apparent in the modelled data. However, this lag was not evident in the XTide water level comparisons (Figure 2.4).

The amplitudes of the modelled and measured current fluctuations were generally well-matched, but there were some spikes in the measured data that were not reproduced. These spikes in the measured data, assuming they were not instrument errors, may have been caused by local-scale events related to wind-driven currents. These events are difficult to reproduce in the model because the horizontal grid scale of the model in this region is 250 m. The GFS wind driving the model can be less accurate close to the coast when sea breeze effects are dominant. The inability of the model to reproduce some spikes observed in the measured data might be explained by inaccuracies in the NCEP wind data near to the Woodside LNG Channel AWAC location.

The vertical layer structure of the model is not considered to be significant in shallow areas – including the majority of Mermaid Sound – during periods of typical ambient wind conditions, but in deeper areas the layering allows differences in current characteristics between the wind-affected surface layers and the near-seabed layers to drive sediment dispersion.

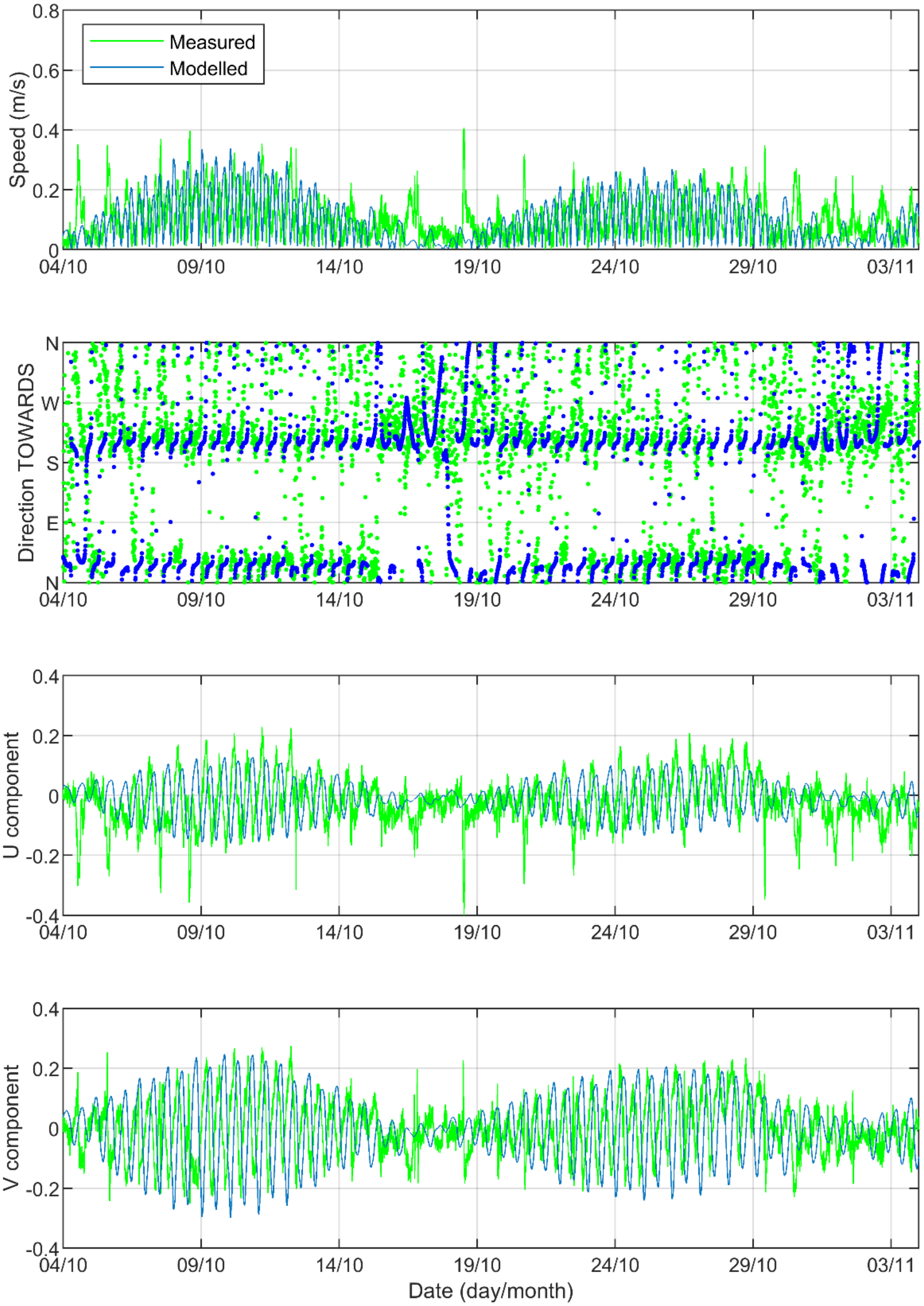

Figure 2.5 Comparisons of modelled (blue line) and measured (green line) currents for a mid-water column depth interval at the Woodside LNG Channel AWAC location during the 2010 validation period.

2.3 Wave Model (D-WAVE)

2.3.1 Model Description

Reliable forecasting for the fate of fine sediments in the study location, which is a wave-exposed coastal region, required the input of wave spectra information to calculate the shear-stress and orbital velocities imposed by waves which will affect the settlement and re-suspension of fine material that is initially suspended by dredging and related operations. D-WAVE is a variant of the well-known SWAN wave model that has been customised for compatibility with the Delft3D software suite.

The D-WAVE model is a spectral phase-averaging wave model originally developed by the Delft University of Technology. D-WAVE, a third-generation model based on the energy balance equation, is a numerical model for simulating realistic estimates of wave parameters in coastal areas for given wind, bottom and current conditions.

D-WAVE includes algorithms for the following wave propagation processes: propagation through geographic space; refraction and shoaling due to bottom and current variations; blocking and reflections by opposing currents; and transmission through or blockage by obstacles. The model also accounts for dissipation effects due to white-capping, bottom friction and wave breaking as well as non-linear wave-wave interactions. D-WAVE is fully spectral (in all directions and frequencies) and computes the evolution of wind waves in coastal regions with shallow water depths and ambient currents.

RPS has successfully applied D-WAVE in many studies in the region, including ambient condition modelling in Mermaid Sound and dredging fate projects in the wider Pilbara region.

2.3.2 Model Implementation

The D-WAVE model was developed to cover the same grid regions defined by the hydrodynamic model (Figure 2.1 and Figure 2.2). The bathymetry and wind data input to the wave model was the same as used for the hydrodynamic model. Time-varying water level information for each grid node in the wave model was provided by the output of the hydrodynamic model. The boundary data to represent swells imposed from a distance was sourced from the WAVEWATCH III 0.5° model, operated by the National Oceanic and Atmospheric Administration (NOAA) (NOAA, 2018).

The wave model was run in a coupled mode with the hydrodynamic model for the years of 2016 and 2017. The model results were independently validated by comparison to other modelled wave data for the Mermaid Sound region that is held internally by RPS. Given the purpose of the wave model is to provide bottom shear-stresses and orbital velocities for settlement and resuspension calculations across a large domain in the sediment dispersion model, rather than a more site-specific application such as the design of a structure, it is believed this is an acceptable level of validation.

3 SEDIMENT FATE MODELLING

3.1 General Approach

Estimates for the three-dimensional distribution of sediments suspended by dredging, disposal and backfill operations have been derived for the full duration of the pipeline dredging and backfill program using numerical modelling. The approach of modelling dredging operations in full and in three dimensions is in line with best practice for sediment dispersion modelling in Western Australia as outlined by WAMSI Dredging Science Node guidance (Sun *et al.*, 2016).

This modelling relied upon specification of sediment discharges over time for each of the expected sources of sediment suspension, and predicted the evolution of the combined sediment plumes via current transport, dispersion, sinking and sedimentation. The model allowed for the subsequent resuspension of settling sediments due to the erosive effects of currents and waves. Thus, the fate of sediments was assessed beyond their initial settling.

Forcing was provided using predictions of three-dimensional current fields and two-dimensional wave fields for the study area, which are described in Section 2.

3.2 Model Description

Modelling of the dispersion of suspended sediment resulting from the various dredging, disposal and backfill operations was undertaken using an advanced sediment fate model, Suspended Sediment FATE (SSFATE), operating within the RPS DREDGEMAP model framework. This model computes the advection, dispersion, differential sinking, settlement and resuspension of sediment particles. The model can be used to represent inputs from a wide range of suspension sources, producing predictions of sediment fate both over the short-term (minutes to days following a discharge source) and longer term (days to years following a discharge source).

SSFATE allows the three-dimensional predictions of SSC and seabed sedimentation to be assessed against allowable exposure thresholds. Sedimentation thresholds often relate to burial depths or rates, while SSC thresholds are usually more complicated, involving tiered exposure duration and intensities. As a result, assessing the project-generated sediment distributions against these thresholds in both three-dimensional space and time is a computationally intensive task. A variety of SSC threshold formulations have recently been applied in Western Australian coastal waters and at present there are no general guidelines.

SSFATE is a computer model originally developed jointly by the US Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) and RPS to estimate SSC generated in the water column and deposition patterns generated due to dredging operations in a current-dominated environment, such as a river (Johnson *et al.*, 2000; Swanson *et al.*, 2000, 2004). RPS has significantly enhanced the capability of SSFATE to allow the prediction of sediment fate in marine and coastal environments where wave forcing becomes important for reworking the distribution of sediments (Swanson *et al.*, 2007).

SSFATE is formulated to simulate far-field effects (~25 m or larger scale) in which the mean transport and turbulence associated with ambient currents are dominant over the initial turbulence generated at the discharge point. A five-class particle-based model predicts the transport and dispersion of the suspended material. The classes include the 0-130 µm range of sediment grain sizes that typically result in plumes. Heavier sediments tend to settle very rapidly, remain more stable over time and are not relevant over the longer durations (>1 hour) and larger spatial scales (>25 m) of interest here. Table 3.1 shows the standard material classes used in SSFATE for suspended sediment.

Table 3.1 Material size classes used in SSFATE.

Material Class Description	Particle Size Range (µm)
Clay	<7
Fine Silt	7-34
Coarse Silt	35-74
Fine Sand	75-130
Coarse Sand	>130

Particle advection is calculated using three-dimensional current fields, obtained from hydrodynamic modelling, thus the model can account for vertical changes in the currents within the water column. For example, as particles sink towards the seabed they will tend to be moved at slower speeds due to the slowing of currents by friction at the seabed. Particle diffusion is assumed to follow a random walk process using a Lagrangian approach of calculating transport, which uses a grid-less space to remove limitations of grid resolution, artefacts due to grid boundaries, and also maintain a high degree of mass conservation.

Following release into the model space, the sediment cloud evolves according to the following processes:

- Advection due to the three-dimensional current field.
- Diffusion by a random walk model with the mass diffusion rate specified, ideally, from measurements at the site. As particles represent an ensemble of real particles, each particle in the model has an associated Gaussian distribution governed by particle age and the mass diffusion properties of the surrounding water.
- Settlement or sinking of the sediment due to buoyancy forces. Settlement rates are determined from the particle class sizes and include allowance for flocculation and other concentration-dependent behaviour, following the model of Teeter (2000). The SSFATE model calculates the settling velocity for four of the five classes, with a settling velocity of 0.1 m/s assumed for coarse sand (Teeter, 2000; Swanson, 2007). The settling velocities are calculated from typical values of coefficients within SSFATE. The formulas used to calculate settling velocities, and the typical values of coefficients from the formulas, are presented below.

$$If\ C\ \geq\ \bar{C}_{ul}\ then$$

$$Ws_i\ = a$$

$$If\ C\ \leq\ \bar{C}_{ll}\ then$$

$$Ws_i = a\left(\frac{\bar{C}_{ll}}{\bar{\bar{C}}_{ul}}\right)^{n_i}$$

  Where:

  - C_{uli} and C_{lli} are the nominal upper and lower concentration limits, respectively, for enhanced settling of grain class *i*, and *C* is the total concentration for all grain size classes (except coarse sand).
  - a_i is a grain-size class average maximum floc settling velocity.
  - n_i is a grain-size dependent exponent.

Table 3.2 Typical values of coefficients for calculating settling velocities in SSFATE.

Sediment Grain Size Class	Size Range (µm)	C_{lli} (mg/L)	C_{uli} (mg/L)	a_i (m/s)	n_i
Clay	<7	50	1,000	0.0008	1.33
Fine Silt	7-34	150	3,000	0.0023	1.10
Coarse Silt	35-74	250	5,000	0.0038	0.90
Fine Sand	75-130	400	8,000	0.0106	0.80

- Potential deposition to the seabed determined using a model that couples the deposition across particle classes (Teeter, 2000). The likelihood and rate of deposition depends on the shear stress at the seabed. High shear inhibits deposition, and in some cases excludes it altogether with sediment remaining in suspension. The model allows for partial deposition of individual particles according to a practical deposition rate, thereby allowing the bulk sediment mass to be represented by fewer particles.
- Potential resuspension from the seabed, if previously deposited, at a rate governed by exceedance of a shear stress threshold at the seabed due to the combined action of waves and currents. Different thresholds are applied for resuspension depending upon the size of the particle and the duration of sedimentation, based on empirical studies that have demonstrated that newly-settled sediments will have higher water content and are more easily resuspended by lower shear stresses (Swanson *et al.*, 2007).

The resuspension flux calculation also accounts for armouring of fine particles within the interstitial spaces of larger particles. Thus, the model can indicate whether deposits will stabilise or continue to erode over time given the shear forces that occur at the site. Resuspended material is released back into the water column to be affected by the processes defined above.

SSFATE formulations and proof of performance have been documented in a series of USACE Dredging Operations and Environmental Research (DOER) Program technical notes (Johnson *et al.*, 2000; Swanson *et al.*, 2000), and published in the peer-reviewed literature (Andersen *et al.*, 2001; Swanson *et al.*, 2004; Swanson *et al.*, 2007). SSFATE has been applied and validated by RPS against observations of sedimentation and suspended sediments at multiple locations in Australia, notably Cockburn Sound for Fremantle Ports and Mermaid Sound for the LNG Foundation Project dredging program.

3.3 Model Limitations

There are inherent limitations to the accuracy of numerical models. The possible sources of uncertainty within the modelling conducted for the sediment fate assessment of the Scarborough development include:

- *The equations and algorithms applied in the model*. The formulations included in the model, as discussed in Section 3.2, were selected to achieve the best possible representation of the relevant processes and have been proven to be valid over a range of projects.
- *The accuracy of the physical (current and wave) inputs to the model*. Current and wave forcing inputs were provided from validated three-dimensional hydrodynamic and wave models created and customised for the study area. The accuracy of these models is suitable, as good correlations with field measurements and independent model predictions have been achieved, with the uncertainties minimised and quantifiable. The hydrodynamic and wave models are described in Section 2. It should be noted that the model inputs are a hindcast of past metocean conditions; the overall trends reflected in this data will be broadly reflected in future conditions, but conditions on any given day during the actual dredging operations may be quite different.
- *The accuracy of dredge methodology inputs to the model*. Specification of the proposed dredge and disposal methodologies was provided by Woodside after consultation with the dredging contractor engaged to perform the work (Boskalis). Any assumptions made to achieve a realistic representation of the dredging and disposal activities are outlined in Section 3.5 and were based on extensive past project experience.
- *The accuracy of the material properties input to the model*. Geotechnical information obtained during site investigations for the Scarborough development (Advisian, 2019a; Fugro, 2019) and during previous site investigations for the LNG Foundation Project (Coffey, 2007) was provided by Woodside and is discussed in Section 3.6. From this data, the properties of the *in situ* material to be dredged are reasonably well-known. However, it is not possible to determine how the material properties will be changed by the action of the dredges and the mixing of the material with seawater in the process of pumping it to the hopper. Therefore, assumptions were made in the model with regard to the material that is released into the water column from dredging and the material properties of the sediments that are to be placed at the spoil grounds.
- *The accuracy of the dredging and disposal sediment source terms input to the model*. The source definition in the model is flexible and can be applied to any sediment source by specifying the time-varying flux rate, particle size distribution (PSD) and vertical profile in the water column. This information will be specific to the equipment used and the material encountered at the site, and therefore can only be determined with confidence from a pilot study at the site or field measurements during dredging. In the absence of such data, conservative assumptions were made with regard to these parameters. The assumptions are outlined in Section 3.7 and were based on literature review, including the recent WAMSI Dredging Science Node reports, and extensive past project experience.

The major sources of uncertainty for the sediment fate modelling are the modelled dredging methodology and sediment source inputs to the model. The assumptions made were based on literature review and experience, and aimed to give a good representation of the sources of suspended sediment that will result from the proposed dredging, disposal and backfill activities. However, as there were uncertainties in the inputs to the model, the results should be considered as indicative of the expected ranges in magnitude and distribution of suspended sediments and sedimentation, rather than an exact prediction.

3.4 Model Domain and Bathymetry

The DREDGEMAP model domain established for the Scarborough dredging works extended approximately 89 km north-south by 125 km east-west (Figure 3.1). The model grid covers the section of the Western Australian coastline from Cape Preston in the west to Point Samson in the east. The offshore boundaries of the domain were imposed at a reasonable distance from the proposed dredging areas, to allow potential sediment drift patterns in offshore directions to be adequately captured.

This region lies within the model domain of the Delft3D hydrodynamic and wave models that provide the current and wave inputs to DREDGEMAP (see Section 2). A grid resolution of 100 m by 100 m was selected to ensure that existing features in the domain, including the many bays, islands and passages of the Dampier Archipelago, were adequately defined.

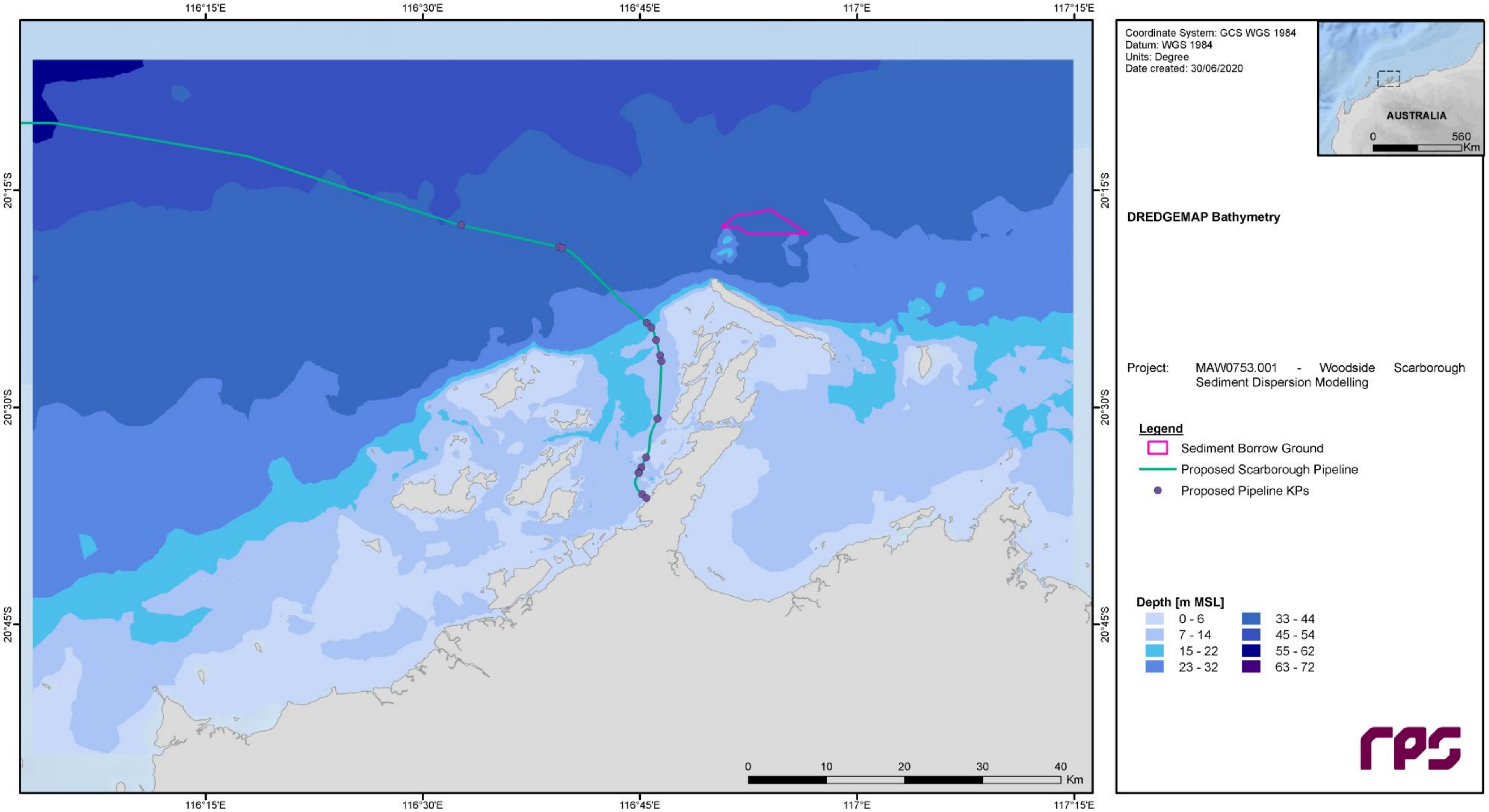

Figure 3.1 DREDGEMAP model domain and bathymetry (m MSL).

3.5 Dredging Project Description and Model Operational Assumptions

3.5.1 Overview

Information outlining the proposed dredging, disposal and backfill operations for the development of Scarborough has been drawn from input data provided by Woodside and its dredging contractor (Woodside, 2020), and subsequent meetings and email discussions. At the time of commencement of modelling, the collated information represented the best available data with regard to geotechnical properties of the project areas, the dredging and construction methodologies expected to be used within these areas, and the characteristics of vessels planned to be engaged for the work.

The operations modelled have been broken into two phases with four main activities:

- Phase 1 (Dredging):
  - Dredging of sediment along the pipeline route.
  - Disposal of dredged sediment at three nominated spoil grounds.
- Phase 2 (Backfilling):
  - Dredging of the borrow ground.
  - Backfill and stabilisation of the pipeline.

The pipeline route, spoil grounds and borrow ground will cover State and Commonwealth Waters (Figure 1.1).

The following sections outline the details of the operations for each of these activities and highlight any assumptions that were made.

3.5.2 Methods and Equipment

3.5.2.1 Pipeline Route Dredging

The material to be dredged from the pipeline route will consist mainly of marine sediments (approximately 1.80 Mm^3) and marine sediment/coarse material mix (approximately 0.07 Mm^3).

The dredging operations for the pipeline route have been divided into twelve sections as outlined in Table 3.3, with nine of these sections requiring dredging. The breakdown of the proposed dredging activities, including the locations of the pipeline KPs and spoil grounds, are shown in Figure 3.2. The dredging in each of the nine sections was assumed to be completed with either a backhoe dredge (BHD) or a trailing suction hopper dredge (TSHD). Typically, a TSHD will dredge unconsolidated sediments and a BHD will dredge sedimentary rock, and the quantities of each material type assumed in this case are detailed in Section 3.5.3. The assumed BHD bucket size was in the range of 20 m^3 (rock) to 30 m^3 (general purpose), while the TSHD hopper size was assumed to be 12,000 m^3. It has been specified that overflow of fines from the TSHD hopper will be permitted, with a ‘green valve’ incorporated into the overflow system, but that dewatering of the split hopper barges that accompany the BHD will not occur.

The estimated cycle times for dredging within each pipeline section where the BHD will operate are presented in Table 3.4, and those for each pipeline section where the TSHD will operate are presented in Table 3.5.

The potential for sediment mobilisation by TSHD propeller-wash effects has been considered along all relevant pipeline sections. This has been done using supplied data on vessel characteristics, and local depth and seabed composition. For the purposes of the modelling assessment, the relevant specifications were as follows:

- Vessel draft: 10.0 m loaded and 6.0 m empty.
- Number of propellers: 2 (ducted).
- Diameter of propellers: 4.0 m.
- Thrust power: 5,800 kW per propeller.

Table 3.3 Provisional outline of proposed pipeline dredging and disposal activities.

Pipeline Zone	Pipeline Location	Vessel	Task Description	Disposal Location
PRE1	KP0.072 – KP0.8	BHD & barges	Dredging of a 3.5 m deep trench. Dredging of pre-treated sediment if required.	AB
PRE2	KP0.8 – KP3.9	BHD & barges	Dredging of a 3.5-4.0 m deep trench.	AB
		TSHD		2B
PRE3	KP3.9 – KP4.6	TSHD	Clearing out of a pre-excavated trench across the NWS Shipping Channel.	2B
PRE4	KP4.6 – KP6.0	BHD & barges	Dredging of a 3.0 m deep trench.	AB
		TSHD		2B
PRE5	KP6.0 – KP11.2	N/A	No dredging.	N/A
PRE6	KP11.2 – KP18.5	TSHD	Dredging of a 2.0-3.0 m deep trench.	2B
PRE7	KP18.5 – KP19.3	N/A	No dredging.	N/A
PRE8	KP19.3 – KP21.3	TSHD	Dredging of a 2.5-3.0 m deep trench.	2B
PRE9A	KP21.3 – KP23.0	N/A	No dredging.	N/A
PRE9B	KP23.0 – KP23.8	TSHD	Dredging of an 800 m section of trench.	2B
PRE10A	KP23.8 – KP38.2	TSHD	Dredging of a 2.5-3.5 m trench along sections with unconsolidated sediment.	2B
				5A
PRE10B	KP38.2 – KP50.3	TSHD	Dredging of a 2.5-3.5 m trench along sections with unconsolidated sediment.	5A

Table 3.4 Estimated cycle times for each pipeline section where the BHD will be operating.

Pipeline Zone	Non-Dewatering Time (min)	Dewatering Time (min)	Disposal Time (min)	Sailing Time (min)	Total Cycle Time (min)
PRE1	354	N/A	15	90	459
PRE2	734	N/A	15	85	834
PRE4	734	N/A	15	75	824

Table 3.5 Estimated cycle times for each pipeline section where the TSHD will be operating.

Pipeline Zone	Non-Overflow Time (min)	Overflow Time (min)	Disposal Time (min)	Sailing Time (min)	Total Cycle Time (min)
PRE2	20	169	15	130	334
PRE3	20	169	15	125	329
PRE4	20	169	15	120	324
PRE6	20	169	15	70	274
PRE8	20	169	15	48	252
PRE9B	20	169	15	33	237
PRE10A	20	169	15	20	224
PRE10B	20	169	15	20	224

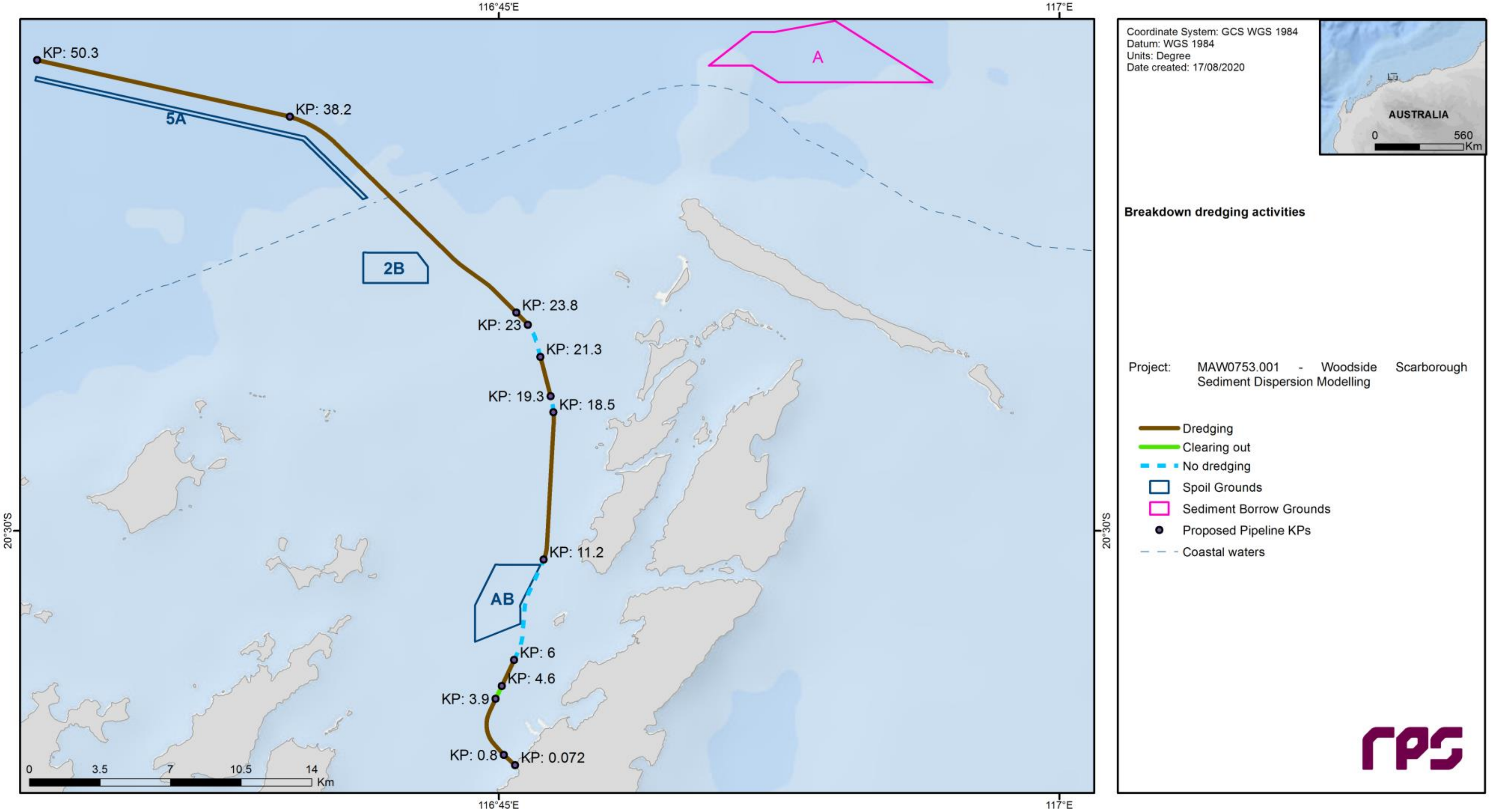

Figure 3.2 Breakdown of proposed dredging activities showing the pipeline KPs and locations of the existing spoil grounds (AB, 2B and 5A) that will be utilised during disposal activities.

3.5.2.2 Spoil Ground Disposal

As outlined in Table 3.3, it was assumed that all material dredged by the BHD will be placed into a waiting split hopper barge and transported to the offshore disposal areas (shown in Figure 3.2), while all material dredged by the TSHD will be transported directly to the offshore disposal areas.

It was assumed that the BHD will be accompanied by two split hopper barges, assumed to be approximately 3,800 m^3 in capacity, to be used for disposal of dredged material. Material discharges from the split hopper barges were assumed to occur between depths of 5.8 m and 1.5 m below mean sea level.

The TSHD hopper doors, from which discharge will occur, were assumed to be opened at a depth of 12.75 m below sea level. The modelled vessel draft will be reduced as spoil is discharged to a minimum depth of 8.75 m below sea level when empty.

The split hopper barges will be pushed or towed by a harbour tug. The potential for sediment mobilisation by tug propeller-wash effects has been considered along all relevant pipeline sections. This has been done using supplied data on vessel characteristics, and local depth and seabed composition. For the purposes of the modelling assessment, the relevant specifications were as follows:

- Vessel draft: 4.5 m (tug).
- Number of propellers: 2 (ducted).
- Diameter of propellers: 2.5 m.
- Thrust power: 1,850 kW per propeller.

The allocations of dredge spoil from each pipeline section to each spoil ground are shown in Table 3.6. It was assumed that the broad aim of the spoil disposal patterns will be to evenly distribute the total volume of allocated material across the entire spoil ground area by the conclusion of all activities, so the spacing of individual disposal operations (which are restricted to a comparatively small area within the spoil ground) was designed to achieve this.

Table 3.6 Anticipated spoil ground allocations of dredge volumes from each pipeline section.

Spoil Ground	Pipeline Zone	Spoil Volume (m^3)	Spoil Ground Area (m^2)	Theoretical Thickness (m)
AB	PRE1, 2 & 4	90,000	4,000,000	0.13
2B	PRE2, 3, 4, 6, 8, 9B & 10A	1,035,772	2,600,000	0.16
5A	PRE10A & 10B	741,087	3,200,000	0.29

3.5.2.3 Borrow Ground Dredging

Dredging of backfill material from the borrow ground locations will consist of the removal of approximately 1.98 Mm^3 of sandy sediments with a low proportion of fines.

It was assumed that dredging of borrow ground A (Figure 3.3) will be conducted using a TSHD. The TSHD hopper size was assumed to be 12,000 m^3 (filled at a rate of approximately 90 m^3/min). It has been specified that overflow of fines from the TSHD hopper will be permitted.

The estimated cycle times for TSHD dredging within borrow ground A and placement of material within each pipeline section are presented in Table 3.7.

The potential for sediment mobilisation by TSHD propeller-wash effects has been considered at the borrow ground. This has been done using supplied data on vessel characteristics, and local depth and seabed composition. For the purposes of the modelling assessment, the relevant specifications were as follows:

- Vessel draft: 10.0 m loaded and 6.0 m empty.
- Number of propellers: 2 (ducted).

- Diameter of propellers: 4.0 m.
- Thrust power: 5,800 kW per propeller.

Table 3.7 Estimated cycle times for each pipeline section where the TSHD will be placing material dredged from borrow ground A.

Pipeline Zone	Non-Overflow Time (min)	Overflow Time (min)	Placement Time (min)	Sailing Time (min)	Total Cycle Time (min)
POST2	20	94	107	225	446
POST4	20	119	107	204	450
POST6	20	119	107	145	391
POST8	20	119	107	123	369
POST9B	20	119	107	123	369
POST10A	20	119	107	133	379
POST10B	20	119	107	133	379

3.5.2.4 Pipeline Route Backfill

The backfill operations for the pipeline route have been divided into twelve sections as outlined in Table 3.8. The breakdown of the proposed backfill activities, including the locations of the pipeline KPs and the backfill material type to be placed along each pipeline section, are shown in Figure 3.3. It was assumed that rock backfill will be placed by a side-dump vessel and sand backfill will be placed by a TSHD.

The side-dump vessel was assumed to have a capacity of 4,500 tonnes with an average installation rate of approximately 2,250 tonnes/hr, with rock dumped from a fixed height at the sea surface. The TSHD hopper size was assumed to be 12,000 m^3 (emptied at a rate of approximately 90 m^3/min), with sand discharged through the suction pipe at an elevation of approximately 5 m above the pipeline.

The potential for sediment mobilisation by TSHD and side-dump vessel propeller-wash effects has been considered along the relevant pipeline sections. This has been done using supplied data on vessel characteristics, and local depth and seabed composition. For the purposes of the modelling assessment, the relevant specifications were as follows:

- Vessel draft:
  - 10.0 m loaded and 6.0 m empty (TSHD).
  - 4.8 m loaded (side-dump vessel).
- Number of propellers:
  - 2 (ducted; TSHD).
  - 2+2 (ducted; side-dump vessel).
- Diameter of propellers:
  - 4.0 m (TSHD).
  - 2.5 m (side-dump vessel).
- Thrust power:
  - 5,800 kW per propeller (TSHD).
  - 2 x 1,250 kW and 2 x 1,000 kW (side-dump vessel).

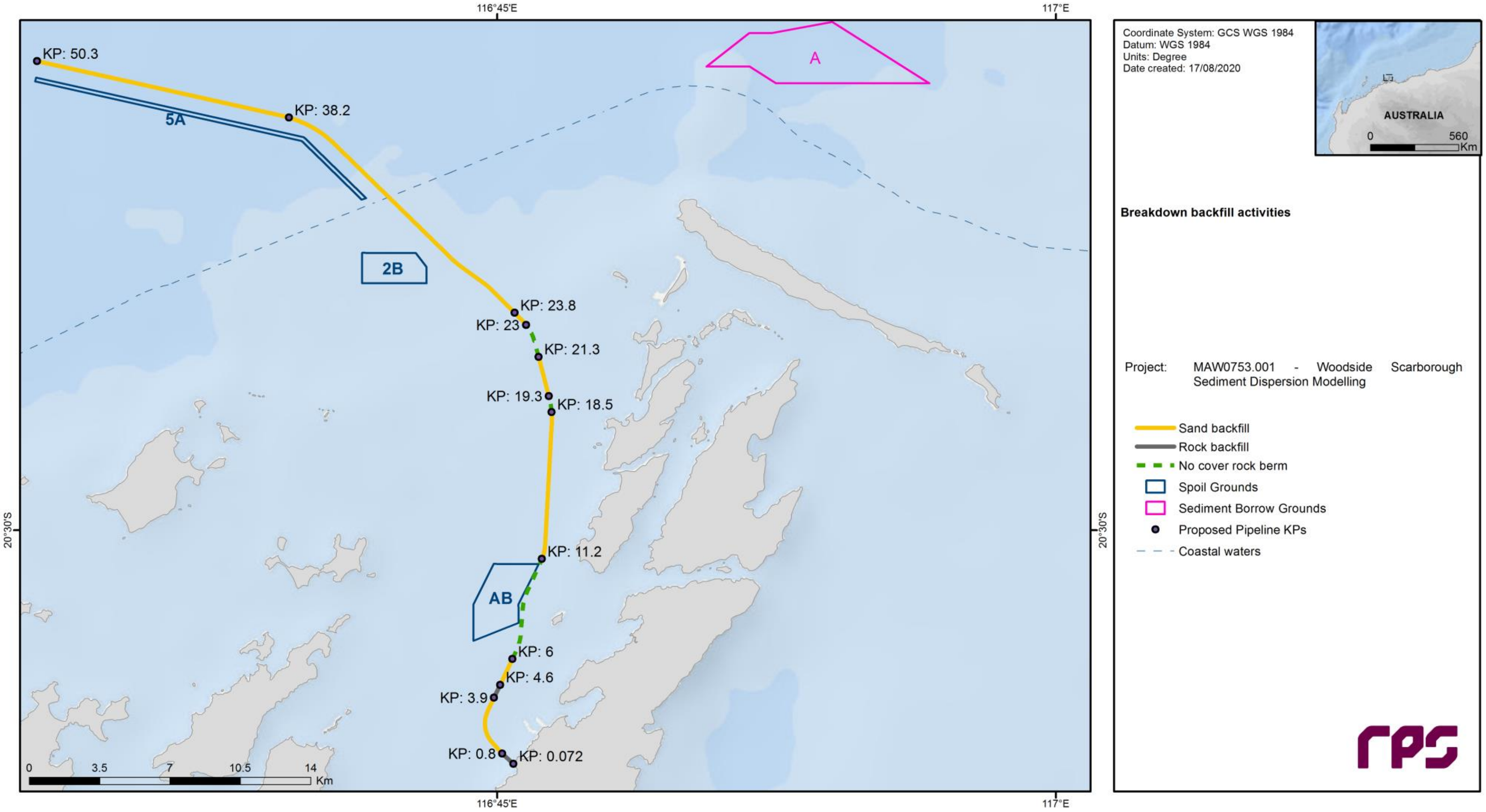

Figure 3.3 Breakdown of proposed backfill activities showing the pipeline KPs, the backfill material type to be placed along each pipeline section, and the location of borrow ground A where sand backfill material is to be sourced.

Table 3.8 Provisional outline of proposed pipeline backfill and stabilisation activities.

Pipeline Zone	Pipeline Location	Vessel	Task Description	Borrow Location
POST1	KP0.072 – KP0.8	Side-dump vessel	Rock backfill (1.2-2.0 m cover over top of pipe).	Rock from the Nickol Bay Quarry.
POST2	KP0.8 – KP3.9	TSHD	Sand backfill (≥3.0 m cover over top of pipe).	Sand from borrow ground A.
POST3	KP3.9 – KP4.6	Side-dump vessel	Rock backfill (2.0 m cover over top of pipe).	Rock from the Nickol Bay Quarry.
POST4	KP4.6 – KP6.0	TSHD	Sand backfill (1.7-2.5 m cover over top of pipe).	Sand from borrow ground A.
POST5	KP6.0 – KP11.2	Side-dump vessel	No cover rock berm (flush to top of pipe).	Rock from the Nickol Bay Quarry.
POST6	KP11.2 – KP18.5	TSHD	Sand backfill (0.8-1.7 m cover over top of pipe).	Sand from borrow ground A.
POST7	KP18.5 – KP19.3	Side-dump vessel	No cover rock berm (flush to top of pipe).	Rock from the Nickol Bay Quarry.
POST8	KP19.3 – KP21.3	TSHD	Sand backfill (1.2-1.7 m cover over top of pipe).	Sand from borrow ground A.
POST9A	KP21.3 – KP23.0	Side-dump vessel	No cover rock berm (flush to top of pipe).	Rock from the Nickol Bay Quarry.
POST9B	KP23.0 – KP23.8	TSHD	Sand backfill of an 800 m section of trench.	Sand from borrow ground A.
POST10A	KP23.8 – KP38.2	TSHD	Sand backfill (0.7-1.7 m cover over top of pipe).	Sand from borrow ground A.
POST10B	KP38.2 – KP50.3	TSHD	Sand backfill (0.7-1.7 m cover over top of pipe).	Sand from borrow ground A.

3.5.3 Quantities and Production Rates

For dredging of each section along the pipeline route, the proposed dredge depths, quantities for each material type, and production rates for each material type were specified for input to the modelling (Table 3.9). The stated quantities include allowances for overdredge and contingency; hence, they are conservative volume estimates. The table has two material categories, defined as “soft” (unconsolidated sediments) and “moderate” (calcareous sedimentary rock). It is understood that no “hard” material (andesite igneous rock) will be present due to its removal during capital dredging activities for the LNG Foundation Project.

For sand backfill of each relevant section along the pipeline route, which involves dredging of borrow ground A, the proposed quantities and production rates for each material type were specified for input to the modelling (Table 3.10). The sole material category within borrow ground A was assumed to be unconsolidated sediments (“soft” material).

For rock backfill sections where rock is to be placed, quantities for each material category were specified (Table 3.11).

It is understood that:

- The estimated material quantities (inclusive of overdredge and contingency) were based on the latest surveyed bathymetry and a geotechnical model incorporating existing geotechnical data.
- The estimated production rates were based on the material type and equipment that may be used for dredging.
- The estimated production rates were average values inclusive of expected downtime estimates. The average production rates were specified by the dredging contractor based on its extensive past project experience and are a combination of: (i) the bulk rate; (ii) a reduced rate when approaching design; and (iii) spot hunting when the design is reached within the majority of the dredge footprint.

Table 3.9 Modelled dredge depths, quantities of material type, and production rates by material type for dredging of each pipeline section.

Pipeline Zone	Dredge Depth (m CD)	Dredged Quantities (m^3)			Production Rates (m^3/week)	
	Target	Soft Material	Moderate Material	Total	Soft Material	Moderate Material
PRE1	+4.3 / -5.5	-	47,100	47,100	-	15-20,000
PRE2	-13.1 / -11.1	240,778	8,884	249,662	250,000	15-20,000
PRE3	-10.7 / -18.6	131,992	-	131,992	250,000	-
PRE4	-9.7 / -11.3	110,598	4,876	115,474	250,000	15-20,000
PRE6	-13.0 / -16.0	208,844	800	209,644	250,000	15-20,000
PRE8	-14.4 / -17.7	48,200	5,500	53,700	250,000	15-20,000
PRE9B	-14.4 / -17.7	18,200	-	18,200	250,000	-
PRE10A	-24.0 / -44.9	486,100	-	486,100	250,000	-
PRE10B	-24.0 / -44.9	554,987		554,987	250,000	-
Totals		**1,799,699**	**67,160**	**1,866,859**	**-**	**-**

Table 3.10 Modelled quantities of material type and production rates by material type for dredging of sand backfill material for each pipeline section from borrow ground A.

Pipeline Zone	Dredged/Backfill Quantities (m^3)	Production Rates (m^3/week)
	Soft Material	Soft Material
POST2	272,537	300,000
POST4	131,223	300,000
POST6	299,069	300,000
POST8	78,200	300,000
POST9B	26,500	300,000
POST10A	599,575	300,000
POST10B	572,237	300,000
Totals	**1,979,341**	**-**

Table 3.11 Modelled quantities of material type for placement of rock backfill material within each pipeline section.

Pipeline Zone	Backfill Quantities (m^3)
	Rock Material
POST1	9,976
POST3	30,374
POST5	16,416
POST7	5,580
POST9A	10,980
Totals	**73,326**

3.5.4 Schedules

For dredging of each section along the pipeline route, the proposed duration and sequencing of operations has been specified for input to the modelling (Table 3.12 and Table 3.13). Table 3.12 has two material categories, as described in Section 3.5.3.

The modelled sequence of dredging has been specified to represent a worst-case scenario where the TSHD and BHD operate concurrently, as outlined in Table 3.13. The TSHD modelled sequence starts in zone PRE2, moving to zone PRE4, then zone PRE3 and then proceeds consecutively from zone PRE6 to zone PRE10B. The BHD modelled sequence starts in zone PRE2 following completion of the TSHD works in PRE2, then moves to zone PRE4 and then zone PRE1 last. Modelling of each section involves a series of dredging and related disposal activities. Allocations of spoil material from each pipeline section to each of the three spoil grounds are outlined in Table 3.3.

For backfill of each section along the pipeline route, the proposed duration and sequencing of operations has been specified for input to the modelling (Table 3.14). The table has two material categories, as described in Section 3.5.3.

The sequence of backfilling has been assumed to involve completing all sand backfill tasks (proceeding consecutively from zone POST2 to zone POST10B) and then completing all rock backfill tasks (proceeding consecutively from zone POST1 to zone POST9B). Modelling of each section involves a series of dredging and related backfill activities. For the pipeline sections where rock backfill will be placed, no associated borrow ground dredging will occur.

Table 3.12 Modelled durations of dredging and disposal operations by material type for each pipeline section.

Pipeline Zone	Duration of Operations (weeks)	
	Soft Material	Moderate Material
PRE1	-	2.69
PRE2	0.96	0.51
PRE3	0.53	-
PRE4	0.44	0.28
PRE6	0.84	0.05
PRE8	0.19	0.31
PRE9B	0.07	-
PRE10A	1.94	-
PRE10B	2.22	-
Totals	**7.19**	**3.84**

Table 3.13 Modelled sequencing of dredging and disposal operations assuming concurrent TSHD and BHD operation.

Week	TSHD			BHD			Comments
	Pipeline Zone	Pipeline Location	Duration (weeks)	Pipeline Zone	Pipeline Location	Duration (weeks)	
1	PRE2	KP0.8 – KP3.9	0.96	-	-	-	-
2	PRE4	KP4.6 – KP6.0	0.44	PRE2	KP0.8 – KP3.9	0.51	BHD dredging follows completion of TSHD works in zone PRE2.
	PRE3	KP3.9 – KP4.6	0.53	PRE4	KP4.6 – KP6.0	0.28	BHD dredging follows completion of TSHD works in zone PRE4.
3	PRE6	KP11.2 – KP18.5	0.89	PRE1	KP0.072 – KP0.8	2.69	Most complex section for BHD dredging, to be undertaken last.
4	PRE8	KP19.3 – KP21.3	0.50				
	PRE9B	KP23.0 – KP23.8	0.07				
4, 5 & 6	PRE10A	KP23.8 – KP38.2	1.94				
6 & 7	PRE10B	KP38.2 – KP50.3	2.22	-	-	-	-
Totals	**-**	**-**	**7.55**	**-**	**-**	**3.48**	**-**

Table 3.14 Modelled durations of dredging and backfill operations by material type for each pipeline section.

Pipeline Zone	Duration of Operations (weeks)		
	Sand Material	Rock Material	Total
POST1	-	0.40	0.40
POST2	1.82	-	1.82
POST3	-	1.20	1.20
POST4	0.87	-	0.87
POST5	-	0.70	0.70
POST6	1.99	-	1.99
POST7	-	0.20	0.20
POST8	0.52	-	0.52
POST9A	-	0.50	0.50
POST9B	0.18	-	0.18
POST10A	4.00	-	4.00
POST10B	3.81	-	3.81
Totals	**13.19**	**3.00**	**16.19**

3.5.5 Scenario Summary

The provisional schedule for the dredging works indicates a July 2021 start for dredging of the pipeline route followed by a December 2021 start for backfill and stabilisation works. Analysis of wind data in the region from 1993-2017 has shown that the period of 2016-2017 is likely to be representative of typical conditions. The dredge modelling simulations were conducted using hydrodynamic and wave data drawn from this period, with nominal start dates for model simulation purposes being chosen as 1st July 2016 (winter) and 1st January 2017 (summer).

A summary of the scenarios that were modelled is as follows:

- Scenario 1: dredging works to commence on 1st July 2016 (winter start):
  - TSHD dredging and disposal operations were programmed to occur between 1st July 2016 and 22nd August 2016.
  - BHD dredging and disposal operations were programmed to occur between 7th July 2016 and 4th August 2016.
  - A simulation run-on period was assumed to occur between 22nd August 2016 and 1st December 2016. Sediments suspended in the water column during previous operations were subject to settlement and progressively-reducing levels of resuspension during this time.
  - TSHD dredging and sand backfill operations were programmed to occur between 1st December 2016 and 3rd March 2017.
  - Side-dump vessel rock backfill operations were programmed to occur between 3rd March 2017 and 24th March 2017.
  - A further simulation run-on period was assumed to occur between 24th March 2017 and 23rd May 2017. Sediments suspended in the water column during previous operations were subject to settlement and progressively-reducing levels of resuspension during this time.
- Scenario 2: dredging works to commence on 1st January 2017 (summer start):
  - TSHD dredging and disposal operations were programmed to occur between 1st January 2017 and 22nd February 2017.
  - BHD dredging and disposal operations were programmed to occur between 7th January 2017 and 4th February 2017.
  - A simulation run-on period was assumed to occur between 22nd February 2017 and 1st June 2017. Sediments suspended in the water column during previous operations were subject to settlement and progressively-reducing levels of resuspension during this time.
  - TSHD dredging and sand backfill operations were programmed to occur between 1st June 2017 and 1st September 2017.
  - Side-dump vessel rock backfill operations were programmed to occur between 1st September 2017 and 22nd September 2017.
  - A further simulation run-on period was assumed to occur between 22nd September 2017 and 21st November 2017. Sediments suspended in the water column during previous operations were subject to settlement and progressively-reducing levels of resuspension during this time.

The outcomes of the summer-start and winter-start scenarios have been analysed and presented separately, for comparison.

3.6 Geotechnical Information

The dredged material from the pipeline route will consist mainly of marine sediments (approximately 1.80 Mm^3) and marine sediment/coarse material mix (approximately 0.07 Mm^3). The backfill material to be dredged from borrow ground A will consist of the removal of approximately 1.98 Mm^3 of sandy sediments with a low proportion of fines.

The critical geotechnical information required as input to the modelling is: (i) PSD data for the sediments to be dredged along the pipeline route; (ii) PSD data for the sediments to be dredged from borrow ground A; and (iii) PSD data for the quarry rock material.

The PSD data used in the modelling was specified by Woodside (2020) for each pipeline zone to be dredged (see Table 3.3) and for the sand backfill from borrow ground A. The specified PSD for each zone was determined based on an average of the PSD results of all samples taken within each zone during site investigations for the Scarborough development (Advisian, 2019a; Fugro, 2019). An example of a calculated average PSD plotted over the corresponding set of raw PSD sample data within zone PRE3 is shown in Figure 3.6. The geotechnical sampling points from which PSDs were acquired within each zone and within borrow ground A are summarised in Table 3.15, including reference to the relevant geotechnical investigation and the total number of PSD samples used to determine the average. The locations of the geotechnical sampling points from the Advisian (2019a) and Fugro (2019) site investigations are shown in Figure 3.4 and Figure 3.5, respectively.

It should be noted that the Advisian (2019a) sampling points were all surface sediment samples which typically contained higher fines content than samples taken below the surface. Therefore, to be conservative, where possible the Advisian (2019a) PSD sample data was selected for use in defining the PSDs for modelling.

The resultant PSDs for each pipeline section and borrow ground A have been redistributed to match the material size classes used in the DREDGEMAP model, as shown in Table 3.16 and Table 3.17.

For the rock backfill operations, in the absence of grading information it has been conservatively assumed that the fraction of material within the quarry rubble classified as “fines” in this context (diameters less than 100 mm) will be 5% of the total volume. From experience, this is a typical upper limit for the “fines” fraction of well-graded limestone rubble, with the breakdown of this figure into smaller size classes usually unknown. Although the most conservative approach would be to further assume that all of the “fines” material is potentially available for resuspension into the water column, the assumed PSD has been heavily slanted towards the least-mobile coarse sand (>130 µm) category to account for the typically minimal proportion of the finest material categories. The chosen PSD is shown in Table 3.18.

In addition to PSD information, data and assumptions relating to the dry bulk density of the material to be dredged from the pipeline route and borrow ground, and of the quarry rock material, was used as input to the modelling.

Dry bulk density information for the project area was available from a geotechnical study conducted by Fugro for the Scarborough development (Fugro, 2019) and from a previous geotechnical study conducted in the vicinity of the project area for the LNG Foundation Project (Coffey, 2007). The Fugro investigation presented ‘low-estimate’, ‘best-estimate’ and ‘high-estimate’ dry bulk density values along the trunkline and within the borrow ground. The high-estimate values were adopted as input to the modelling, as these values are most conservative in terms of sediment mass and also lie within the range of values presented in the earlier Coffey report. The dry bulk density values applied to each zone are outlined in Table 3.19. For the quarry rock material, a conservative dry bulk density value of 1,950 kg/m^3 was assumed based on learnings from the Pluto LNG Foundation Project, which utilised rock from the Nickol Bay quarry (located between Dampier and Karratha, Western Australia).

Table 3.15 Summary of geotechnical data used in the derivation of model PSDs for each pipeline zone and borrow ground A.

Pipeline Zone	Pipeline Location	Source Study	No. of PSD Samples	Location Figure
PRE1	KP0.072 – KP0.8	KP0.0 – KP3.6 (Advisian, 2019a)	35	Figure 3.4
PRE2	KP0.8 – KP3.9			
PRE3	KP3.9 – KP4.6	KP3.6 – KP4.6 (Advisian, 2019a)	8	Figure 3.4
PRE4	KP4.6 – KP6.0	KP4.6 – KP6.2 (Advisian, 2019a)	2	Figure 3.4
PRE6	KP11.2 – KP18.5	KP11.0 – KP15.0 (Advisian, 2019a)	21	Figure 3.4
PRE8	KP19.3 – KP21.3	KP18.0 – KP23.8 (Fugro, 2019)	3	Figure 3.5
PRE9B	KP23.0 – KP23.8	KP23.2 – KP23.8 (Fugro, 2019)	2	Figure 3.5
PRE10A	KP23.8 – KP38.2	KP23.8 – KP38.1 (Fugro, 2019)	10	Figure 3.5
PRE10B	KP38.2 – KP50.3	KP38.2 – KP50.0 (Fugro, 2019)	4	Figure 3.5
Borrow Ground A	N/A	Sand Search Area (Fugro, 2019)	5	Figure 3.5

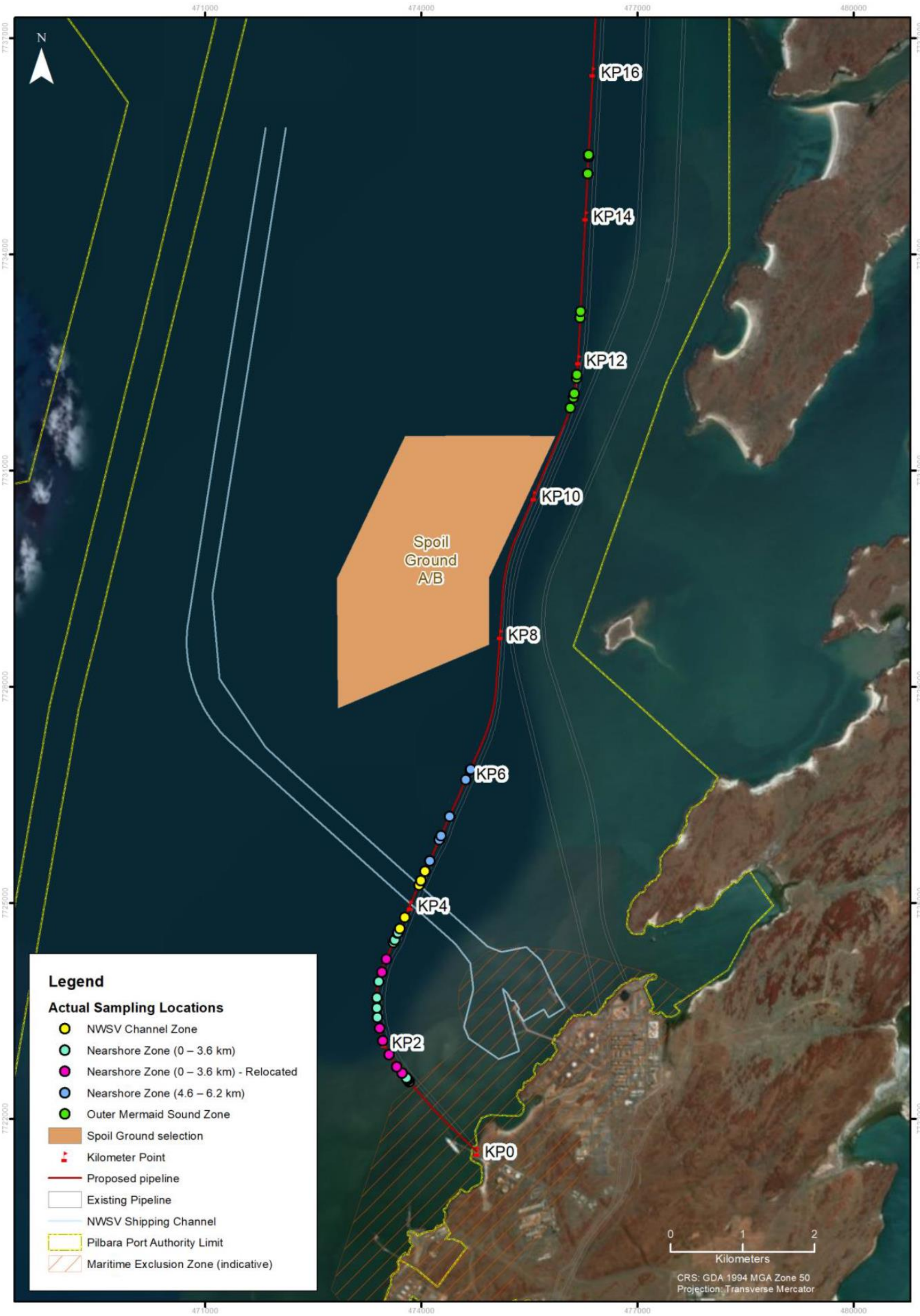

Figure 3.4 SAP implementation actual sampling locations, March 2019 (source: Advisian, 2019b).

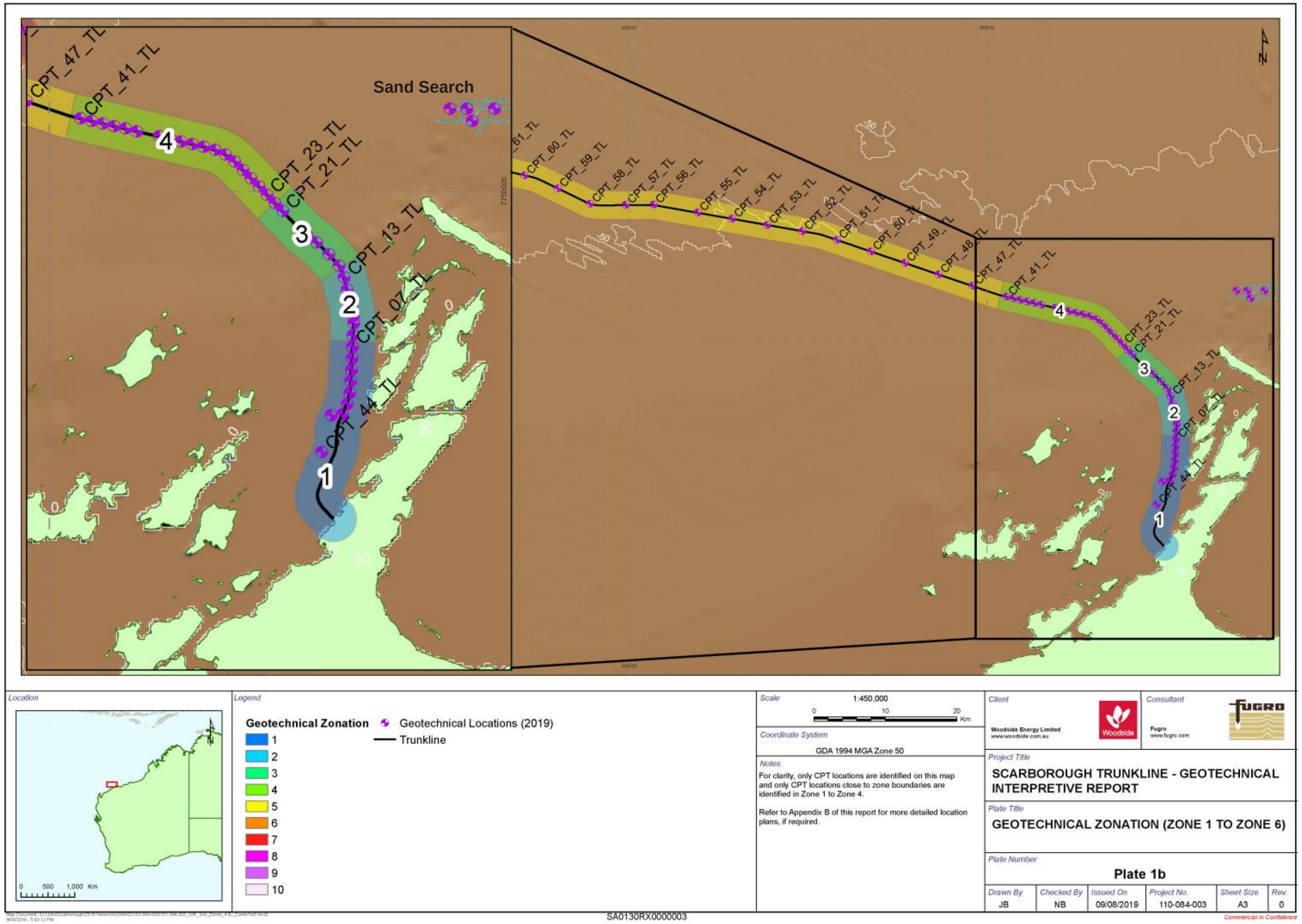

Figure 3.5 Locations of geotechnical sample points along the trunkline and in the sand search area, extracted and modified from Fugro (2019). Note Zone 1 is from KP0-16.5, Zone 2 is from KP16.5-23.0, Zone 3 is from KP23.0-31.0 and Zone 4 is from KP31.0-51.0.

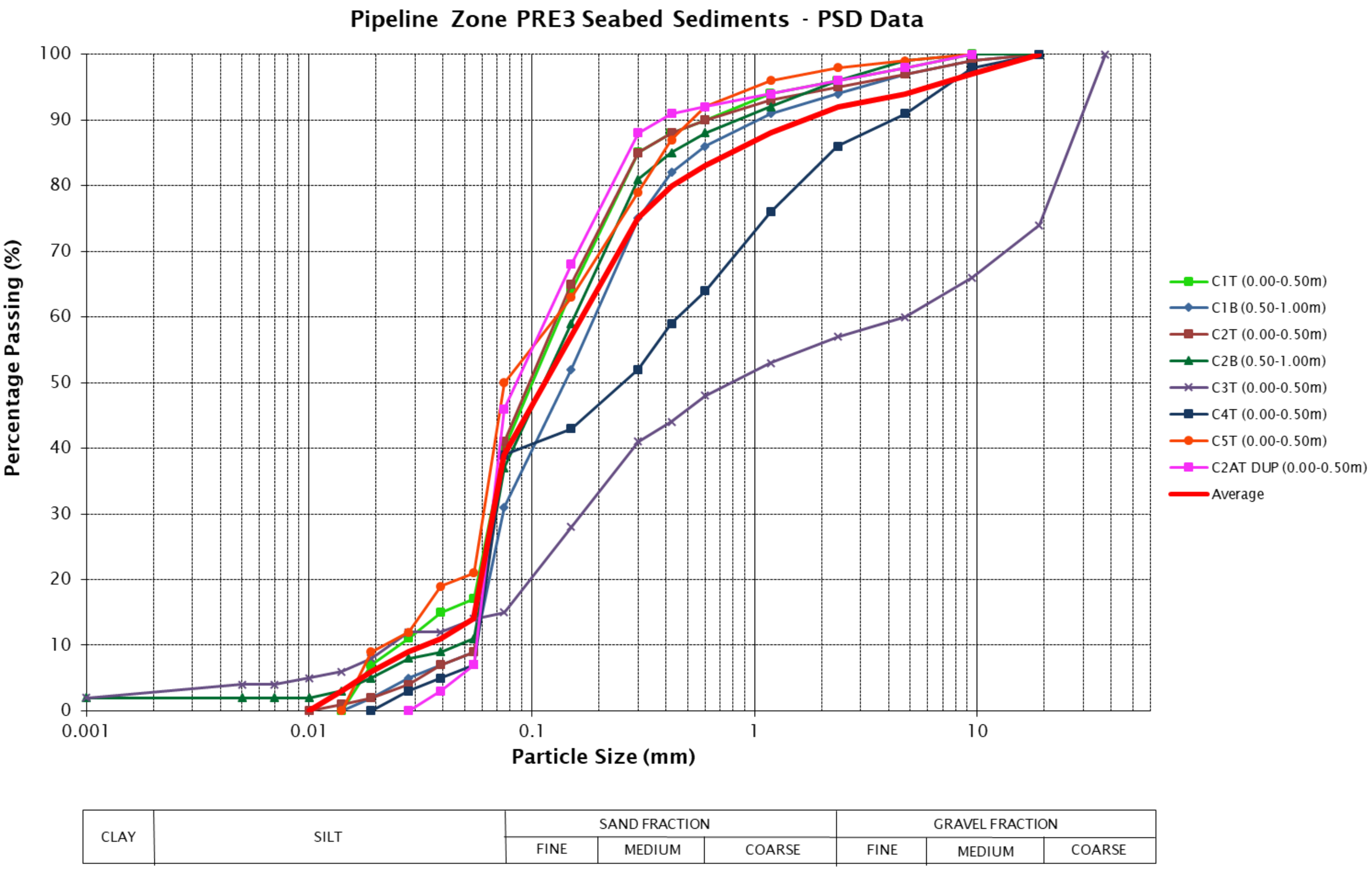

Figure 3.6 Calculated average PSD (solid red line) overlain on raw PSD data for all samples from pipeline zone PRE3.

Table 3.16 ***In situ*** **PSDs broken down into DREDGEMAP material classes for each pipeline section to be dredged, derived from available geotechnical information.**

Sediment Grain Size Class	Size Range (µm)	Zone PRE1 (%)	Zone PRE2 (%)	Zone PRE3 (%)	Zone PRE4 (%)	Zone PRE6 (%)	Zone PRE8 (%)	Zone PRE9B (%)	Zone PRE10A (%)	Zone PRE10B (%)
Clay	<7	4.58	4.58	0.97	6.80	0.51	7.33	11.00	8.80	2.75
Fine Silt	7-34	8.51	8.51	8.89	7.63	11.52	6.33	9.50	5.40	2.00
Coarse Silt	35-74	18.31	18.31	28.37	11.94	25.94	16.33	21.00	10.80	7.75
Fine Sand	75-130	32.70	32.70	18.04	23.71	32.19	13.67	20.00	20.70	18.00
Coarse Sand	>130	35.90	35.90	43.73	49.92	29.84	56.34	38.50	54.30	69.50

Table 3.17 ***In situ*** **PSDs broken down into DREDGEMAP material classes for the sand backfill material dredged from borrow ground A for each pipeline section, derived from available geotechnical information.**

Sediment Grain Size Class	Size Range (µm)	Zone POST2 (%)	Zone POST4 (%)	Zone POST6 (%)	Zone POST8 (%)	Zone POST9B (%)	Zone POST10A (%)	Zone POST10B (%)
Clay	<7	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Fine Silt	7-34	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Coarse Silt	35-74	1.13	1.13	1.13	1.13	1.13	1.13	1.13
Fine Sand	75-130	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Coarse Sand	>130	94.00	94.00	94.00	94.00	94.00	94.00	94.00

Table 3.18 ***In situ*** **PSDs broken down into DREDGEMAP material classes for the rock backfill material of each pipeline section, assumed as typical values for well-graded limestone rubble.**

Sediment Grain Size Class	Size Range (µm)	Zone POST1 (%)	Zone POST3 (%)	Zone POST5 (%)	Zone POST7 (%)	Zone POST9A (%)
Clay	<7	0.50	0.50	0.50	0.50	0.50
Fine Silt	7-34	0.50	0.50	0.50	0.50	0.50
Coarse Silt	35-74	0.50	0.50	0.50	0.50	0.50
Fine Sand	75-130	0.50	0.50	0.50	0.50	0.50
Coarse Sand	>130	98.00	98.00	98.00	98.00	98.00

Table 3.19 *In situ* dry bulk densities, based on the 'high estimate' values specified in Fugro (2019).

Zone	Dry Bulk Density (t/m^3)
PRE1	1.54
PRE2	1.54
PRE3	1.54
PRE4	1.54
PRE5	1.54
PRE6	1.54
PRE7	1.54
PRE8	1.54
PRE9A	1.54
PRE9B	1.54
PRE10A	1.54
PRE10B	1.54
Borrow Ground A	1.78

3.7 Model Sediment Sources

3.7.1 Overview

To accurately represent the pipeline dredging, disposal and backfill operations in DREDGEMAP, a range of information was defined for the proposed operations, including dredge, disposal and backfill methodology, production rates, sediment/rock types and quantities (see Section 3.5). It is evident that there will be seven different sources of suspended sediment plumes during dredging, disposal and backfill operations, which can be broadly defined as:

- Direct suspension of material from the BHD bucket, from grabbing and lifting unconsolidated sediments and sedimentary rock through the water column, accounting for periods of no-dewatering and dewatering from the split hopper barge.
- Disposal of sediment and rock excavated by the BHD from split hopper barges to the nominated spoil grounds.
- Direct suspension of material by the TSHD during dredging of unconsolidated sediments, accounting for no-overflow and overflow periods.
- Disposal of sediment dredged by the TSHD to the nominated spoil grounds.
- Indirect suspension of material due to the propeller-wash of the BHD barge tug and TSHD while dredging.
- Suspension of material during backfill activities, via TSHD, using sediments dredged from the borrow ground.
- Suspension of material during backfill activities, via side-dump vessel, using rock from onshore quarries.

Each of these sources of suspended sediment plumes will vary in strength and persistence depending on the nature of the operations. In the DREDGEMAP model, each source is defined by specifying the time-varying flux rate, PSD and vertical profile in the water column. The following sections outline how the information provided has been used to represent the dredging operations in the model and explain any assumptions that have been made to supplement the available information.

3.7.2 Representation of BHD Dredging

A BHD will be used to excavate all unconsolidated sediments and sedimentary rock material from zone PRE1, and all sedimentary rock material from zones PRE2 and PRE4 (following TSHD dredging of unconsolidated sediments in these zones) (Figure 3.7). The BHD will use a large excavator arm fitted with an open bucket of (nominally) 20-30 m^3 capacity. The excavator will lift material in the bucket and deliver it to one of two waiting split hopper barges – assumed for the purposes of modelling to be 3,800 m^3 in capacity – for transport to spoil ground AB for disposal.

Sources of sediment suspension from this type of operation include:

- Disturbance of the seabed sediments by the excavator bucket.
- Dewatering of the split hopper barge, resulting in the discharge of water and entrained sediments.

Only the first of these sources was considered in this modelling study, as it is understood that dewatering of split hopper barges is not planned to occur during BHD dredging operations for the Scarborough development.

Past observations have shown that material is suspended due to the initial grab at the seabed. Further suspension is generated as sediment spills from the bucket as it is lifted through the water column. Spillage of water and sediment also occurs as the bucket breaks free of the water surface and drains freely. Only sediments <130 µm in diameter are considered “lost” (i.e. suspended into the water column), because the coarser material spilled from the bucket while being lifted to the surface will fall immediately to the bottom where it will be re-dredged during subsequent grabs. As such, the distribution of material suspended by the bucket spillage is assumed to be distributed across the four smaller sediment size classes in the model.

For the dredging of the unconsolidated sediments, the PSD used in the model is based on PSDs from nearby boreholes (see Section 3.6), with the proportion >130 µm removed and the remaining distribution normalised to 100% by scaling up the proportions in the four remaining size classes (Table 3.20). The same PSD is used for the sedimentary rock component, assuming that due to the excavation action of the BHD the rock will break down into similar proportions of fines. Because the dredging action of the excavator involves no cutting or hydraulic pumping, this is a conservative assumption.

Table 3.21 shows the assumed vertical distribution of the suspended material during the BHD operations. The distribution is higher at the seabed and water surface, to represent the larger loss rate of material during the initial grab and as the bucket breaks free of the water column.

Table 3.20 Assumed PSDs of sediments initially suspended into the water column during BHD dredging operations along the pipeline route.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment and Sedimentary Rock Removal – Zone PRE1	PSD (%) for Sedimentary Rock Removal – Zone PRE2	PSD (%) for Sedimentary Rock Removal – Zone PRE4
Clay	<7	7.15	7.15	13.58
Fine Silt	7-34	13.28	13.28	15.24
Coarse Silt	35-74	28.56	28.56	23.84
Fine Sand	75-130	51.01	51.01	47.34
Coarse Sand	>130	0.00	0.00	0.00

Table 3.21 Assumed vertical distribution of sediments initially suspended into the water column during BHD dredging operations along the pipeline route.

Elevation	Example Elevation (m ASB) – 10 m Water Depth	Vertical Distribution (%) of Sediments
Surface/water depth	10.0	23.0
0.80 x water depth	8.0	16.0
0.50 x water depth	5.0	14.0
0.30 x water depth	3.0	19.0
0.10 x water depth	1.0	28.0

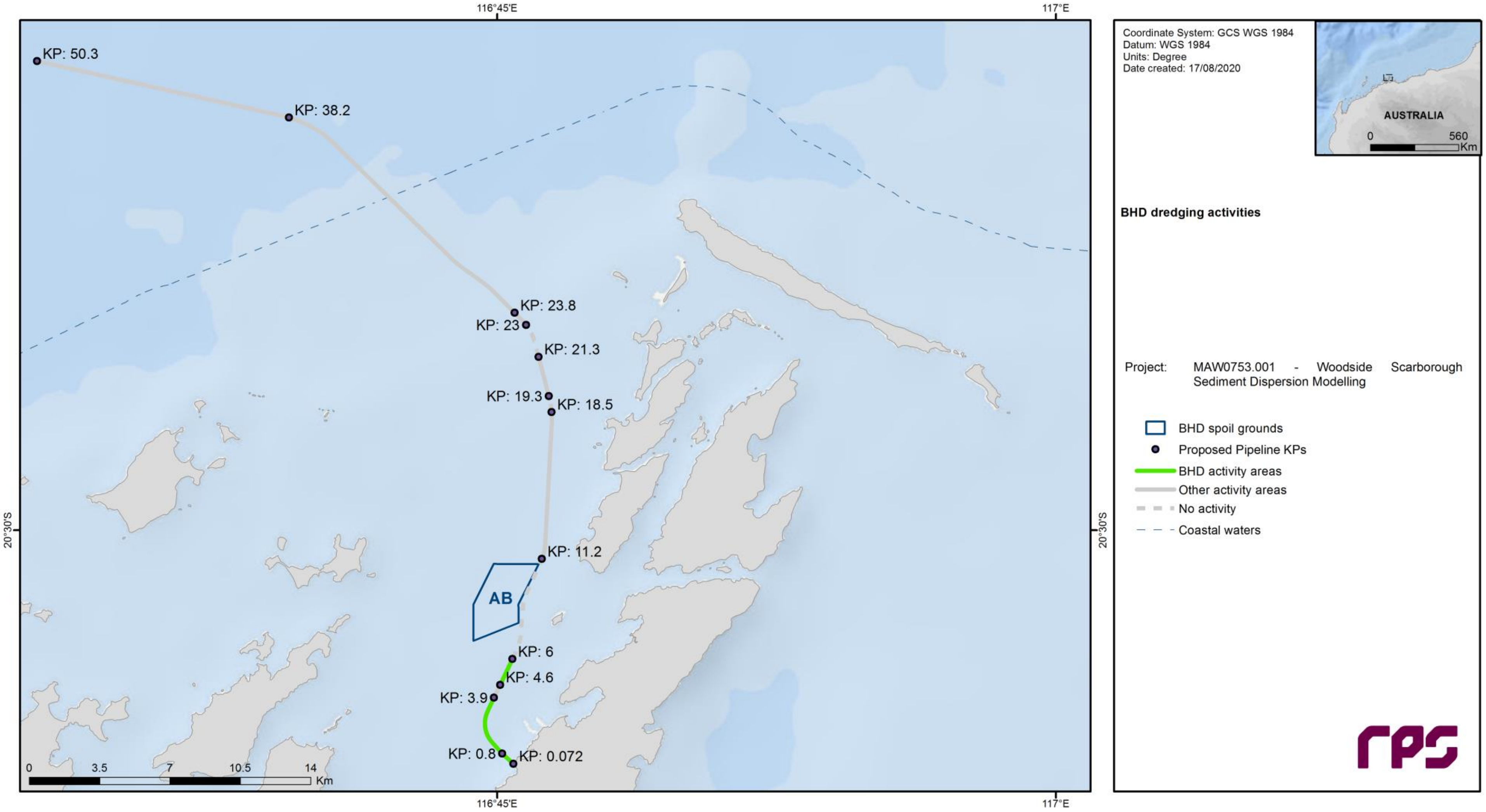

Figure 3.7 Overview of BHD dredging activity areas, showing the pipeline KPs and location of spoil ground AB that will be utilised during disposal activities.

Loss rates from similar operations are known to vary based on such factors as the size and type of bucket (i.e. open or closed), nature of the seabed material, presence of debris, current speed and depth of water, as well as the care of the operator (Hayes & Wu, 2001; Anchor Environmental, 2003). Reported rates compared by Anchor Environmental (2003) varied from 0.1% to 10%, with a mean of 2.1%. In the absence of measurements for the specific situation and equipment, the mean of 2.1% of production rate is assumed for all BHD operations.

3.7.3 Representation of Disposal of BHD-Dredged Material

All material dredged by the BHD will be placed into one of two waiting 3,800 m^3 split hopper barges and transported (by harbour tug) to spoil ground AB for disposal (Figure 3.7). This material will include all unconsolidated sediments and sedimentary rock material from zone PRE1, and all sedimentary rock material from zones PRE2 and PRE4.

For the disposal of the unconsolidated sediments dredged by BHD, the PSD used in the model is based on PSDs from nearby boreholes (see Section 3.6). The same PSD is used for the sedimentary rock component, assuming that due to the excavation action of the BHD the rock will break down into similar proportions of fines. Because the dredging action of the excavator involves no cutting or hydraulic pumping, this is a conservative assumption. This PSD is adjusted by removal of the component treated as suspended during dredging (see Section 3.7.2), but as this represents only 2.1% of the mass for the minor components, the modified PSD is not significantly different to the *in situ* PSD (Table 3.22).

Once at the AB spoil ground, the split hopper barge will open to release the sediments from the bottom of the hull at a depth of approximately 5.8 m below sea level. Previous observations of sediment dumping from hopper vessels (e.g. CSMW, 2005) have shown that there is an initial rapid descent of solids, with the heavy particles tending to entrain lighter particles, followed by a billowing of lighter components back into the water column after contact with the seabed (Figure 3.8). A proportion of the lighter components will also remain suspended and may be trapped by density layers, if present.

Because simulations in this study focused on the far-field fate of sediment particles due to transport and sinking after the initial dump phase, simulations were run with the initial vertical distribution specified to represent the post-collision phase for a case where a high proportion of the sediments are resuspended after collision with the seabed. To represent this, an assumed vertical distribution for the sediments (Table 3.23) has been specified following published information from previous hopper disposal operations (CSMW, 2005; NEPA, 2001). This vertical distribution, with the majority of the material input near the seabed and only 7% of the material released in the upper half of the water column, is in line with values quoted in the recent literature review by Mills & Kemps (2016), which found that sediment resuspension from individual dredged material disposal events was generally less than 10% of the disposed material load.

It is estimated that 95-99% of the bulk load deposits directly onto the seabed in a typical case, with the remainder released into the water column (CSMW, 2005, NEPA, 2001). It is difficult to find other definitive source values in the literature, but a value of 5% of each load agrees well with past experience and appears to be a conservative estimate based on the values quoted above. Accordingly, 5% of each hopper load was placed in suspension in the water column in the sediment fate model.

In addition to the proportion of material immediately suspended in the water column, disposal from the barge will result in the stockpiling of sediment as a mound on the seabed that will be subject to resuspension by tidal and wave forces. Because fine sediments in the deposited mass may be subject to ongoing resuspension and dispersion over time, it was necessary to specify the deposits as a further source of sediment potentially subject to resuspension.

The proportion of the newly deposited trenched material available for resuspension is characterised by a finite limit regulated by PSDs and the occurrence of natural sediment capping. As a result of the selective resuspension of the smaller-sized particles (silts and clays), the deposited mound surface layer gradually contains a greater proportion of larger particle sizes. These larger particles act as armouring against bottom shear stress, protecting and retaining the remaining fine particles in the mound. Therefore, in the model it was assumed that 5% of the deposited mass – representing the volume of the upper surface layer – would be subject to resuspension. It should be noted that the model maintains a mass balance estimate of the remaining sediment of each size class within each grid cell to derive an estimate of the median particle size in the surface-layer sediments. In turn, the potential for ongoing resuspension of fines is calculated. In this way, the model represents the increased armouring of sediments as the average particle size increases.

The disposal time for the barge material within each dredge cycle was assumed to be 15 minutes (Table 3.4). The disposal location within spoil ground AB was varied for each dredge cycle in a randomised manner, with the ultimate aim of ensuring an even distribution of dredged material within the spoil ground by the conclusion of all activities.

Table 3.22 Assumed PSDs of sediments initially suspended into the water column during split hopper barge disposal operations at spoil ground AB.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment and Sedimentary Rock Disposal – Zone PRE1	PSD (%) for Sedimentary Rock Disposal – Zone PRE2	PSD (%) for Sedimentary Rock Disposal – Zone PRE4
Clay	<7	4.43	4.43	6.51
Fine Silt	7-34	8.23	8.23	7.31
Coarse Silt	35-74	17.71	17.71	11.44
Fine Sand	75-130	31.63	31.63	22.72
Coarse Sand	>130	38.00	38.00	52.02

Table 3.23 Assumed vertical distribution of sediments initially suspended into the water column during split hopper barge disposal operations at spoil ground AB.

Elevation	Example Elevation (m ASB) – 10 m Water Depth	Vertical Distribution (%) of Sediments
Surface/water depth	10.0	2.0
0.60 x water depth	6.0	5.0
0.40 x water depth	4.0	15.0
0.15 x water depth	1.5	35.0
0.10 x water depth	1.0	43.0

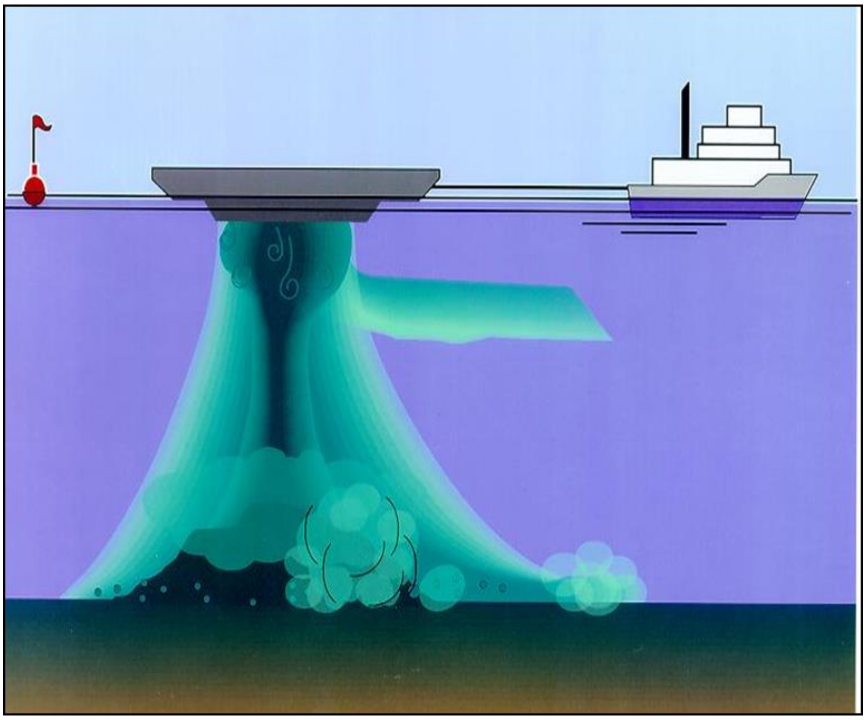

Figure 3.8 Conceptual diagram showing the general behaviour of sediments dumped from a split hopper barge and the vertical distribution of material set up by entrainment and billowing (source: ASA, 2004).

3.7.4 Representation of TSHD Dredging

A TSHD will be used to excavate all unconsolidated sediments from zones PRE2, PRE3, PRE4, PRE6, PRE8 and PRE9B with disposal at spoil ground 2B, and zones PRE10A and PRE10B with disposal at spoil ground 5A (Figure 3.9). The TSHD will also be used to dredge backfill material from borrow ground A, with disposal along the pipeline route. For the purposes of modelling, the capacity of the TSHD to be used for dredging of the pipeline route and borrow ground A was assumed to be 12,000 m^3.

TSHD vessels remove sediments by dragging a large drag-head over the seabed and drawing up the disturbed sediment by hydraulic suction. Sources of sediment suspension from this type of operation include:

- Hydraulic disturbance of the seabed sediments by the trailing arm.
- Propeller-wash generated as the vessel manoeuvres.
- Overflow of the on-board hoppers, resulting in the discharge of water and entrained sediments.

The characteristics of each of these sources vary greatly due to a wide range of factors (USACE, 2008) making the generalisation of source terms difficult. It appears however, that the overflow source term is dominant, being typically an order of magnitude greater than the drag-head and propeller-wash terms.

For the dredging of the unconsolidated sediments during periods with no overflow, the PSDs used in the model are based on PSDs from nearby boreholes (see Section 3.6). The PSDs applied to dredging along the pipeline route and within the borrow ground are shown in Table 3.24 and Table 3.26, respectively. During overflow periods, an increase in the rate of release of fine sediments, and hence initial turbidity, is observed (Anchor Environmental, 2003). The overflow water contains a high proportion of fines because the coarse material settles rapidly in the hopper while the fine material remains in suspension. After the hopper begins overflowing, PSDs heavily weighted towards finer particles have been assumed based on previous field measurements of hopper barge dewatering at Geraldton Port (OPR, 2010), with the proportion >75 µm removed and the remaining distribution normalised to 100% by scaling up the proportions in the three remaining size classes. The PSDs applied to dredging along the pipeline route and within the borrow ground are shown in Table 3.25 and Table 3.27, respectively.

Table 3.28 shows the assumed vertical distribution of the suspended material during the TSHD operations while the hopper is not overflowing. The distribution is concentrated near the seabed and decreases in intensity towards the surface, to represent the disturbance of seabed material by the drag-head and propeller-wash effects (HR Wallingford, 2003). After the hopper begins overflowing, a uniform distribution of sediments throughout the water column, between the hull depth and the seabed, has been assumed to represent a continuous stream of material being discharged from the hopper through an overflow system incorporating a ‘green valve’ (Table 3.29). This is consistent with measured ADCP profiles presented by Hitchcock & Bell (2004), which show a reasonably even distribution of sediment through the water column during hopper overflow.

It should be noted that the installation of a green valve within an overflow system is designed to reduce the proportion of air entrained into the overflow mixture, which in turns will result in a lessened phenomenon of discharged material mixing and billowing upwards to the water surface. To account for this process in the modelling, the vertical distribution applied during hopper overflow (Table 3.29) is not uniform throughout the entire water column, but only from the hull depth to the seabed.

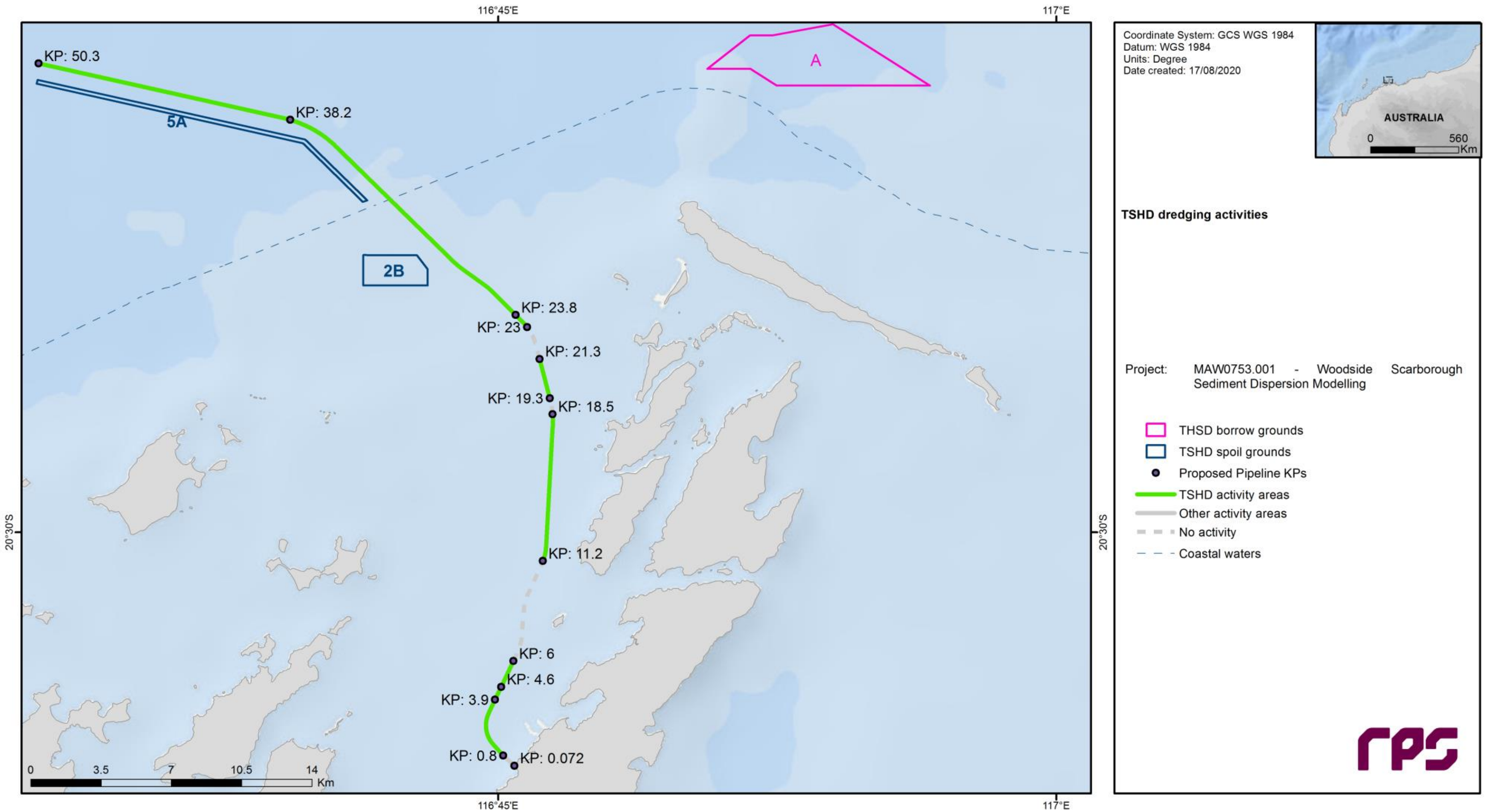

Figure 3.9 Overview of TSHD dredging activity areas, showing the pipeline KPs, locations of spoil grounds 2B and 5A that will be utilised during disposal activities, and location of borrow ground A where sand backfill material is to be sourced.

Table 3.24 Assumed PSDs of sediments initially suspended into the water column during TSHD dredging operations along the pipeline route while the hopper is not overflowing.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment Removal							
		Zone PRE2	Zone PRE3	Zone PRE4	Zone PRE6	Zone PRE8	Zone PRE9B	Zone PRE10A	Zone PRE10B
Clay	<7	4.58	0.97	6.80	0.51	7.33	11.00	8.80	2.75
Fine Silt	7-34	8.51	8.89	7.63	11.52	6.33	9.50	5.40	2.00
Coarse Silt	35-74	18.31	28.37	11.94	25.94	16.33	21.00	10.80	7.75
Fine Sand	75-130	32.70	18.04	23.71	32.19	13.67	20.00	20.70	18.00
Coarse Sand	>130	35.90	43.73	49.92	29.84	56.34	38.50	54.30	69.50

Table 3.25 Assumed PSDs of sediments initially suspended into the water column during TSHD dredging operations along the pipeline route while the hopper is overflowing.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment Removal							
		Zone PRE2	Zone PRE3	Zone PRE4	Zone PRE6	Zone PRE8	Zone PRE9B	Zone PRE10A	Zone PRE10B
Clay	<7	42.31	34.94	47.30	34.63	45.84	43.18	50.05	50.88
Fine Silt	7-34	27.03	25.57	27.51	28.27	25.23	25.30	25.65	25.63
Coarse Silt	35-74	30.66	39.49	25.19	37.11	28.93	31.53	24.30	23.50
Fine Sand	75-130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coarse Sand	>130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.26 Assumed PSDs of sediments initially suspended into the water column during TSHD dredging operations at borrow ground A while the hopper is not overflowing.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment Removal – Borrow Ground A
Clay	<7	1.13
Fine Silt	7-34	1.13
Coarse Silt	35-74	1.13
Fine Sand	75-130	3.00
Coarse Sand	>130	94.00

Table 3.27 Assumed PSDs of sediments initially suspended into the water column during TSHD dredging operations at borrow ground A while the hopper is overflowing.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment Removal – Borrow Ground A
Clay	<7	54.48
Fine Silt	7-34	27.32
Coarse Silt	35-74	18.59
Fine Sand	75-130	0.0
Coarse Sand	>130	0.0

Table 3.28 Assumed vertical distribution of sediments initially suspended into the water column during TSHD dredging operations along the pipeline route and at borrow ground A while the hopper is not overflowing.

Elevation	Example Elevation (m ASB) – 30 m Water Depth	Vertical Distribution (%) of Sediments
10.0 m (ASB)	10.0	5.0
7.0 m (ASB)	7.0	15.0
3.0 m (ASB)	3.0	20.0
2.0 m (ASB)	2.0	40.0
1.0 m (ASB)	1.0	20.0

Table 3.29 Assumed vertical distribution of sediments initially suspended into the water column during TSHD dredging operations along the pipeline route and at borrow ground A while the hopper is overflowing.

Elevation	Example Elevation (m ASB) – 30 m Water Depth and 10 m Hull Depth	Vertical Distribution (%) of Sediments
Hopper hull elevation	20.0	20.0
0.75 x hull elevation	15.0	20.0
0.50 x hull elevation	10.0	20.0
0.25 x hull elevation	5.0	20.0
0.50 m (ASB)	0.5	20.0

The resuspension of sediment when the TSHD hopper is not overflowing was estimated by combining the drag-head and propeller-wash terms. The propeller-wash component typically dominates the drag-head component, but both sources were assessed. Propeller-wash generation was estimated by applying a model of the bed-induced shear stress from the TSHD vessel over the range of under-keel clearances expected during the dredging operations.

Field measurements of drag-head-induced sediment suspension was reported by Coastline Surveys Ltd (CSL, 1999). The inferred production rate was less than 1 kg/s and it was concluded that, generally, drag-head production is small in comparison to the quantity of sediment released via overflow. Given the above, a loss rate of 0.6% of the gross production rate, representing a combined sediment flux due to losses from the drag-head and propeller-wash, was assumed when the TSHD is not overflowing. This rate is within the range of values (less than 1%) summarised in a review of contemporary practice conducted as part of the WAMSI Dredging Science Node by Kemps & Masini (2017).

The resuspension of sediment from hopper overflow is the most complex source term associated with a TSHD. The discharged water-sediment mixture forms a negatively-buoyant jet (dynamic plume) that descends towards the seabed. Due to mixing and entrainment as the plume descends, not all of the sediment in the dynamic plume directly descends to the seabed, forming a passive plume in the water column below the TSHD. Based on evidence from numerous field measurements, Spearman *et al.* (2011) state that the dynamic plume retains the bulk of the overflow sediment, with a small proportion (in the range of 5-15%) contained in the passive plume. The proportion of sediment contained in the passive plume is a function of the air content in the overflow mixture, with the use of a green valve shown to significantly reduce the proportion of the overflow sediment that forms the passive plume (Spearman *et al.*, 2011).

The overflow source term was calculated for each discrete dredge zone based on a method outlined in Becker *et al.* (2015) and recommended in Kemps & Masini (2017). This method was applied as it allows the proportion of fines in the material being dredged in each zone to be considered in determination of the source terms. This is important for this project given the significant variations in the fines proportion between dredge zones. Additionally, this method allows for the use of a green valve in the overflow system to be accounted for in the source term estimates.

The Becker *et al.* (2015) method considers the following parameters:

- The total flux of fines entering the hopper during dredging.

- The proportion of the dredged fines flux that settles (and is trapped) in the hopper.
- The proportion of the dredged fines flux that exits the hopper in the overflow water.
- The relative proportions of the overflow fines flux that contribute to the dynamic and passive plumes.

In calculating these parameters, the method takes into account:

- The PSDs and dry bulk densities of the material to be dredged.
- The production/pumping rates of the TSHD.
- The rate at which material settles/traps in the hopper.
- The overflow-to-loading ratio based on the dredge cycle times.

Becker *et al.* (2015) state that a reasonable estimate of the proportion of overflow fines that becomes the passive plume will fall in the range of 0-20%. This broadly agrees with the range of 5-15% found in Spearman *et al.* (2011). Values of this order of magnitude are confirmed by field measurements taken during operation of a sand dredger (8,225 m^3 capacity) in Hong Kong, which suggested 15% of the overflow fines flux contributed to the passive plume (Whiteside *et al.*, 1995).

It should be noted that in the Hong Kong study a green valve was not employed to moderate the overflow. There is limited experimental data available on the degree to which a green valve will reduce the proportion of the overflow fines flux that becomes a passive plume. DHI (2010) state that an appropriate estimate for the proportion of fines remaining in the passive plume when a green valve is in use is around 7% of the total overflow fines flux, with this assessment informed by monitoring activities undertaken in the vicinity of marine construction vessels in Singapore.

The proposed use of a green valve during the Scarborough development is accounted for in this modelling study by assuming that 10% of the overflow fines flux will become a passive plume. This represents a moderate value in the context of the ranges stated above. Calculation of the overflow source rates using a proportional value of 10% are presented in Table 3.30 for each dredge zone, expressed as a proportion of the dredging production rate.

Table 3.30 Calculated source rates of sediments initially suspended into the water column during TSHD hopper overflow, using the methodology outlined in Becker *et al.* (2015).

Zone	Source Rate (% Production Rate)
PRE1	2.77
PRE2	2.77
PRE3	3.96
PRE4	2.73
PRE6	3.74
PRE8	3.21
PRE9B	4.44
PRE10A	2.17
PRE10B	1.08
Borrow Ground A	0.30

The overflow source rate values calculated using the Becker *et al.* (2015) method range from 0.30% to 3.96% of the gross production rate, which compares well with the range of published measurements from TSHD operations (0.1-5.0%; Hayes & Wu, 2001) and is within the range of values used in modelling studies (0.3-9.8%) outlined in a review of contemporary practice by Kemps & Masini (2017). The lower overflow source rate values (<1.5% of total production) were calculated for the dredge areas containing material that had lower fines content, such as borrow ground A and zone PRE10B (see Section 3.6). Overflow source rate values quoted in literature for areas with low fines content range from 0.3 to 2.1% of total production, giving confidence in the calculated values. For the trenching areas where the fines content is higher (zones PRE1 through PRE9; Section 3.6), the calculated overflow source rate values are in the mid-range of the literature values.

To further contextualise the overflow source rate values calculated using the Becker *et al.* (2015) method, the corresponding TSS concentrations in the hopper overflow have been calculated and compared to values found in literature. Passive plume concentrations calculated without accounting for a green valve are in the range 2,300-4,700 mg/L for the areas with lower fines content (borrow ground A and zone PRE10), and in the range 9,000-14,000 mg/L for the remaining trenching areas. When a green valve is considered, the calculated concentrations are reduced to 1,900-3,800 mg/L for the areas with lower fines content and 7,500-11,500 mg/L for the remaining areas.

Field measurements taken of the TSS concentrations within overflowing waters are typically in the 5,000-6,000 mg/L range, and are generally less than 10,000 mg/L adjacent to the hopper (Hitchcock & Bell, 2004). These values correlate well with data drawn from other Western Australian projects that cannot be cited here for reasons of confidentiality. From comparisons, it is clear that the calculated values above fall into a range that past experience suggests is realistic.

3.7.5 Representation of Disposal of TSHD-Dredged Material

All material dredged by the TSHD along the pipeline route will be transported to spoil ground 2B or 5A (as appropriate) for disposal (Figure 3.9). This material will include all unconsolidated sediments from zones PRE2, PRE3, PRE4, PRE6, PRE8, PRE9B, PRE10A and PRE10B.

For the disposal of the unconsolidated sediments dredged by TSHD, the PSDs used in the model are based on PSDs from nearby boreholes (see Section 3.6). These PSDs are adjusted by removal of the component treated as suspended during dredging along the pipeline route (see Section 3.7.4), but as this represents only between 0.6% and 5.0% (averaged value depending on the relative contributions of overflow and non-overflow periods to the overall mass flux) of the mass for the minor components, the modified PSDs are not significantly different to the *in situ* PSDs (Table 3.31).

Once at the appropriate spoil ground, the hopper will open to release the sediments from the bottom of the hull at a depth of approximately 12.75 m below sea level. Previous observations of sediment dumping from hopper vessels (e.g. CSMW, 2005) have shown that there is an initial rapid descent of solids, with the heavy particles tending to entrain lighter particles, followed by a billowing of lighter components back into the water column after contact with the seabed (Figure 3.10). A proportion of the lighter components will also remain suspended and may be trapped by density layers, if present.

Because simulations in this study focused on the far-field fate of sediment particles due to transport and sinking after the initial dump phase, simulations were run with the initial vertical distribution specified to represent the post-collision phase for a case where a high proportion of the sediments are resuspended after collision with the seabed. To represent this, an assumed vertical distribution for the sediments (Table 3.32) has been specified following published information from previous hopper disposal operations (CSMW, 2005; NEPA, 2001). This vertical distribution, with the majority of the material input near the seabed and only 15% of the material released at hull depth or above, is in line with values quoted in the recent literature review by Mills & Kemps (2016), which found that sediment resuspension from individual dredged material disposal events was generally less than 10% of the disposed material load.

It is estimated that 95-99% of the bulk load deposits directly onto the seabed in a typical case, with the remainder released into the water column (CSMW, 2005, NEPA, 2001). It is difficult to find other definitive source values in the literature, but a value of 5% of each load agrees well with past experience and appears to be a conservative estimate based on the values quoted above. Accordingly, 5% of each hopper load was placed in suspension in the water column in the sediment fate model.

In addition to the proportion of material immediately suspended in the water column, disposal from the hopper will result in the stockpiling of sediment as a mound on the seabed that will be subject to resuspension by tidal and wave forces. Because fine sediments in the deposited mass may be subject to ongoing resuspension and dispersion over time, it was necessary to specify the deposits as a further source of sediment potentially subject to resuspension.

The proportion of the newly deposited trenched material available for resuspension is characterised by a finite limit regulated by PSDs and the occurrence of natural sediment capping. As a result of the selective resuspension of the smaller-sized particles (silts and clays), the deposited mound surface layer gradually contains a greater proportion of larger particle sizes. These larger particles act as armouring against bottom shear stress, protecting and retaining the remaining fine particles in the mound. Therefore, in the model it was assumed that 5% of the deposited mass – representing the volume of the upper surface layer – would be subject to resuspension. It should be noted that the model maintains a mass balance estimate of the remaining sediment of each size class within each grid cell to derive an estimate of the median particle size in the surface-layer sediments. In turn, the potential for ongoing resuspension of fines is calculated. In this way, the model represents the increased armouring of sediments as the average particle size increases.

The disposal time for the hopper material within each dredge cycle was assumed to be 15 minutes (Table 3.5). The disposal location within the relevant spoil ground was varied for each dredge cycle in a randomised manner, with the ultimate aim of ensuring an even distribution of dredged material within each spoil ground by the conclusion of all activities (Table 3.6).

Table 3.31 Assumed PSDs of sediments initially suspended into the water column during TSHD hopper disposal operations at spoil grounds AB, 2B and 5A.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment Disposal							
		Zone PRE2	Zone PRE3	Zone PRE4	Zone PRE6	Zone PRE8	Zone PRE9B	Zone PRE10A	Zone PRE10B
Clay	<7	3.15	0.00	5.22	0.00	5.58	8.82	7.42	1.89
Fine Silt	7-34	7.60	7.10	6.71	9.30	5.37	8.22	4.69	1.57
Coarse Silt	35-74	17.28	26.57	11.10	24.33	15.23	19.41	10.13	7.35
Fine Sand	75-130	32.70	18.04	23.71	32.19	13.67	20.00	20.70	18.00
Coarse Sand	>130	39.27	48.29	53.25	34.18	60.15	43.54	57.07	71.18

Table 3.32 Assumed vertical distribution of sediments initially suspended into the water column during TSHD hopper disposal operations at spoil grounds AB, 2B and 5A.

Elevation	Example Elevation (m ASB) – 20 m Water Depth and 12.75 m Hull Depth	Vertical Distribution (%) of Sediments
Surface/water depth	20.0	5.0
Hopper hull elevation	7.5	10.0
0.75 x hull elevation	5.6	20.0
0.50 x hull elevation	3.8	30.0
0.25 x hull elevation	1.9	35.0

3.7.6 Representation of BHD Barge Tug/TSHD Propeller-Wash

Modelling of sediment suspended by propeller-induced motion at the seabed was conducted to estimate likely sediment concentrations generated by the TSHD and harbour tug propellers while manoeuvring during dredging operations. A specialised numerical model developed by RPS, named PROPMAP, was used to estimate a time- and space-varying rate of sediment flux from the seabed due to the thrust imposed by each vessel's propellers at the seabed level behind the moving vessel. The model uses characteristics of the vessel of interest to estimate the three-dimensional thrust-field generated by the propellers. This thrust-field is then combined with the grain size and degree of cohesion of the seabed sediments, and the varying under-keel clearance along the typical vessel paths, to calculate variations in the suspended sediment flux from the seabed in time and space.

The following details were used as input to PROPMAP to calculate variable rates of sediment flux from the seabed due to propeller-wash effects:

- Vessel tracks and speeds.
- Vessel draft, engine power and propeller size.
- Bathymetry along the vessel tracks.
- Grain size distributions of the sediment, defining the proportions of clay and silt along the vessel tracks.

The calculation steps applied by PROPMAP at discrete intervals along each vessel path were as follows:

- Based on the vessel's engine power and propeller size, determine the propeller-induced velocity profile.
- Based on the vessel's draft and the local bathymetry, determine the intersection of the thrust-field with the seabed and find the thrust imposed on it.
- Based on the velocity of water flow at the seabed, calculate the shear stress acting on it.
- Based on the calculated shear stress, and the sediment grain size and cohesiveness, calculate a theoretical erosion flux (mass per unit time) for seabed sediment.

Propeller-induced velocity profiles were calculated using empirical expressions from Blaauw & van de Kaa (1978). Thrust at the seabed will depend upon the level of the bed, which will intersect as a plane (Figure 3.10). For an under-keel clearance of 1 m, a velocity field exceeding 5 m/s would intersect the bed in this example, while at a clearance of 4 m the bed velocity would be reduced to <2 m/s. The influence of this thrust will vary with the sediment grain size. Consequently, outcomes will be sensitive to the magnitude of the thrust, the under-keel clearance and the PSD of the bed.

Sediment erosion flux was estimated from the derived velocity field using the empirical formulations of van Rijn (1989). The sediment flux component attributable to propeller-wash was found to be depth-limited for areas where the under-keel clearance was less than 3 m, assuming a fully-loaded vessel (maximum draft). Simulations over deeper areas, including the areas where vessels would transit to the spoil grounds, indicated that flux would be minimal (compared to other sources) and representative of short-lived suspension of the surface-layer sediments followed by rapid settlement. This settlement time was estimated to be shorter than the simulation output time step. Propeller-wash was found to be more significant in the shallow areas and would be greater over sediments previously suspended by dredging.

These findings were used to inform the definition of the sediment flux rates during TSHD dredging operations (see Section 3.7.4).

In summary, propeller-wash effects were considered: (i) along each pipeline section during dredging; and (ii) between each pipeline section and the spoil grounds during dredging. During backfilling, the typical depths at borrow ground A and the waters between it and the pipeline mean propeller-wash effects are less relevant and therefore were not considered.

In the absence of definitive information relating to the seabed composition of the areas traversed by the barge tug or TSHD between the pipeline and the spoil grounds, for simplicity the seabed composition was assumed to be described by the PSD of the area from which the vessel began its journey.

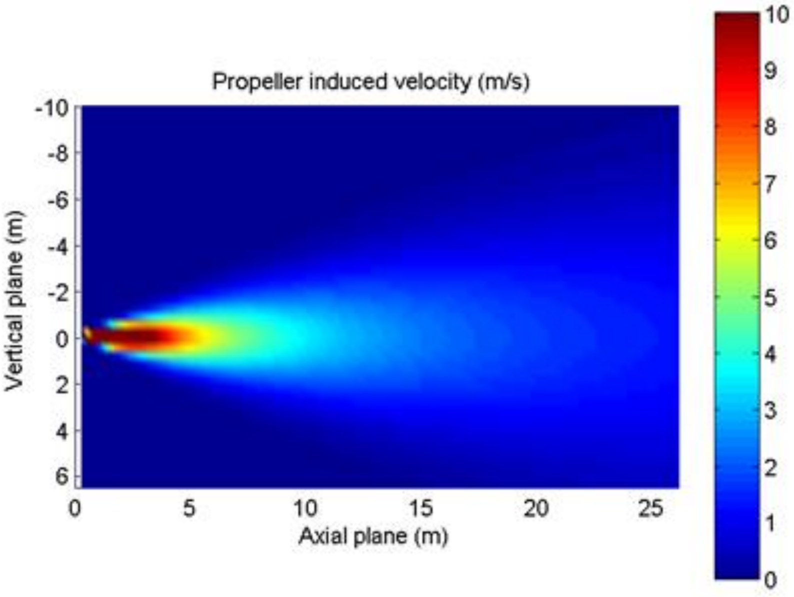

Figure 3.10 Two-dimensional view of a propeller-induced velocity profile.

3.7.7 Representation of TSHD Backfill

All material dredged by the TSHD within borrow ground A will be transported to sections POST2, POST4, POST6, POST8, POST9B, POST10A and POST10B of the pipeline route for placement (Figure 3.3).

For the backfill of the pipeline using unconsolidated sediments dredged by TSHD, the PSD used in the model is based on PSDs from nearby boreholes (see Section 3.6). This PSD is adjusted by removal of the component treated as suspended during dredging within the borrow ground (see Section 3.7.4), but as this represents only between 0.6% and 0.9% (averaged value depending on the relative contributions of overflow and non-overflow periods to the overall mass flux) of the mass for the minor components, the modified PSDs are not significantly different to the *in situ* PSDs (Table 3.33). It has been assumed, conservatively, that all sediment dredged from the borrow ground is available for use as backfill material.

Once at the appropriate location, the TSHD suction pipe will discharge material at a minimum elevation of 3 m above the pipeline (Figure 3.12). This gap will vary, and for modelling purposes the elevation above the pipeline has been assumed to be a constant 5 m. Sediment release from the suction pipe will occur as a jet of slurry that will have an initial rapid descent of solids followed by a billowing of lighter components back into the water column after contact with the seabed/pipeline (Swanson *et al.*, 2004). The plume that results from disposal of a jet of slurry from a pipe is typically concentrated near the seabed, with most of the material within 3 m of the bottom, and lower concentrations extend up towards the surface (Figure 3.11). Table 3.34 shows the assumed vertical distribution of the suspended material for the TSHD backfill source.

It is estimated that 95-99% of the bulk load deposits directly onto the seabed in a typical case, with the remainder released into the water column (CSMW, 2005, NEPA, 2001). It is difficult to find other definitive source values in the literature, and no site-specific sampling has been conducted for TSHD backfill placement operations, but a value of 5% of each load agrees well with past experience and appears to be a conservative estimate based on the values quoted above. Accordingly, 5% of each hopper load was placed in suspension in the water column in the sediment fate model.

The placement time for the hopper material within each dredge cycle was assumed to be 107 minutes (Table 3.7).

Table 3.33 Assumed PSD of sediments initially suspended into the water column during TSHD backfill operations using material dredged at borrow ground A.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Sediment Backfill – Borrow Ground A
Clay	<7	0.64
Fine Silt	7-34	0.88
Coarse Silt	35-74	0.96
Fine Sand	75-130	3.00
Coarse Sand	>130	94.90

Table 3.34 Assumed vertical distribution of sediments initially suspended into the water column during TSHD backfill operations using material dredged at borrow ground A.

Elevation	Example Elevation (m ASB) – 20 m Water Depth and 5 m Pipe Elevation	Vertical Distribution (%) of Sediments
Surface/water depth	20.0	5.0
Suction pipe elevation	5.0	10.0
0.75 x pipe elevation	3.8	15.0
0.50 x pipe elevation	2.5	20.0
0.25 x pipe elevation	1.3	50.0

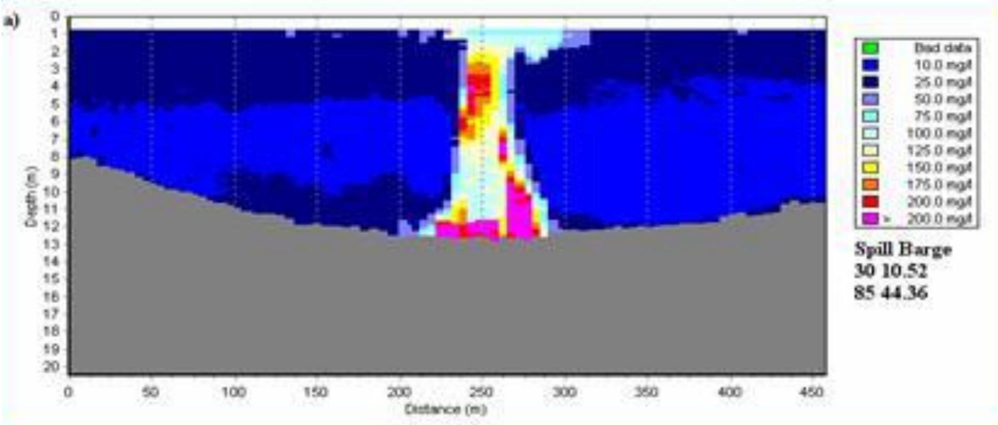

Figure 3.11 Example of a vertical cross-section through a typical open-water discharge plume from a spreader barge pipe (source: Swanson *et al.*, 2004).

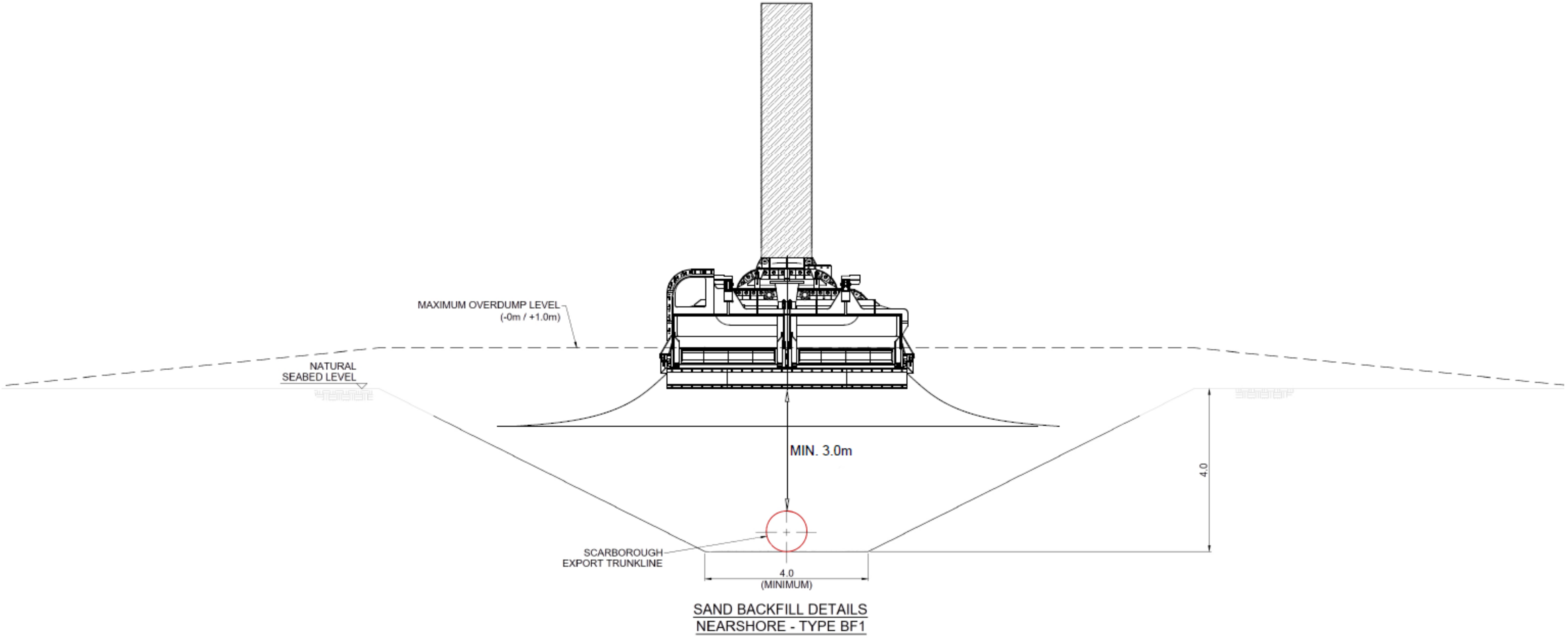

Figure 3.12: Schematic diagram showing how the TSHD draghead will be used to discharge sand backfill material along the pipeline (source: Boskalis, 2020).

3.7.8 Representation of Side-Dump Vessel Backfill

Rock material from an onshore quarry source will be transported by a side-dump vessel to sections POST1, POST3, POST5, POST7 and POST9A of the pipeline route for placement (Figure 3.3).

Based on previous project experience, quarry rock used for breakwater core construction or pipeline armouring typically contains around 5% material with diameters less than 100 mm. Therefore, a conservative loss rate of 5% of the total volume of dumped rock material was applied in the modelling. Based on material testing at the quarry from previous projects, the volume of quarried core/rock material less than 130 µm in size is typically even lower, in the order of 2%. Table 3.35 (equivalent to Table 3.18) presents the PSD that was applied in the modelling of the rock backfill source. The composition of the material is dominated by coarse sand and larger particles, with the 2% of finer material assumed to be evenly spread over the four smaller material classes. Although coarse sand material will be initially suspended in the water column, it will not be available for resuspension once it settles.

Because the rock backfill material will be dumped from the deck of the vessel, it will move through the whole water column as it falls to the seabed. Therefore, a uniform vertical distribution of suspended material in the water column has been assumed (Table 3.36).

The placement time for the rock material within each cycle was assumed to be 120 minutes. Other than an increased placement time, the operational cycle is assumed to be equivalent to that for TSHD backfill operations outlined in Table 3.7.

Table 3.35 Assumed PSDs of sediments initially suspended into the water column during side-dump vessel backfill operations using material from an onshore quarry.

Sediment Grain Size Class	Size Range (µm)	PSD (%) for Rock Backfill
Clay	<7	0.5
Fine Silt	7-34	0.5
Coarse Silt	35-74	0.5
Fine Sand	75-130	0.5
Coarse Sand	>130	98.0

Table 3.36 Assumed vertical distribution of sediments initially suspended into the water column during side-dump vessel backfill operations using material from an onshore quarry.

Elevation	Example Elevation (m ASB) – 10 m Water Depth	Vertical Distribution (%) of Sediments
Surface/water depth	10.0	20.0
0.8 x water depth	8.0	20.0
0.6 x water depth	6.0	20.0
0.4 x water depth	4.0	20.0
0.2 x water depth	2.0	20.0

3.7.9 Summary of Source Rates

For each source of suspended sediment plumes during dredging, disposal and backfill operations, as described in the preceding sections, Table 3.37 and Table 3.38 summarises the associated loss rates and approximate volumes of suspended sediment expected. The volumes assigned to the respective non-overflow and overflow periods for TSHD dredging, and non-dewatering period for BHD dredging, are based on the modelled cycle times detailed in Table 3.4, Table 3.5 and Table 3.7.

A total of approximately 259,085 m^3 of sediment is expected to be initially suspended in the water column over the course of the modelled program. This volume represents approximately 6.6% of the in situ dredged (and quarry) volume. If all deposited material assumed to be available for potential resuspension following spoil ground disposal operations is actually resuspended, a total of 349,951 m^3 of sediment will be suspended in the water column over the program duration; this will represent approximately 8.9% of the in situ dredged (and quarry) volume.

Table 3.37 Summary of sediment sources applied in the model.

Phase	Operation	Source Rate (% Production Rate)	Dredged Volume (m^3)	Suspended Volume (m^3)
Pipeline dredging	BHD excavator bucket	2.10	60,860	1,278
	BHD excavator bucket + dewatering from barge	N/A		
	Disposal from hopper barge	5 (water column) 5 (seabed; *potential*)		2,979 *2,979*
	TSHD drag-head + propeller-wash	0.60	1,805,999	48,256
	TSHD drag-head + propeller-wash + overflow	Specified per zone (see Table 3.38)		
	Disposal from TSHD	5 (water column) 5 (seabed; *potential*)		87,887 *87,887*
Pipeline backfilling	TSHD drag-head + propeller-wash	0.60	1,979,341	16,896
	TSHD drag-head + propeller-wash + overflow	Specified for borrow ground A (see Table 3.38)		
	Placement from TSHD	5.00		98,122
	Placement from side-dump vessel	5.00	73,326	3,666
		Totals	**3,919,526**	**259,085** ***349,951***

Table 3.38 Sediment source rates applied in the model for the TSHD while overflowing.

Zone	Source Rate (% Production Rate)
PRE1	3.37
PRE2	3.37
PRE3	4.56
PRE4	3.33
PRE6	4.34
PRE8	3.81
PRE9B	5.04
PRE10A	2.77
PRE10B	1.68
Borrow Ground A	0.90

4 ENVIRONMENTAL THRESHOLD ANALYSIS

4.1 Overview

Predictions of SSC for each scenario were assessed against a series of water quality thresholds to categorise the modelled outcomes into management zones of influence and impact, defined with regard to environmental sensitivities in the study region. These thresholds, and the technical justification which followed guidance from the WAMSI Dredging Science Node, were supplied to RPS by Advisian (MScience, 2019). Thresholds were selected for benthic habitats on the basis of past and present mapping of communities in the project area.

Thresholds for three management zones – a Zone of Influence (ZoI), a Zone of Moderate Impact (ZoMI) and a Zone of High Impact (ZoHI) – were defined. The criteria associated with each management zone also varied across three ecological zones, which were broadly defined based on past studies of these areas (MScience, 2019). The ecological zones are named as follows, with reference to the pipeline chainages shown in Figure 1.1, and with the spatial extents agreed for this study shown in Figure 4.1:

- Offshore: the pipeline area beyond KP25, and generally all areas north of a boundary line containing Rosemary Island, Legendre Island and Delambre Island.
- Zone B: the pipeline area between KP8 and KP25, adjacent coral and macroalgae habitats within Mermaid Sound, and generally all coral, macroalgae and mixed community habitats between Dolphin Island and Bezout Island.
- Zone A: the pipeline area between the shoreline and KP8, adjacent macroalgae and mangrove habitats within Mermaid Sound, and generally all mangrove, marsh and seagrass habitats between Nickol Bay and Point Samson.

Thresholds for coral habitats within Zone B were developed with the aid of data collected during a previous dredging campaign at Barrow Island, which is considered a similar habitat. Water quality within Zone A is more turbid, and coral communities are comprised of more sediment-tolerant or resilient species. Offshore habitats are not likely to contain corals.

In developing the thresholds, it was assumed that benthic communities around Spoil Ground 2B and Borrow Ground A (see Figure 1.1) will be sparse and made up largely of sponges and filter feeders without corals.

4.2 Baseline Water Quality

Water quality data collected during the LNG Foundation Project over the period of 2007 to 2010 (MScience, 2010) demonstrated that turbidity at sites within the Zone A and Zone B management areas was raised by 0.7 NTU and 0.3 NTU, respectively, as a result of dredging activities. Subtraction of these dredge-induced values across the 2007-2010 data set yielded a set of baseline turbidity measurements.

Table 4.1 presents the mean and 80th-percentile SSC values calculated from the background turbidity measurements in each zone. For the purposes of threshold assessment, it has been assumed that the summer season comprises the period of November to March and the winter season contains the months of April to October.

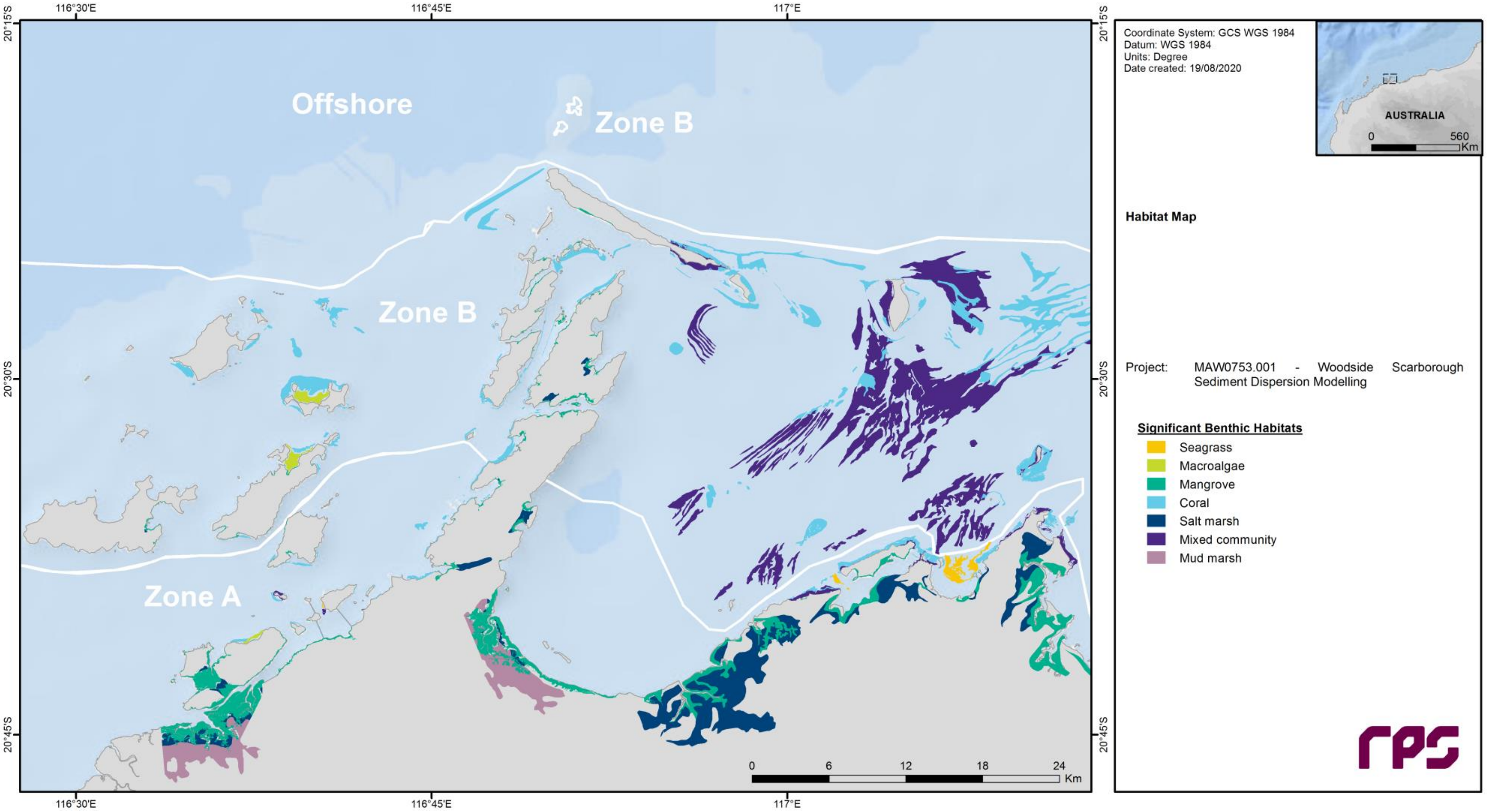

Figure 4.1 **Delineation of the proposed ecological zones (Zone A, Zone B and Offshore) in the context of known habitat areas and types. Thresholds used to define the management zones will vary in magnitude between the ecological zones.**

Table 4.1 Baseline mean and 80th percentile SSC values calculated from measurements undertaken during the LNG Foundation Project (2007-2010), categorised into summer and winter seasons for each of the three ecological zones.

Ecological Zone	Season	Mean SSC (mg/L)	80th Percentile SSC (mg/L)
A	Summer	4.1	5.0
	Winter	1.8	2.3
B	Summer	2.5	2.7
	Winter	1.2	1.6
Offshore	Summer	1.8	1.8
	Winter	0.6	0.9

4.3 Zone of Influence (ZoI)

The ZoI is defined as "*a zone where impacts to water quality will be detectable but below a level causing detectable impacts to biota*" (MScience, 2019). This is generally considered equivalent to the area around dredging activities where a plume may be visible to the naked eye.

The ZoI threshold will be exceeded at any point within the model domain where dredging is forecast to increase the depth-averaged concentration of SSC (specifically the contribution attributable to dredging activities) by a level greater than the seasonal 80th percentile baseline SSC over a 24-hour average period.

Table 4.2 presents the threshold SSC values used to define the extents of the ZoI. A background SSC value appropriate for each ecological zone and month of the year was added to the dredge-induced SSC predictions from the sediment fate model prior to evaluation of the thresholds.

Potential exceedances of the threshold were evaluated over the duration of each dredge scenario by:

- Creating a three-dimensional time series of dredge-excess SSC values in each model grid cell (with each scenario spanning a period of more than ten months, the data sets comprised more than 7,500 time steps).
- Adding appropriate background SSC values to each cell.
- Calculating a rolling 24-hour average of the total (dredge plus background) SSC values in each cell, with this time-window progressing through the data set at hourly increments (the temporal resolution of the data set).
- Calculating the 95th percentile value of each cell.
- Assessing the 95th percentile data against the threshold SSC values.

Typically, averaging discrete data points over an arbitrary time period will serve to reduce the influence of transient spikes in concentration, thereby reducing the possibility of spurious exceedances. More rarely, a transient concentration spike of sufficient magnitude to skew the rolling average to an above-threshold state may result in exceedances being recorded for a longer period than will be the case in reality. Generally, applying a time-average to a data set for the purposes of threshold analysis will result in a smaller zone of effect than if instantaneous data is evaluated. This methodology also has a strong connection to critical exposure times for benthic habitats or species of concern in the project area.

Table 4.2 Background, dredge-excess and threshold SSC values used as the criteria to define the ZoI outer boundary within each ecological zone.

Ecological Zone	Season	Time-Averaged Period (hours)	Background SSC (mg/L) [a]	Dredge-Excess SSC (mg/L) [b]	Threshold SSC (mg/L) [c]
A	Summer	24	4.1	5.0	9.1
	Winter	24	1.8	2.3	4.1
B	Summer	24	2.5	2.7	5.2
	Winter	24	1.2	1.6	2.8
Offshore	Summer	24	1.8	1.8	3.6
	Winter	24	0.6	0.9	1.5

[a] Background values are equivalent to 'Mean SSC' values in Table 4.1.

[b] Dredge-excess values are equivalent to '80th Percentile SSC' values in Table 4.1.

[c] Threshold values are the sum of background and dredge-excess values.

4.4 Zone of Moderate Impact (ZoMI)

The ZoMI is defined as "*a zone where impacts are sub-lethal or lethal but recoverable (in terms of the community) within a five-year period*" (MScience, 2019).

The ZoMI threshold will be exceeded at any point within the model domain where dredging is forecast to increase the depth-averaged concentration of SSC to a level sufficient to trigger impacts to EC_{10} (10% Effect Concentration or 10% Inhibition) or to cause bleaching through loss of light or sedimentation.

Thresholds chosen to indicate a transition between the ZoI and ZoMI areas are largely based on the 'possible mortality' thresholds of Fisher *et al.* (2019). These thresholds are based on analysis of water quality and coral monitoring data collected during a previous dredging project at Barrow Island, where coral communities exist in clear, near-oceanic conditions. Distinctions must be made between the thresholds most appropriate for each ecological zone.

Within the offshore zone, only thresholds of relevance to sponges and filter feeders are appropriate because corals, seagrasses and macroalgae are not known to form significant communities. A threshold relating to an LC_{10} (10% Lethal Concentration) effect on filter feeder-sponge habitats over a 28-day exposure period was selected (Pineda *et al.*, 2017).

For Zone B, coral communities experience similar conditions to those monitored at Barrow Island and the moderate-impact thresholds of Fisher *et al.* (2019) for coral/mixed benthos communities were deemed to be appropriate (MScience, 2019).

For Zone A, coral communities experience more turbid conditions and are more tolerant of elevated SSC levels and lowered light levels than their neighbours in Zone B due to adaptation and a different mix of species. To account for this greater tolerance, the moderate-impact thresholds in Zone A were defined as those of Zone B multiplied by a factor of 1.5, which is believed to be a conservative multiplier (MScience, 2019). Within both Zones A and B, spongers and filter feeders will occur among the corals, and the mixed community is best evaluated using coral-focused thresholds.

The taxa-specific thresholds and appropriate time-averaging periods (related to exposure times from experimental data) used to define the extents of the ZoMI are detailed in Table 4.3. A background SSC value appropriate for each ecological zone and month of the year was added to the dredge-induced SSC predictions from the sediment fate model prior to evaluation of the thresholds.

Potential exceedances of the thresholds were evaluated over the duration of each dredge scenario by calculating rolling 3-day, 7-day, 10-day, 14-day and 28-day averages (as appropriate in each ecological zone) of SSC values in each model grid cell and checking for breaches as this time-window progressed through the data set at hourly increments (the temporal resolution of the data set). If any time-average SSC value exceeds the corresponding threshold value at any time, even if only on one occasion, the model grid cell is included in the appropriate ZoMI area.

Table 4.3 Threshold SSC values used as the criteria to define the ZoMI outer boundary within each ecological zone.

Ecological Zone	Time-Averaged Period (days)	Threshold SSC (mg/L)
A	3	29.1
	7	22.5
	10	19.6
	14	17.6
B	3	19.4
	7	14.7
	10	13.1
	14	11.7
Offshore	28	22.5

4.5 Zone of High Impact (ZoHI)

Thresholds chosen to indicate a transition between the ZoMI and ZoHI areas are largely based on the 'probable mortality' thresholds of Fisher *et al.* (2019).

Within the offshore zone, a threshold relating to an LC_{50} (50% Lethal Concentration) effect on filter feeder-sponge habitats over a 28-day exposure period was selected (Pineda *et al.*, 2017).

For Zone B, the high-impact thresholds of Fisher *et al.* (2019) for coral/mixed benthos communities were deemed to be appropriate (MScience, 2019).

For Zone A, the high-impact thresholds were defined as those of Zone B multiplied by a factor of 1.5, which is believed to be a conservative multiplier (MScience, 2019).

The taxa-specific thresholds and appropriate time-averaging periods (related to exposure times from experimental data) used to define the extents of the ZoHI are detailed in Table 4.4. A background SSC value appropriate for each ecological zone and month of the year was added to the dredge-induced SSC predictions from the sediment fate model prior to evaluation of the thresholds.

Potential exceedances of the thresholds were evaluated over the duration of each dredge scenario by calculating rolling 3-day, 7-day, 10-day, 14-day and 28-day averages (as appropriate in each ecological zone) of SSC values in each model grid cell and checking for breaches as this time-window progressed through the data set at hourly increments (the temporal resolution of the data set). If any time-average SSC value exceeds the corresponding threshold value at any time, even if only on one occasion, the model grid cell is included in the appropriate ZoHI area.

Table 4.4 Threshold SSC values used as the criteria to define the ZoHI outer boundary within each ecological zone.

Ecological Zone	Time-Averaged Period (days)	Threshold SSC (mg/L)
A	3	53.6
	7	36.8
	10	31.4
	14	27.0
B	3	35.7
	7	24.5
	10	20.9
	14	18.0
Offshore	28	47.0

5 RESULTS OF SEDIMENT FATE MODELLING

5.1 Spatial Distributions of SSC

5.1.1 Summary

Simulations indicated that there may be significant spatial patchiness in the distribution of SSC at any point in time during the dredging, disposal and backfill operations because of variability in the number of sediment suspension sources, variability in the flux from each of these sources, and the varying dynamics of the transport, settlement and resuspension processes affecting the sediments.

The most pronounced differences in the predicted concentrations at any point in time are found in the vertical distributions, with a distinct increase in concentration towards the seabed. Most material will initially be suspended low in the water column, and material suspended higher in the water column will sink as it moves away from the source. Frequent resuspension of material will also mostly affect the lower reaches. Thus, the spatial area affected above a given concentration is typically greater in the near-seabed layer than in the near-surface layer. It should be noted, however, that there are instances throughout the simulations where elevated concentrations will occur in the near-surface layers – during TSHD overflow operations or during strong resuspension events affecting sediments that have migrated to shallow areas – but these will typically not be sustained for extended periods of time.

Although many of the activities related to dredging and backfilling of the pipeline will take place within Mermaid Sound, which is dominated by tidal currents year-round and is relatively sheltered from the variations in large-scale circulation observed beyond approximately KP30, reasonably distinct seasonal trends are evident in the modelling outcomes of each scenario.

The results observed on any given day will not always be representative of the given season’s prevailing transport patterns, and plume concentrations and distributions are forecast to vary markedly. To explore this variability, statistical distributions for each scenario are examined. Percentile distributions will summarise the outcomes over the entire scenario and do not represent an instantaneous plume footprint at any point in time.

Forecasts of median depth-averaged SSC values (values exceeded 50% of the time) do not exceed 0.1 mg/L in either scenario. At the 95th percentile, forecasts of depth-averaged SSC values 5 mg/L or greater are found in nearshore areas between Intercourse Island and King Bay for project works commencing in summer (Scenario 2; Figure 5.4), and also near Angel Island and Conzinc Island for project works commencing in winter (Scenario 1; Figure 5.2).

When examined over the course of an entire scenario, the sediment distributions reveal areas that broadly straddle the dredging and disposal zones where recurrent elevations of near-seabed SSC are expected as a consequence of dredging operations. The forecast in each scenario is that the greatest concentrations will typically be found in the inshore waters of Mermaid Sound along the pipeline between the KP5 and KP25 points. This zone contains a significant volume of the overall in situ volume to be dredged, and there are many shallow locales where strong tidal flows both inhibit settlement of fine suspended sediments and stimulate significant levels of resuspension of sediments deposited after initial release in the water column. Dredging of backfill material from the offshore borrow ground causes an additional plume signature north of Legendre Island, with recurrent elevations of near-seabed SSC and subsequent resuspension of this material as it is transported towards Nickol Bay by tidal movements.

Concentrations of suspended sediment in the key activity areas will represent the combined influence of new discharges and resuspension of fine sediments from earlier discharges. Temporal variations in intensity of the dredging operations, including overlap of multiple operations in time or downtime periods, will also influence turbidity peaks and troughs. At progressively more distant areas, the importance of resuspension as a contributor to the distribution of SSC values in general, and near-seabed concentrations in particular, becomes a greater factor. The areas forecast to receive elevated concentrations are substantially larger than would be affected by plumes only from the initial sources. The plume extents tend to expand over periods of several weeks in the direction of net drift, indicating the progressive transport of fine sediments through continuous patterns of settlement and resuspension.

With the duration of each scenario (more than ten months) spanning almost the entire range of seasonal conditions, the direction of net drift will shift from summertime trends (generally longshore in a north-easterly direction) to wintertime trends (generally longshore in a south-westerly direction), or vice versa, depending on commencement times (winter for Scenario 1 and summer for Scenario 2). A progressive shift in the available source of resuspendable fine sediments is also indicated. Periodic high wave-energy events will be a major contributor to estimates of high SSC in the near-seabed layer, particularly in shallow exposed areas. While these processes are forecast to extend the influence of dredging activities over a wider area, the longshore dispersal of finer sediments is indicated to be an important mechanism for limiting the trapping and build-up of fine sediments in the local region around the key activity areas. The build-up of resuspendable fine sediments in areas remote from dredging activities indicates that the supply of fines to these areas will be greater than their removal due to ongoing resuspension and longshore transport, for as long as sediment input from dredging activities continues.

5.1.2 Pipeline Dredging Activities

For pipeline dredging activities during winter conditions (Scenario 1), sediment plumes at low concentrations are forecast to drift generally towards the south-west. The plumes tend to follow the bathymetric contours between East Intercourse Island and East Lewis Island, and also between West Lewis Island and Rosemary Island.

In contrast, the net drift direction forecast for sediment plumes from pipeline dredging activities during summer conditions (Scenario 2) is towards the north-east, with the plumes following the bathymetric contours as they turn around Legendre Island towards Delambre Island. This drift is imposed by the prevailing south-westerly winds over the summer season. In general, the majority of the dispersing suspended material is forecast to migrate offshore rather than through Flying Foam Passage and Searipple Passage, which is attributable to the local bathymetric features. Much of the dredging occurs in water depths greater than that found within each passage, but strong tidal currents will drive significant sediment concentrations in and out of the passages on a regular basis.

Sections A.1 (Figures A.1 to A.5) and A.2 (Figures A.12 to A.16) in Appendix A contain, for Scenarios 1 and 2 respectively, sequential images of instantaneous SSC values at monthly intervals from pipeline dredging commencement until residual suspended sediments have settled throughout the model domain (prior to commencement of pipeline backfill activities). In both scenarios, the patterns of initial sediment plume generation and longer-term plume migration from inshore-to-offshore dredging and disposal operations are evident. These figures capture transient plumes in areas that may not be represented in the percentile figures in Section 5.1.4, such as the elevated levels of SSC in the vicinity of spoil ground 2B (Figures A.2 and A.13) and to the north of West Lewis Island (Figure A.14).

5.1.3 Pipeline Backfill Activities

The bulk of the sediment suspended by dredging is forecast to remain in Commonwealth waters and be dispersed in the offshore area between the borrow ground and Legendre Island in both scenarios. It should be noted that sediment plumes in this area are more dilute than those expected in Mermaid Sound due to the effects of depth-averaging over greater water depths in offshore areas.

The migration patterns of sediment plumes entering State waters are controlled by seasonal conditions. Strong tidal flows between Hauy Island and Delambre Island will aid movement of sediment towards the shallow waters of Nickol Bay, with this effect being greater during summer (Scenario 1, following pipeline dredging activities in winter) due to predominant net drift towards the east imposed by prevailing south-westerly winds. In contrast, the net drift direction forecast during winter conditions (Scenario 2) is towards the south-west, mostly following the bathymetric contours to the north of Rosemary Island. The sediment plume from operations in this area is forecast to migrate to the offshore pipeline and spoil ground areas, most noticeably in Scenario 2 when borrow ground dredging occurs in winter (following pipeline dredging activities in summer) but at lower concentrations than will have already occurred during pipeline dredging activities.

Sections A.1 (Figures A.6 to A.11) and A.2 (Figures A.17 to A.22) in Appendix A contain, for Scenarios 1 and 2 respectively, sequential images of instantaneous SSC values at monthly intervals from pipeline backfill commencement until residual suspended sediments have settled throughout the model domain. In both scenarios, the generation and migration patterns of sediment plumes from borrow-ground dredging operations are evident, with near-negligible plume contributions from placement of backfill material along the pipeline route.

5.1.4 Spatial Outcomes

5.1.4.1 Scenario 1: Dredging Operations Commencing during Winter, with Backfill Material Sourced from Borrow Ground A

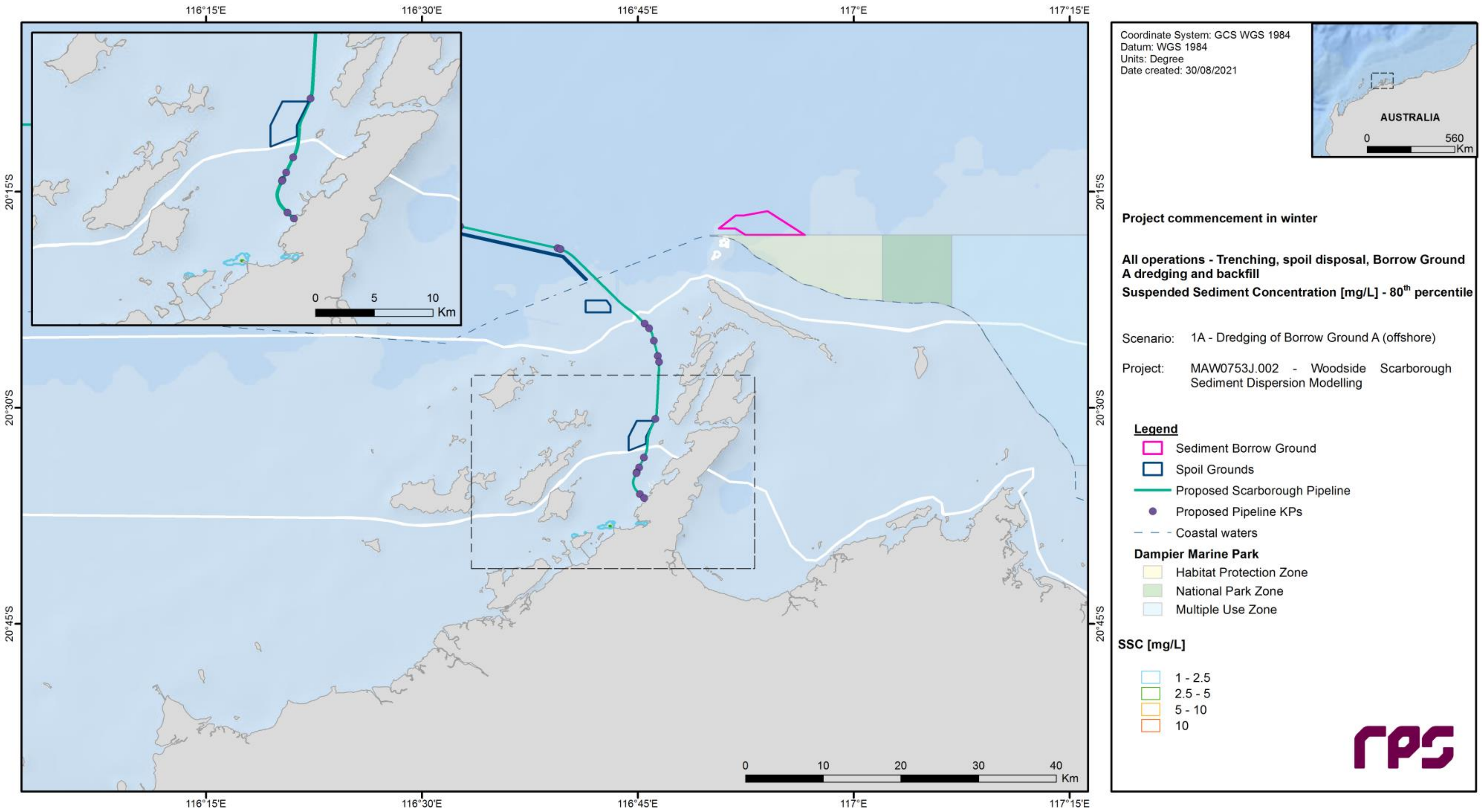

Figure 5.1 Predicted 80th percentile dredge-excess SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

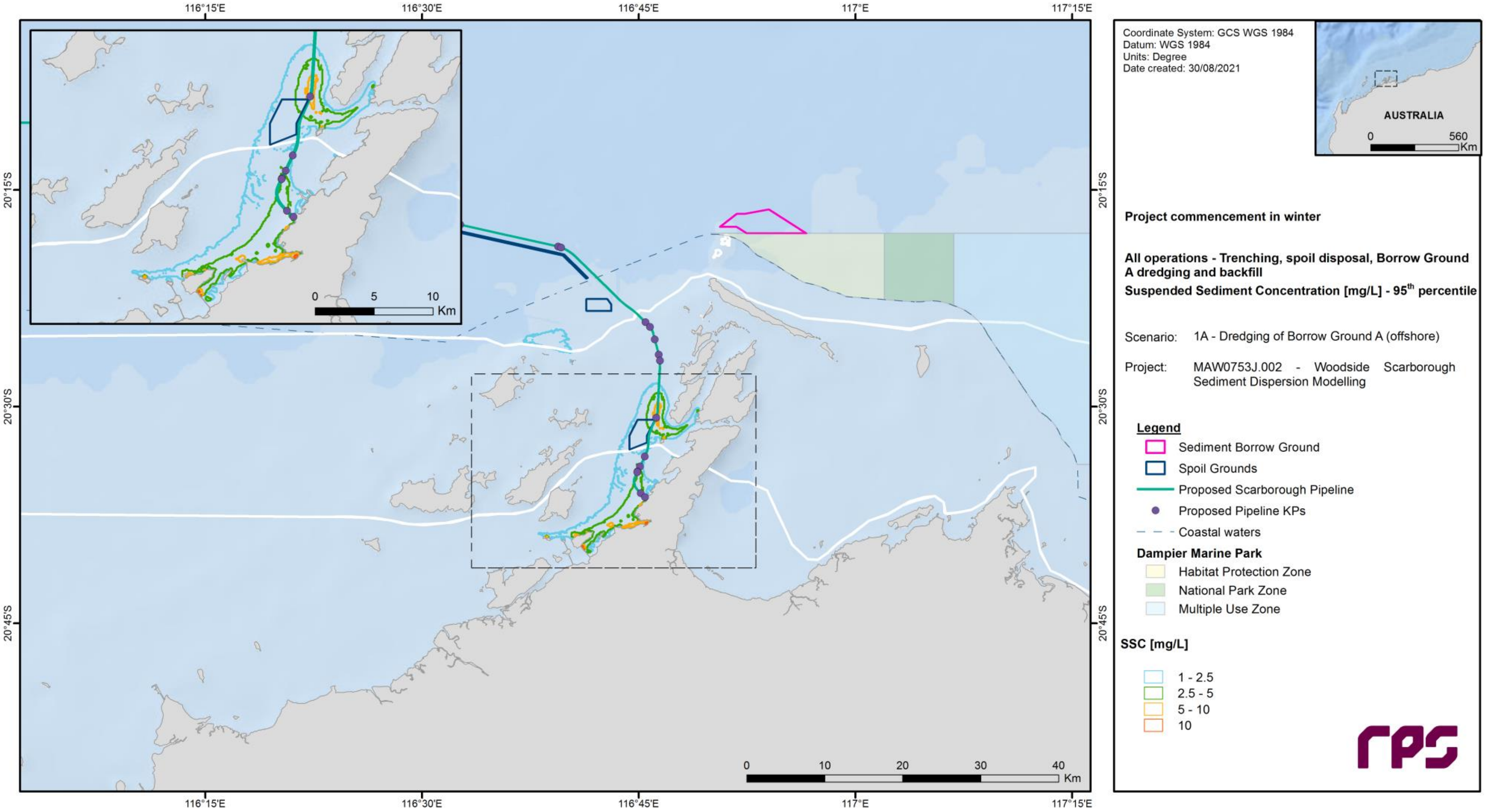

Figure 5.2 Predicted 95th percentile dredge-excess SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

5.1.4.2 Scenario 2: Dredging Operations Commencing during Summer, with Backfill Material Sourced from Borrow Ground A

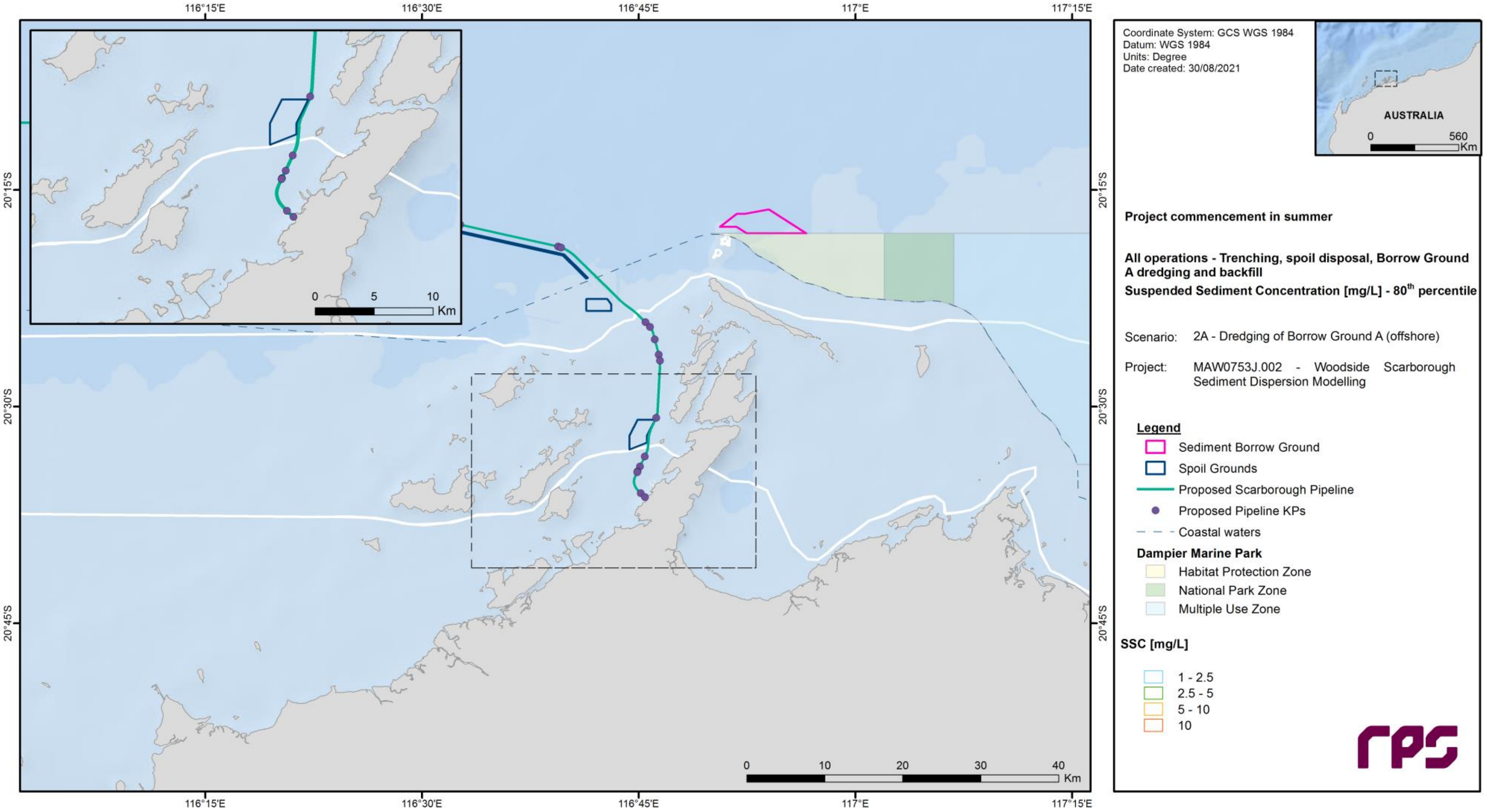

Figure 5.3 Predicted 80th percentile dredge-excess SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

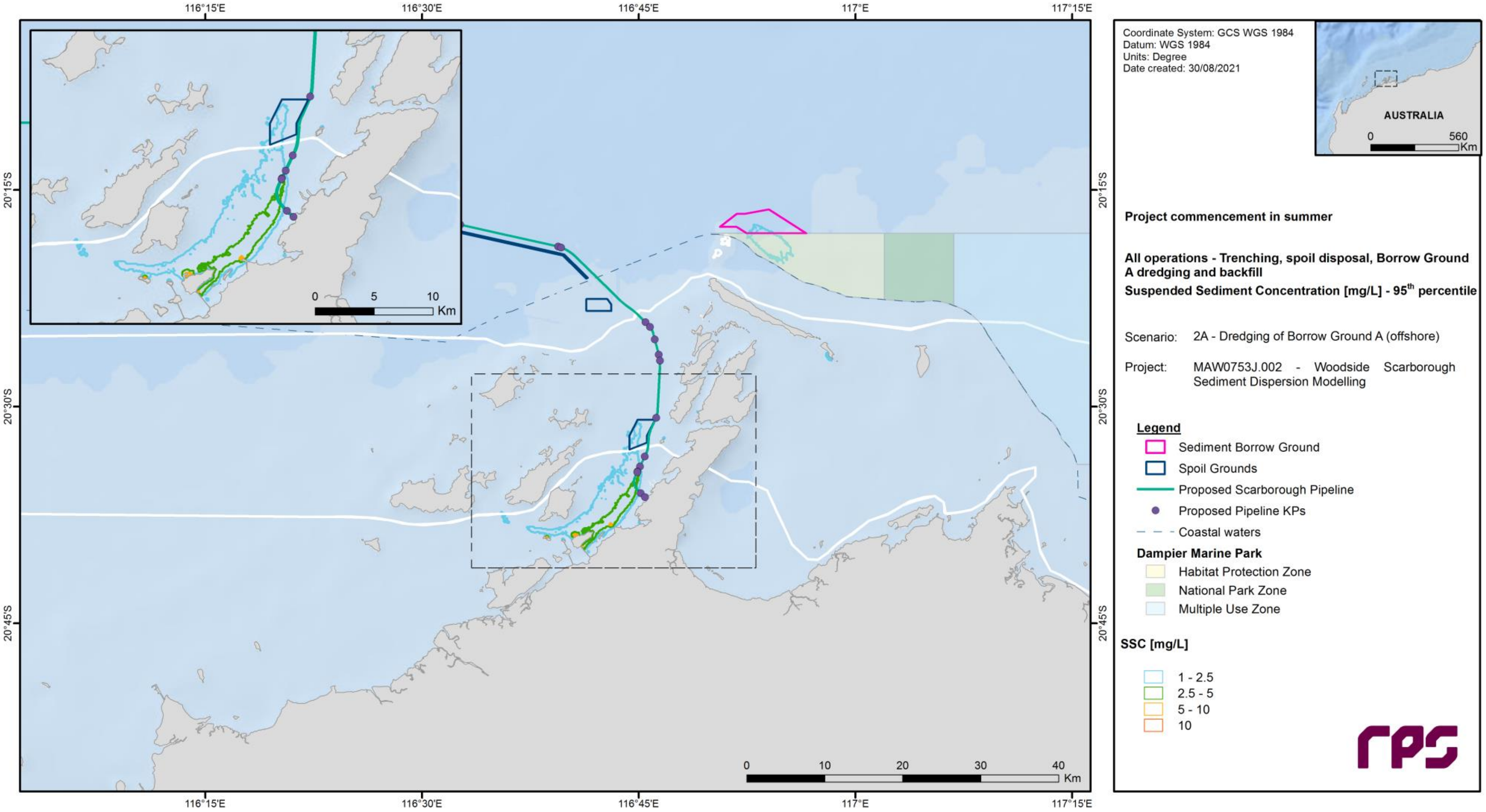

Figure 5.4 **Predicted 95th percentile dredge-excess SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).**

5.2 Predictions of Management Zone Extents

5.2.1 Summary

Figures showing the calculated extents of the defined management zones – ZoI, ZoMI and ZoHI – over the entire program of dredging, disposal and backfill operations are listed in Table 5.1 for each scenario.

Presentation of the ZoI areas is done on the basis of 95th percentile threshold exceedances for the 24-hour rolling average data.

It should be noted that the indicated management zone extents in each case represent a cumulative measure of exceedances of the relevant thresholds over a more than ten-month period, following the threshold criteria described in Section 4. They do not represent an instantaneous plume footprint at any point in time.

The indicated areas of threshold exceedances are largely a reflection of the areas of sediment confluence due to the proximity to key activity areas, where there is a sustained input of suspended sediments over periods of several months, and the influence of local metocean conditions acting to inhibit rates of settling and increase rates of resuspension.

The north-south ZoI extents in ecological Zones A and B are broadly similar in both scenarios, stretching from Angel Island to East Intercourse Island, with a larger overall footprint area in Scenario 1 (where pipeline dredging operations will occur during winter) relative to Scenario 2 (where these operations will occur during summer). In the Offshore ecological zone, a significantly larger ZoI is forecast along the pipeline in the vicinity of spoil grounds 2B and 5A for Scenario 1 than for Scenario 2. Both of these findings are largely a consequence of the lower thresholds applicable during the winter period, and consequently the lower levels of dredge-excess SSC required to cause exceedances. In a similar manner, the larger ZoI predicted at the offshore borrow ground for Scenario 2 (where, following project commencement in summer, pipeline backfill operations will occur during winter) than for Scenario 1 (where these operations will occur during summer) is attributable to the lower winter thresholds.

The ZoMI threshold exceedances in isolated pockets of King Bay and around the Intercourse Islands may be attributable to the combined effects of model bathymetry and hydrodynamics, representing sediments that are transported into the shallowest-possible grid cells and then “trapped” upon reversal of the tide. While it is clear that there is a potential for dredged sediments to be found in the indicated areas, the persistently high concentrations at the water-land boundaries may be overstated – particularly in light of the long durations required to trigger the ZoMI thresholds.

No ZoHI threshold exceedances are predicted to occur in either scenario.

Table 5.1 Index of the ZoI, ZoMI and ZoHI figures for each scenario.

Management Zone	Scenario 1	Scenario 2
Zone of Influence (95th percentile): 24-hour rolling average of total SSC	Figure 5.5	Figure 5.14
Zone of Moderate Impact: 3-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.6	Figure 5.15
Zone of Moderate Impact: 7-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.7	Figure 5.16
Zone of Moderate Impact: 10-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.8	Figure 5.17
Zone of Moderate Impact: 14-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.9	Figure 5.18
Zone of High Impact: 3-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.10	Figure 5.19
Zone of High Impact: 7-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.11	Figure 5.20
Zone of High Impact: 10-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.12	Figure 5.21
Zone of High Impact: 14-day (Zones A and B) and 28-day (Offshore) rolling average of total SSC	Figure 5.13	Figure 5.22

5.2.2 Spatial Outcomes

5.2.2.1 Scenario 1: Dredging Operations Commencing during Winter, with Backfill Material Sourced from Borrow Ground A

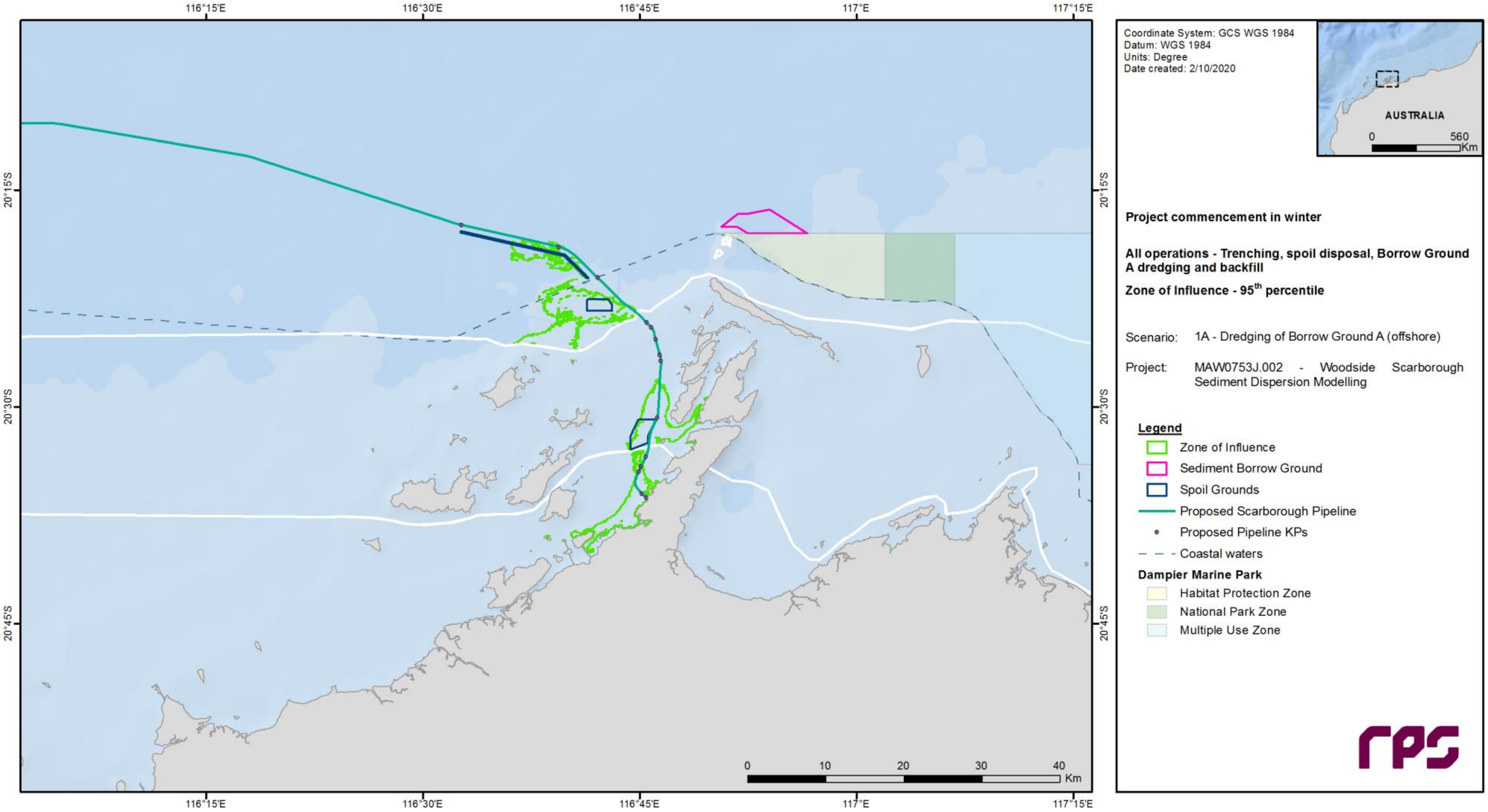

Figure 5.5 Predicted 95th percentile Zone of Influence following application of the appropriate spatial thresholds in Table 4.2 to a 24-hour rolling average of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

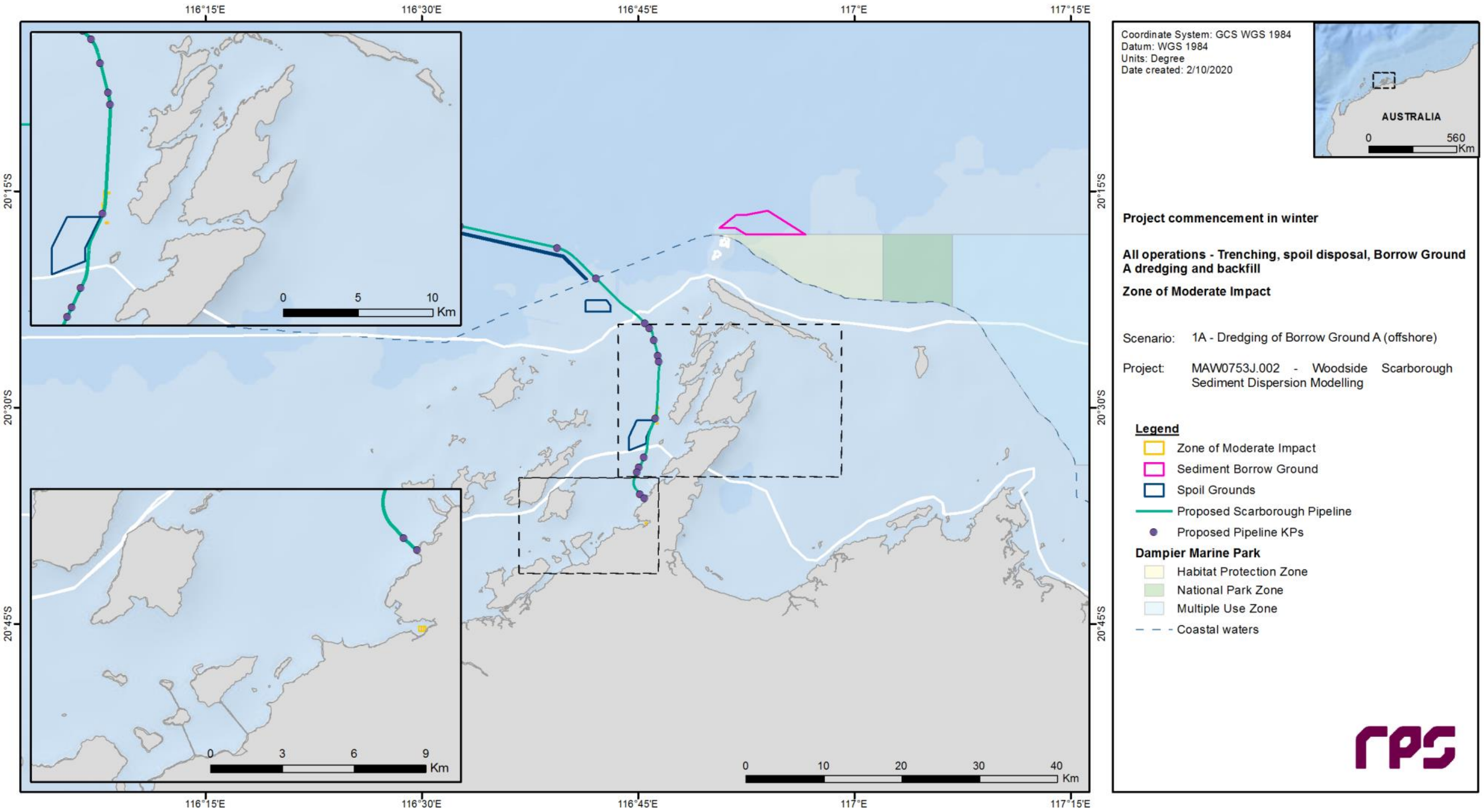

Figure 5.6 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

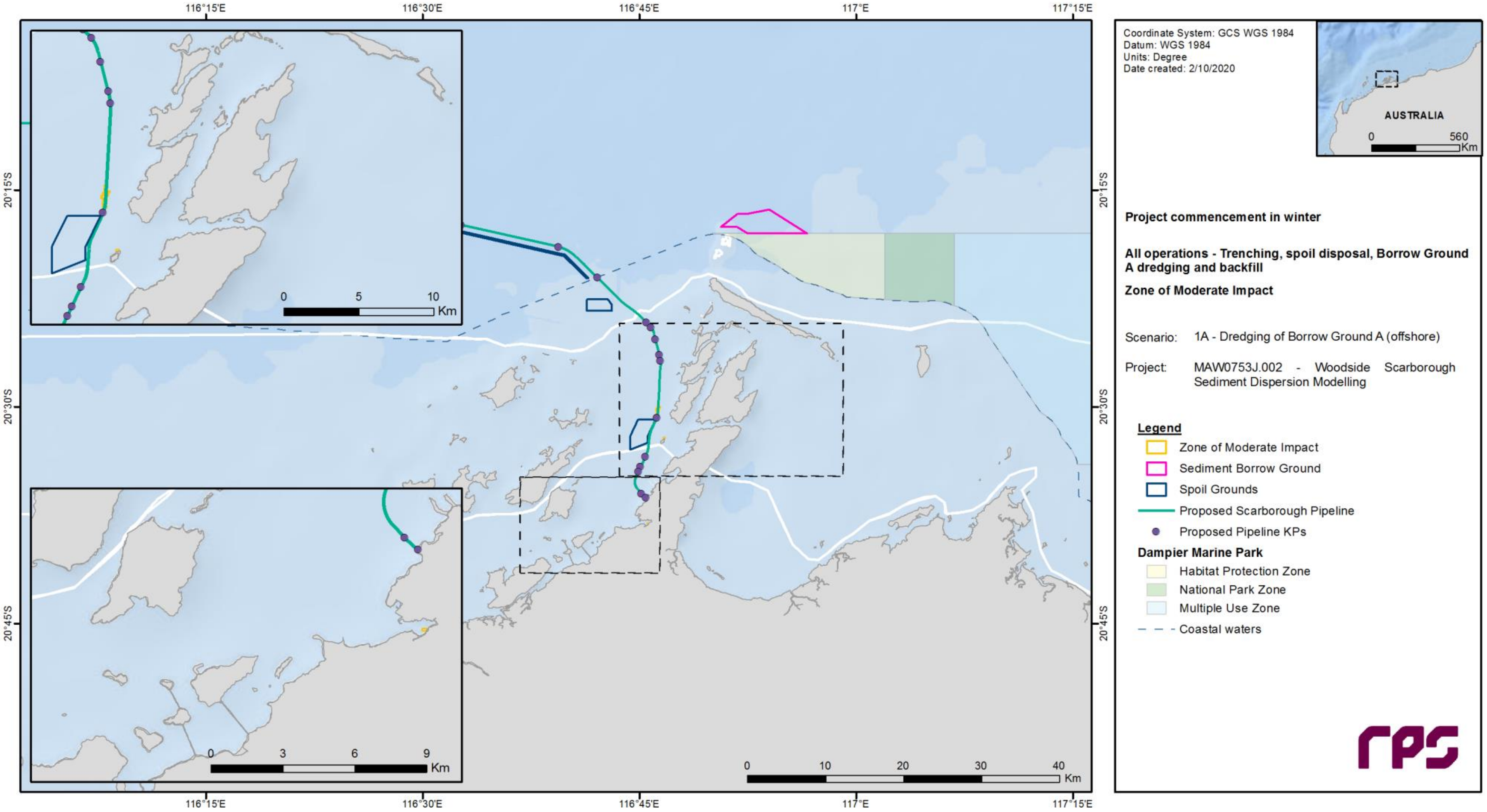

Figure 5.7 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

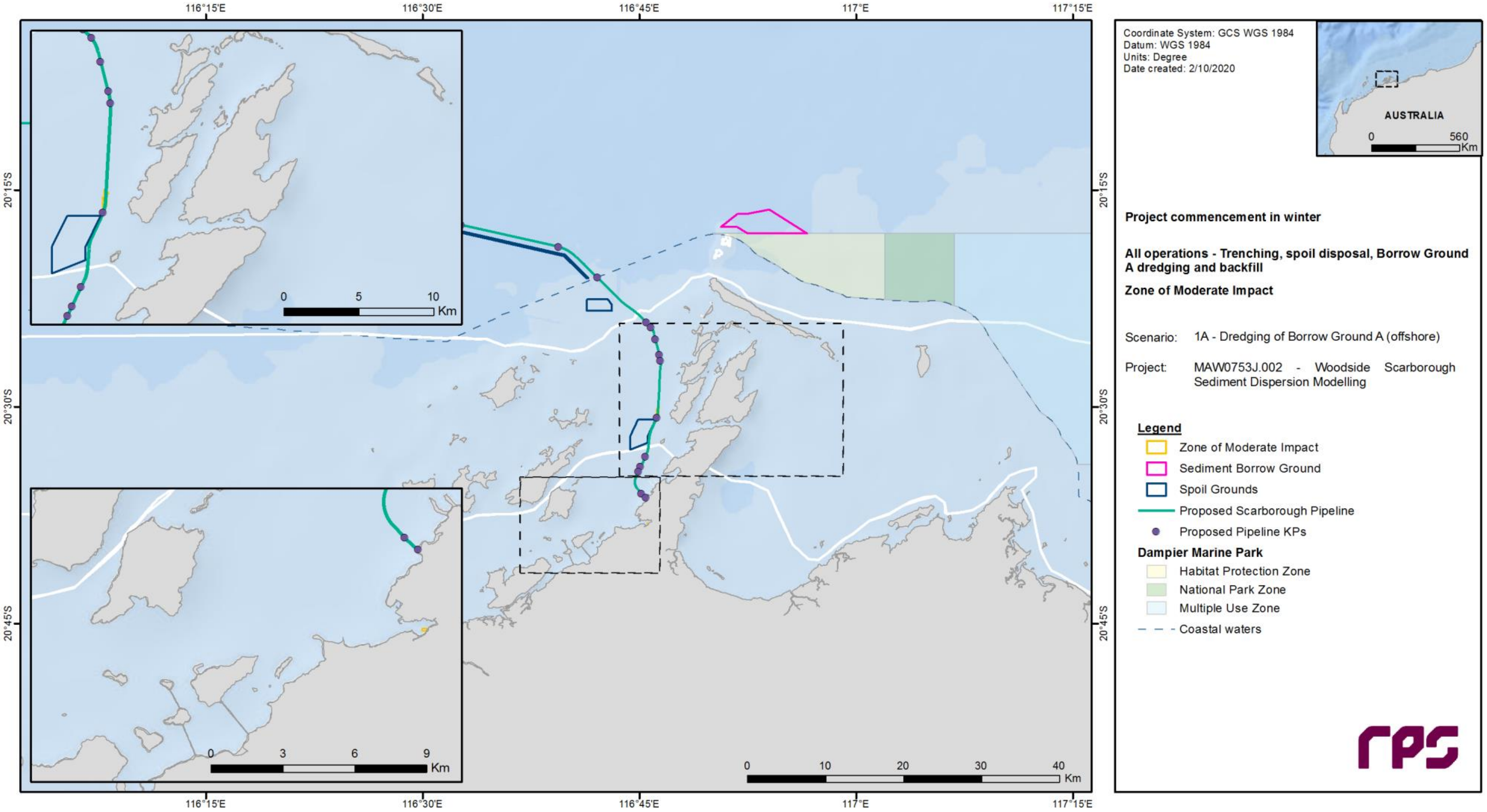

Figure 5.8 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

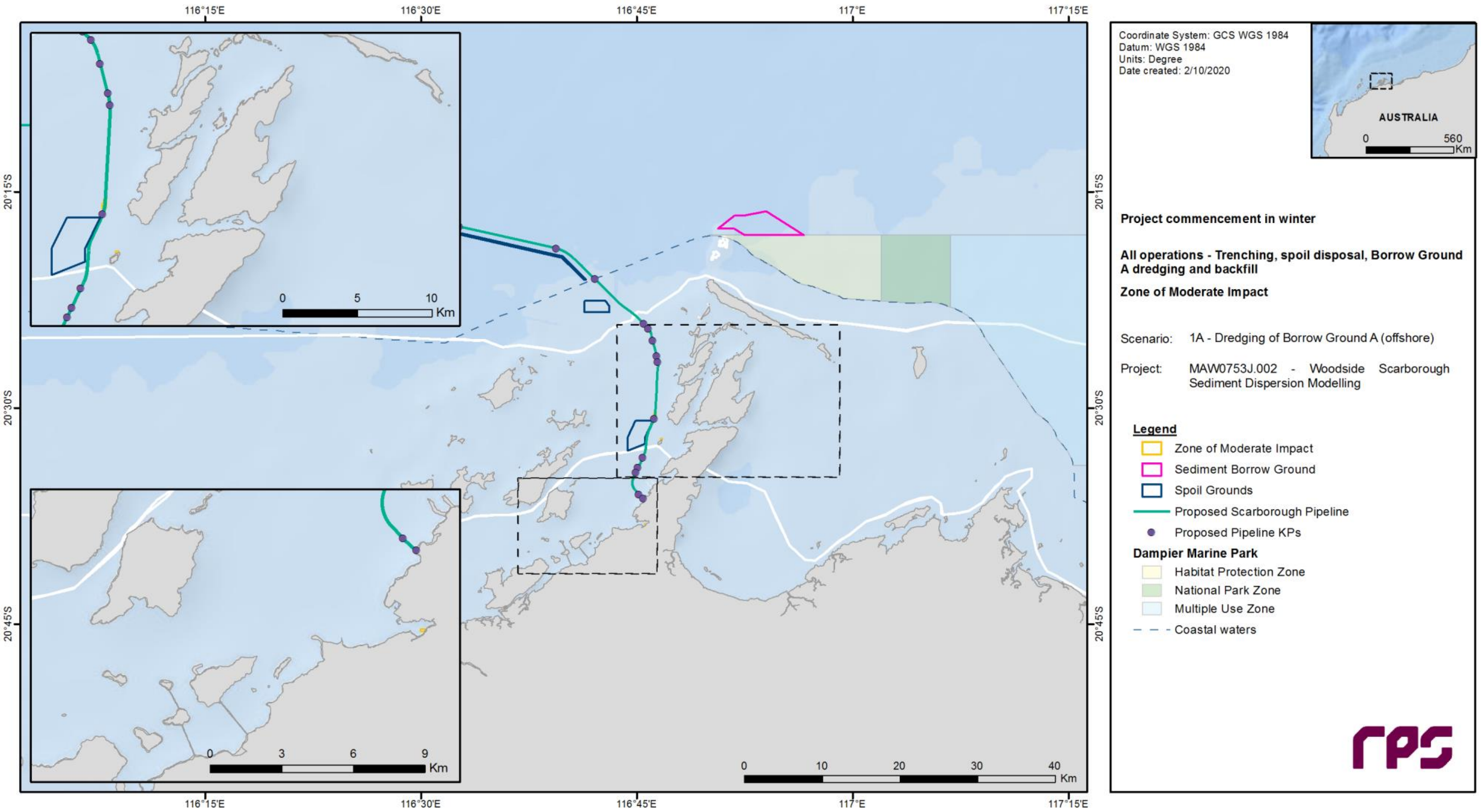

Figure 5.9 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

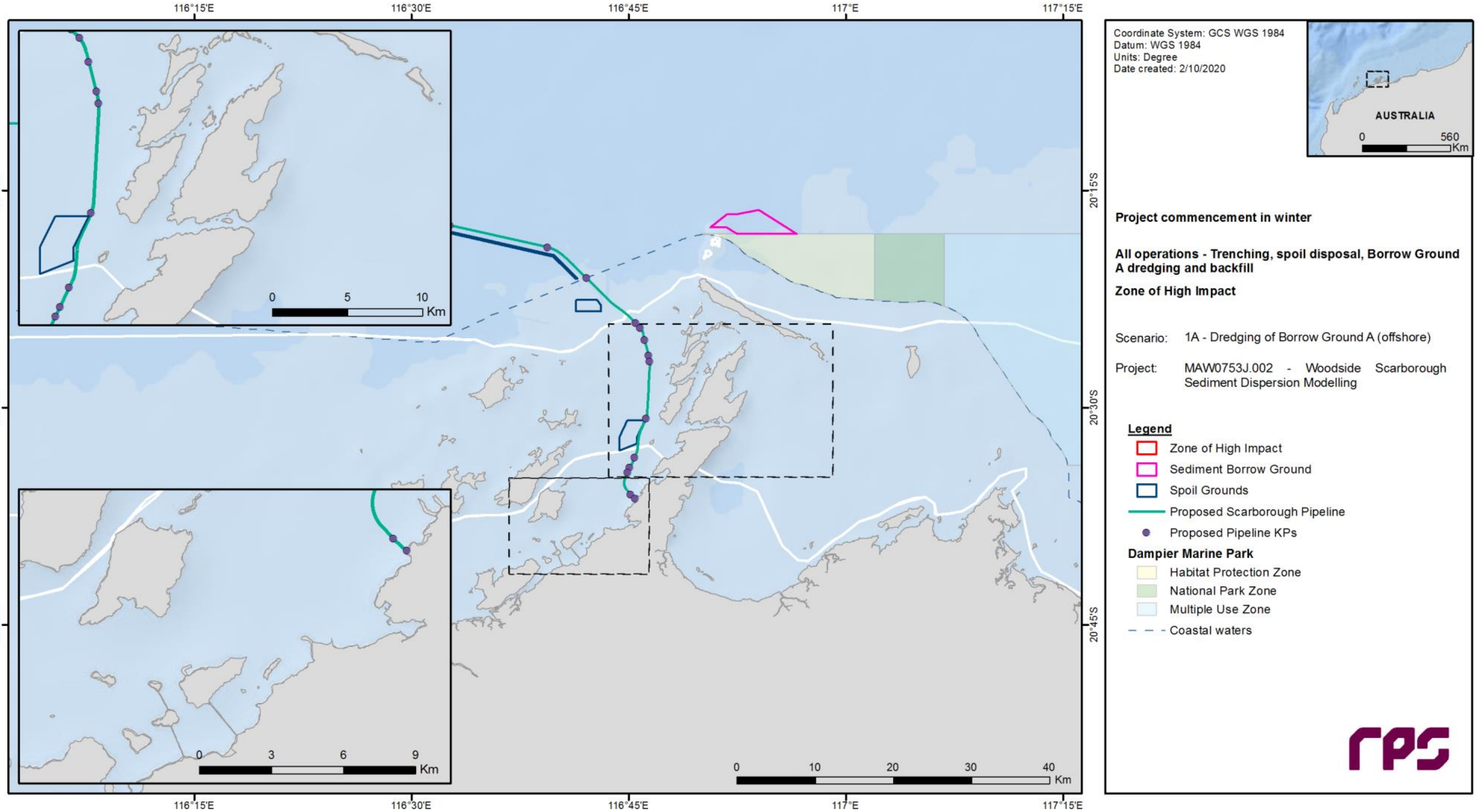

Figure 5.10 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

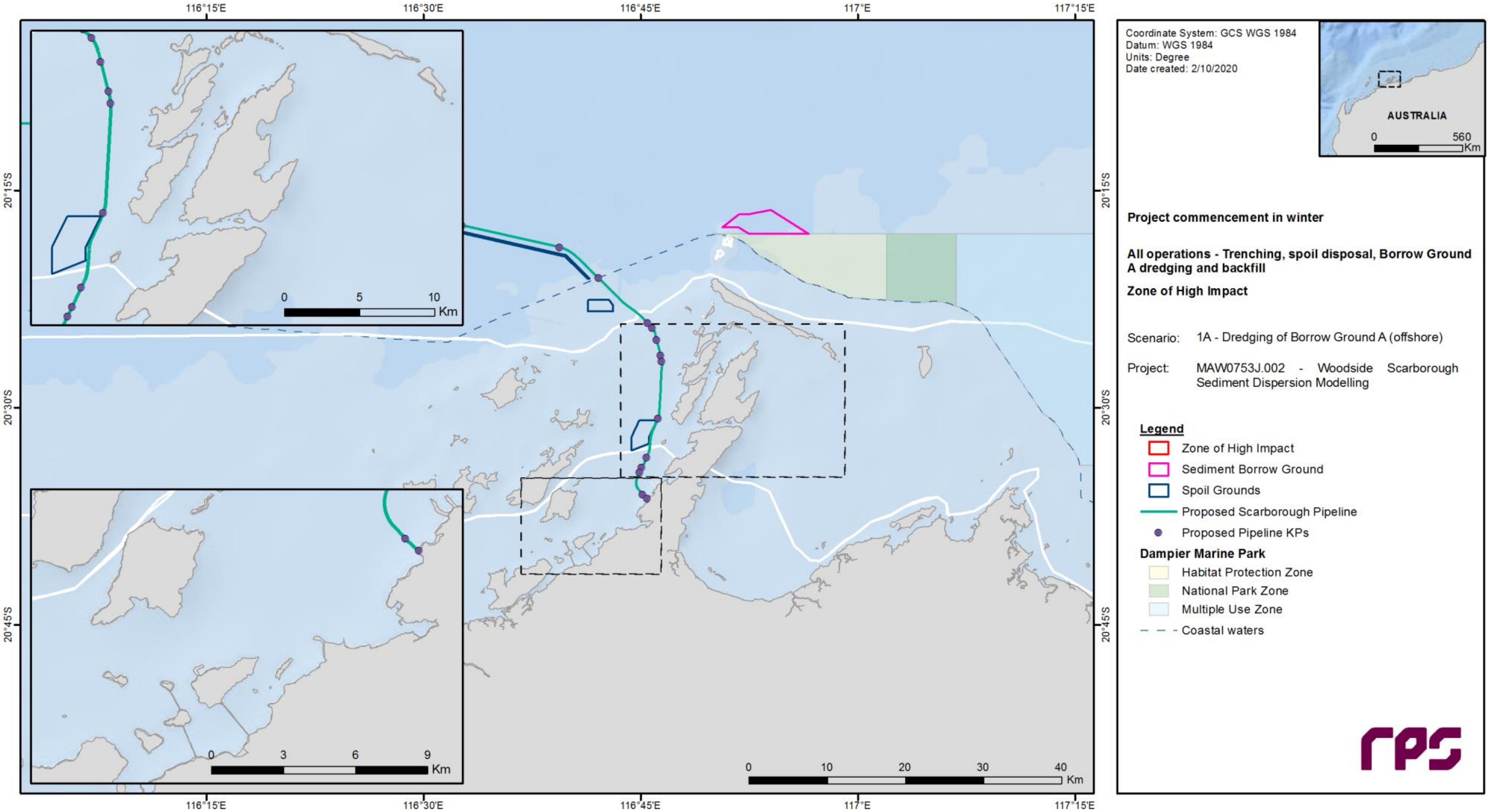

Figure 5.11 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

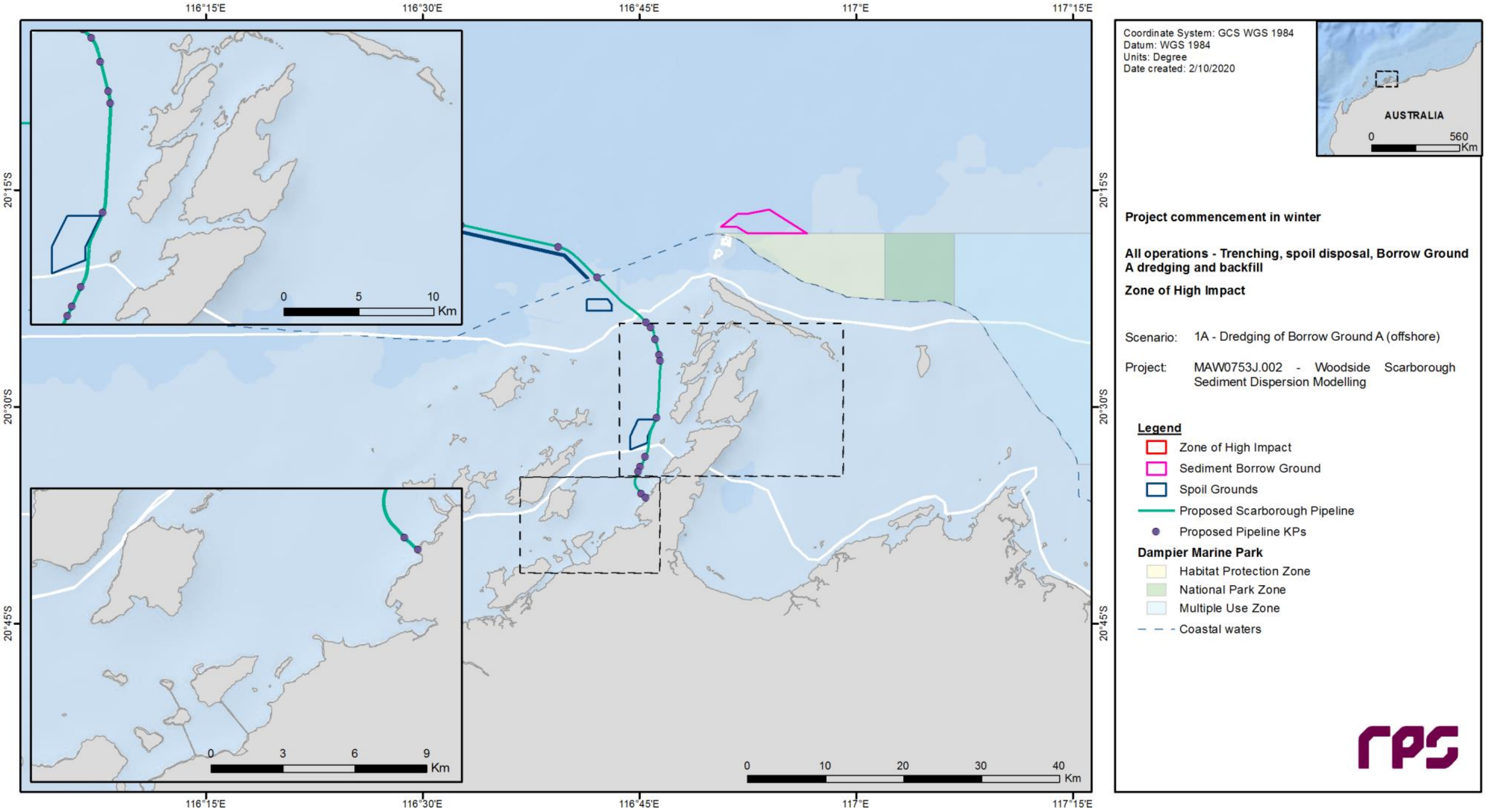

Figure 5.12 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

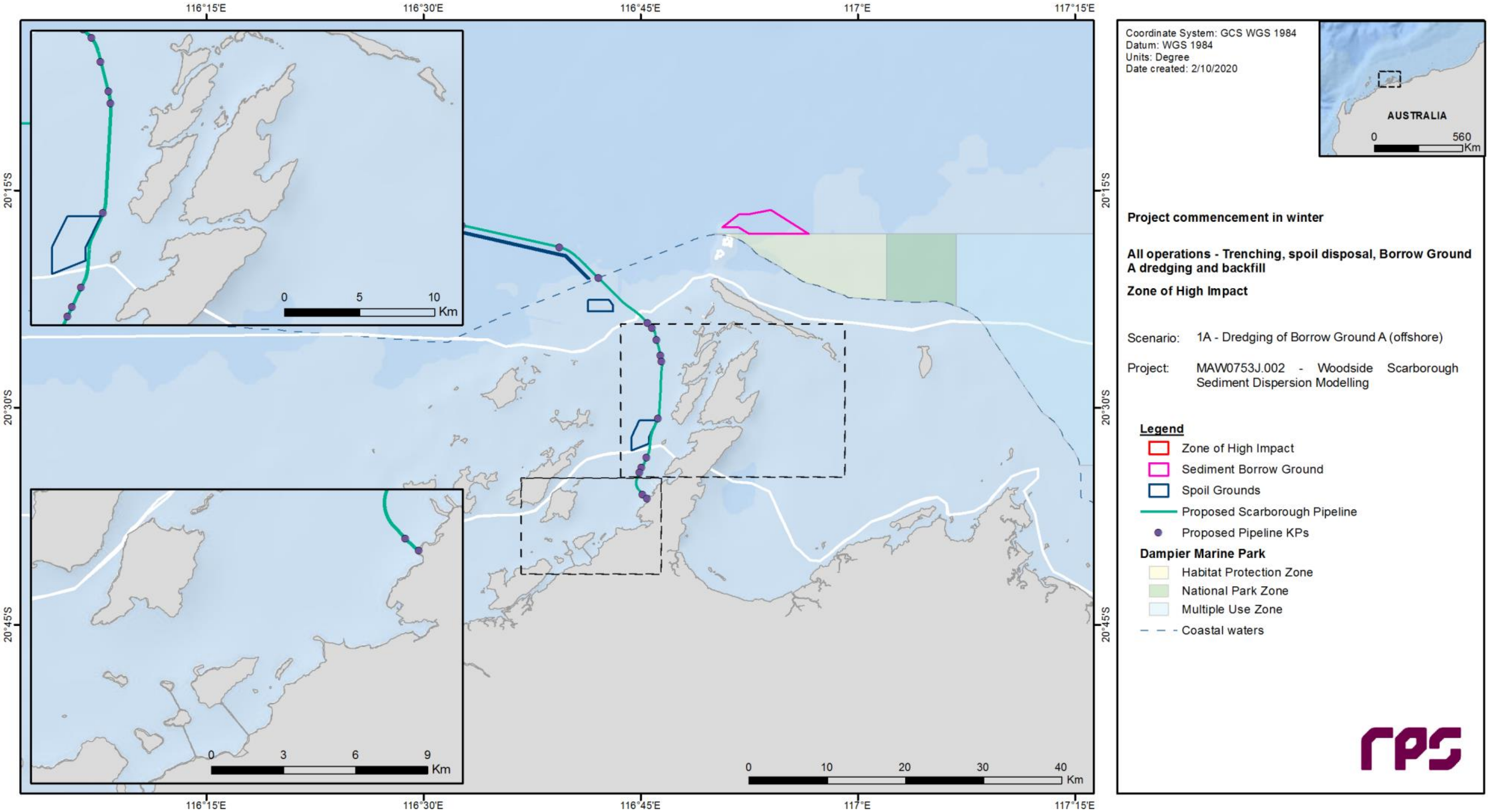

Figure 5.13 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st July 2016 to 23rd May 2017).

5.2.2.2 Scenario 2: Dredging Operations Commencing during Summer, with Backfill Material Sourced from Borrow Ground A

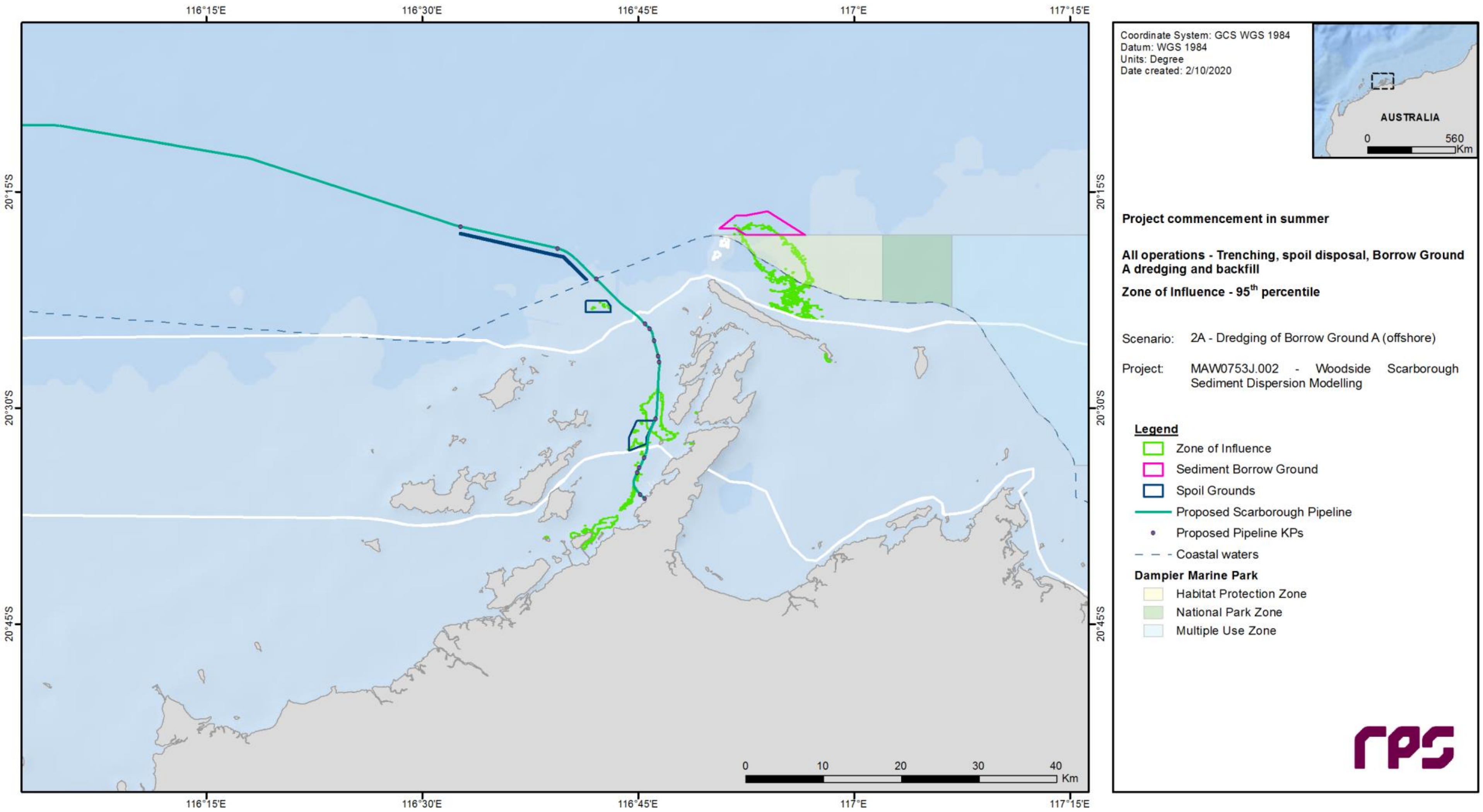

Figure 5.14 Predicted 95th percentile Zone of Influence following application of the appropriate spatial thresholds in Table 4.2 to a 24-hour rolling average of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

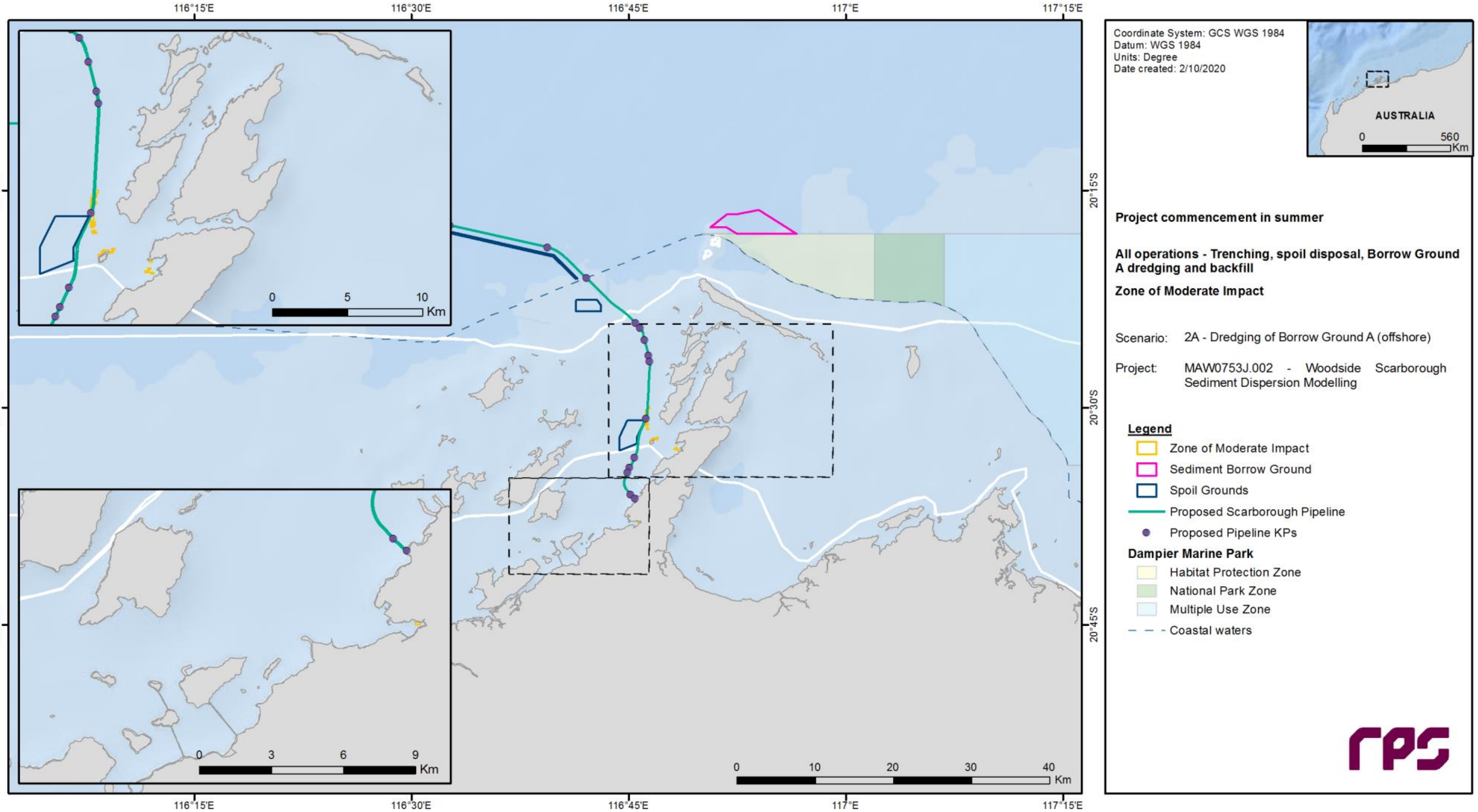

Figure 5.15 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

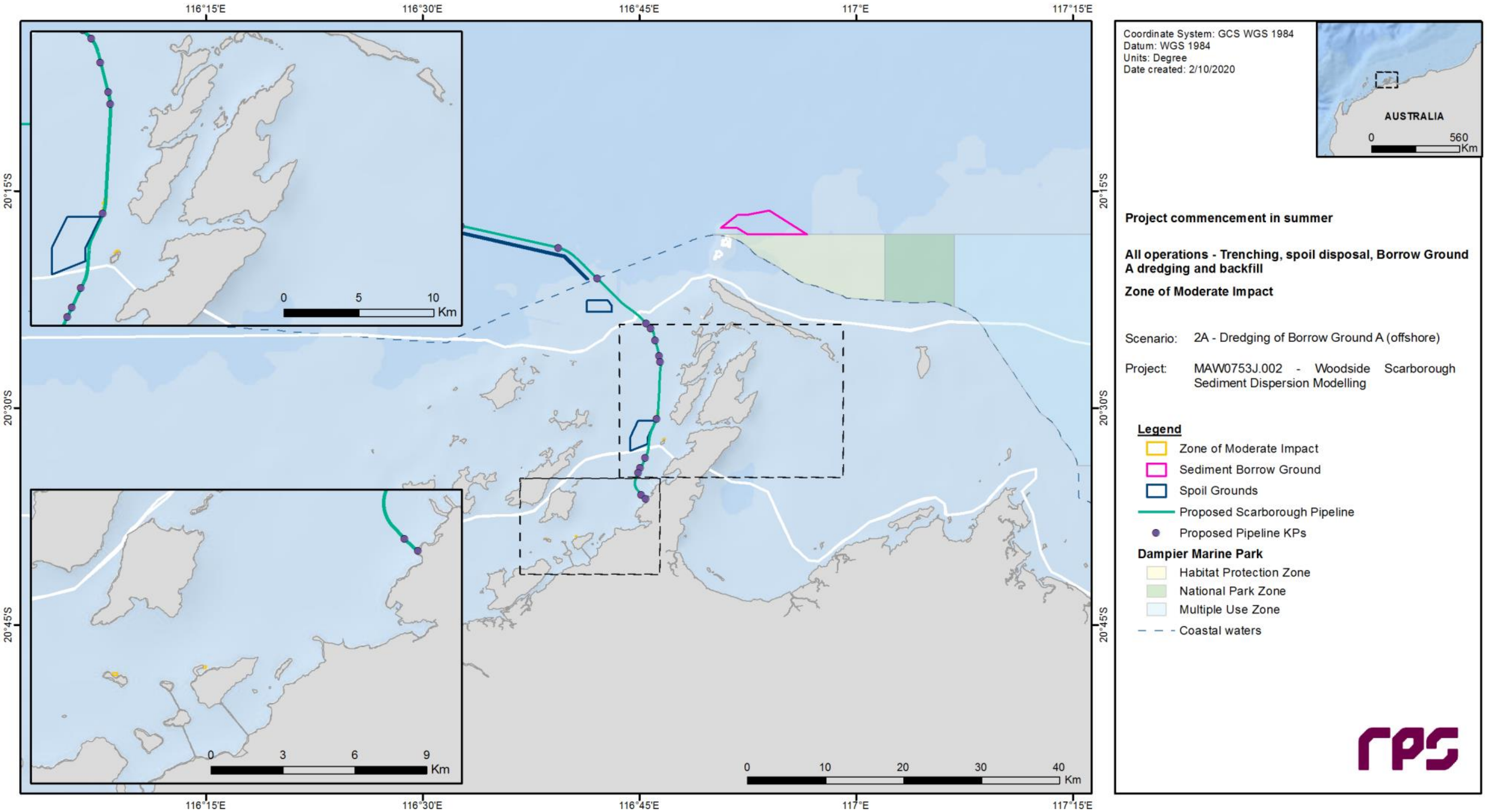

Figure 5.16 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

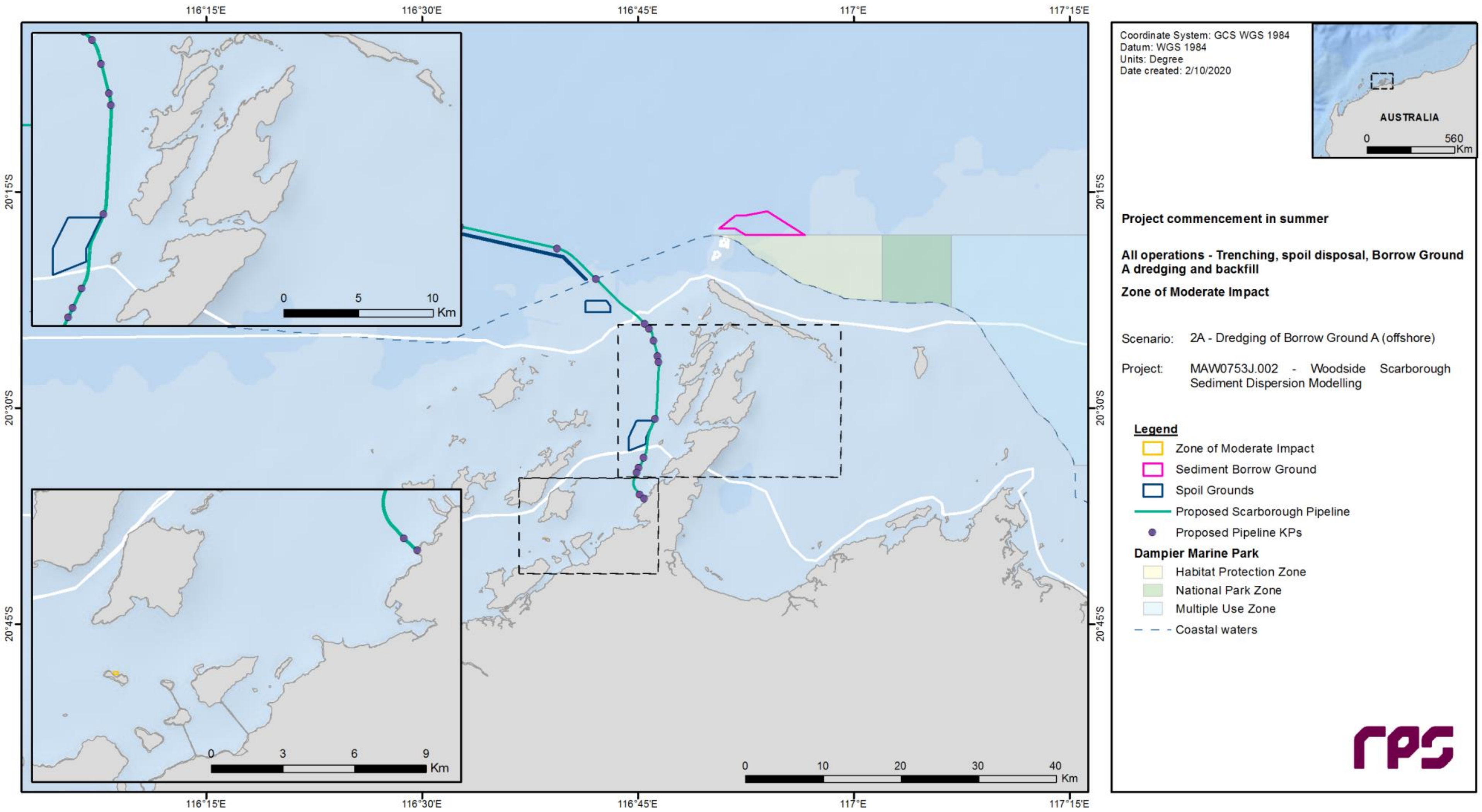

Figure 5.17 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

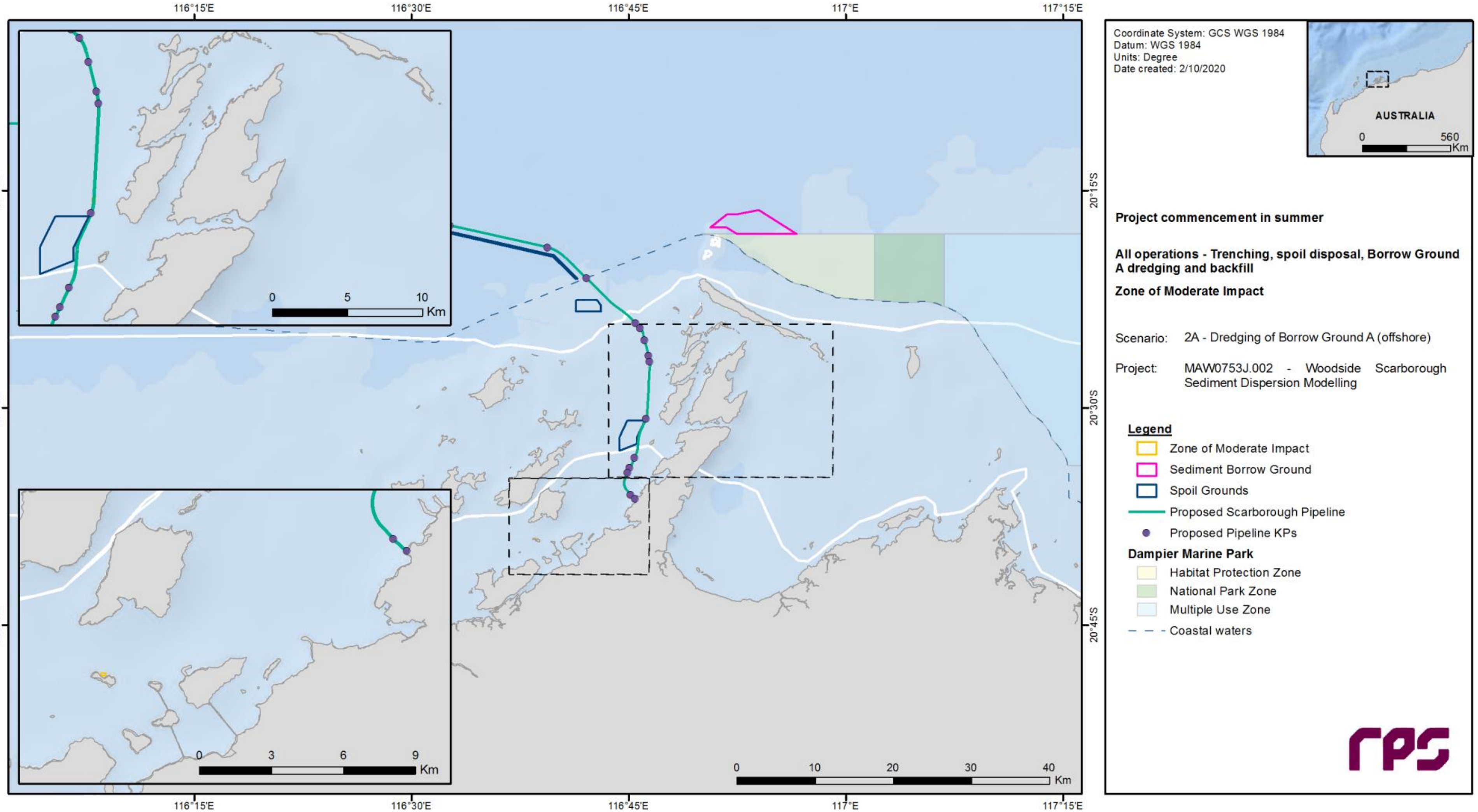

Figure 5.18 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

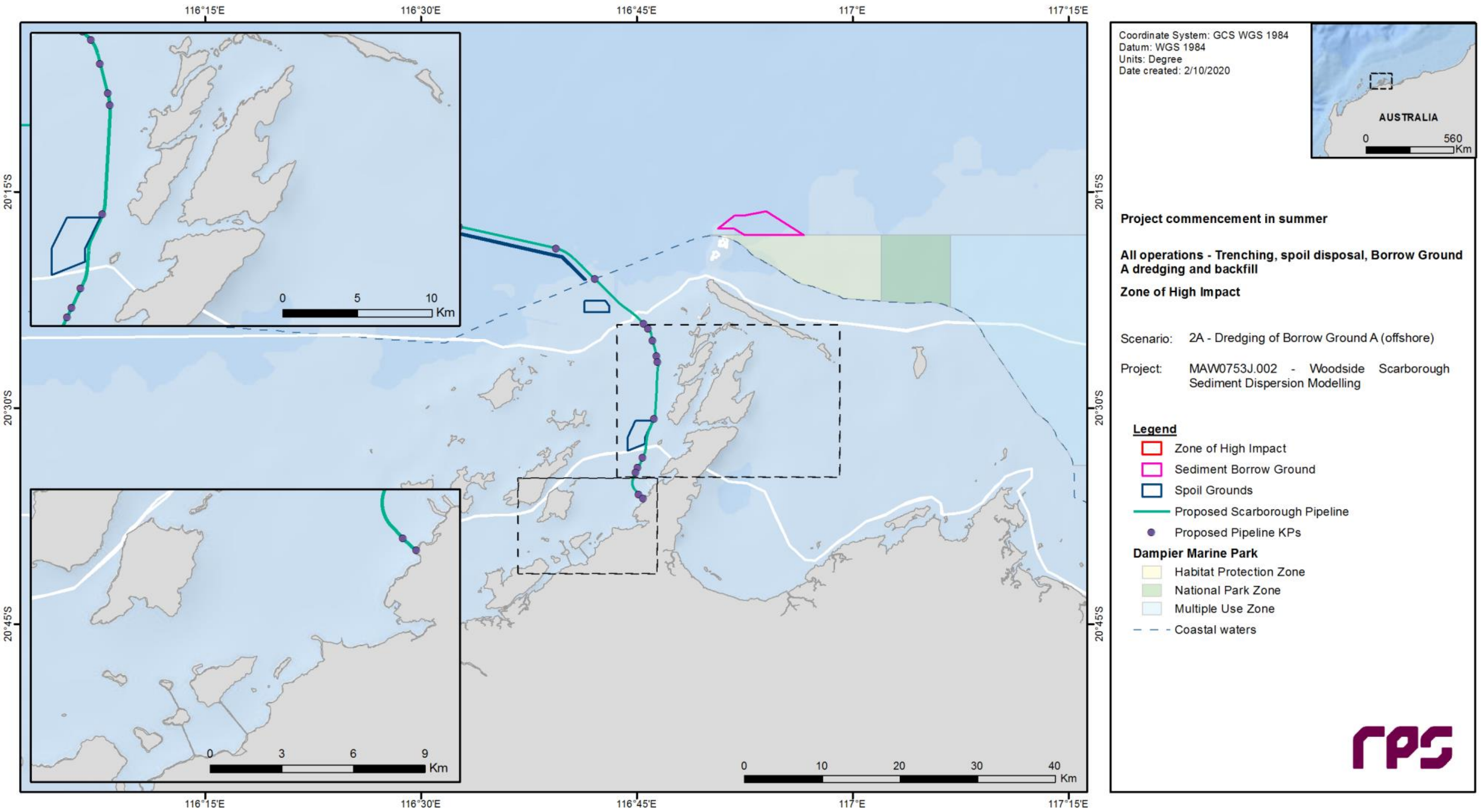

Figure 5.19 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

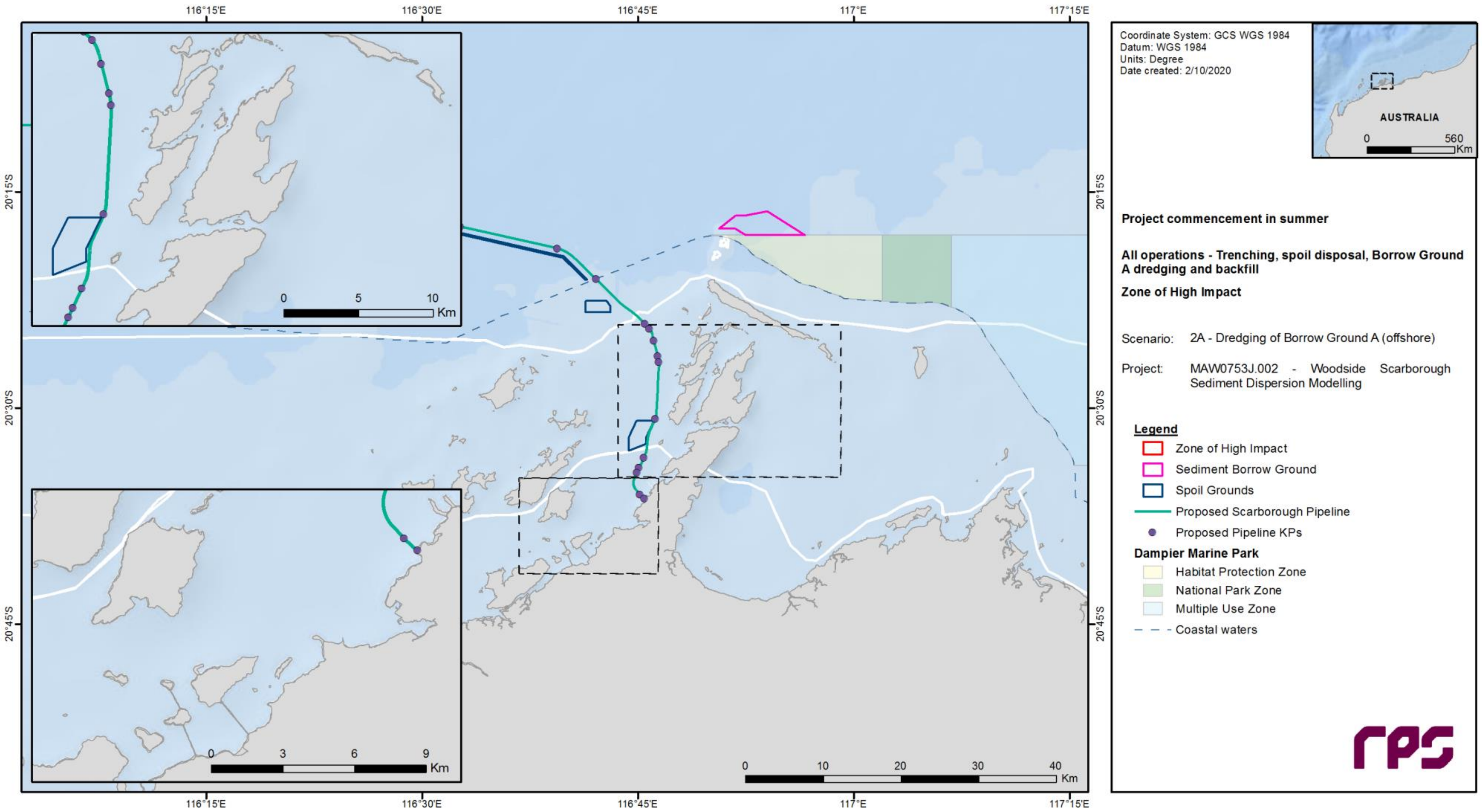

Figure 5.20 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

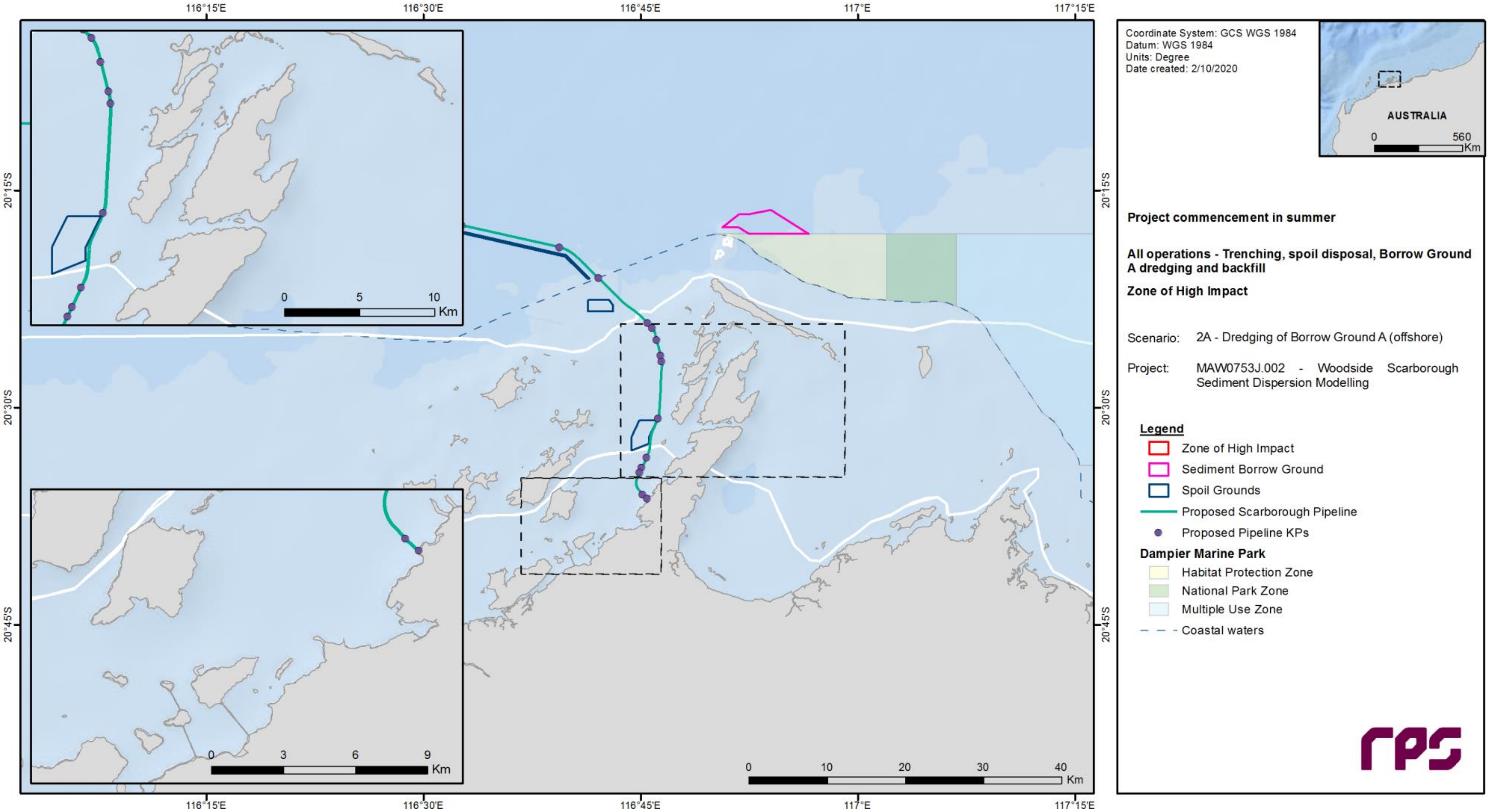

Figure 5.21 **Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).**

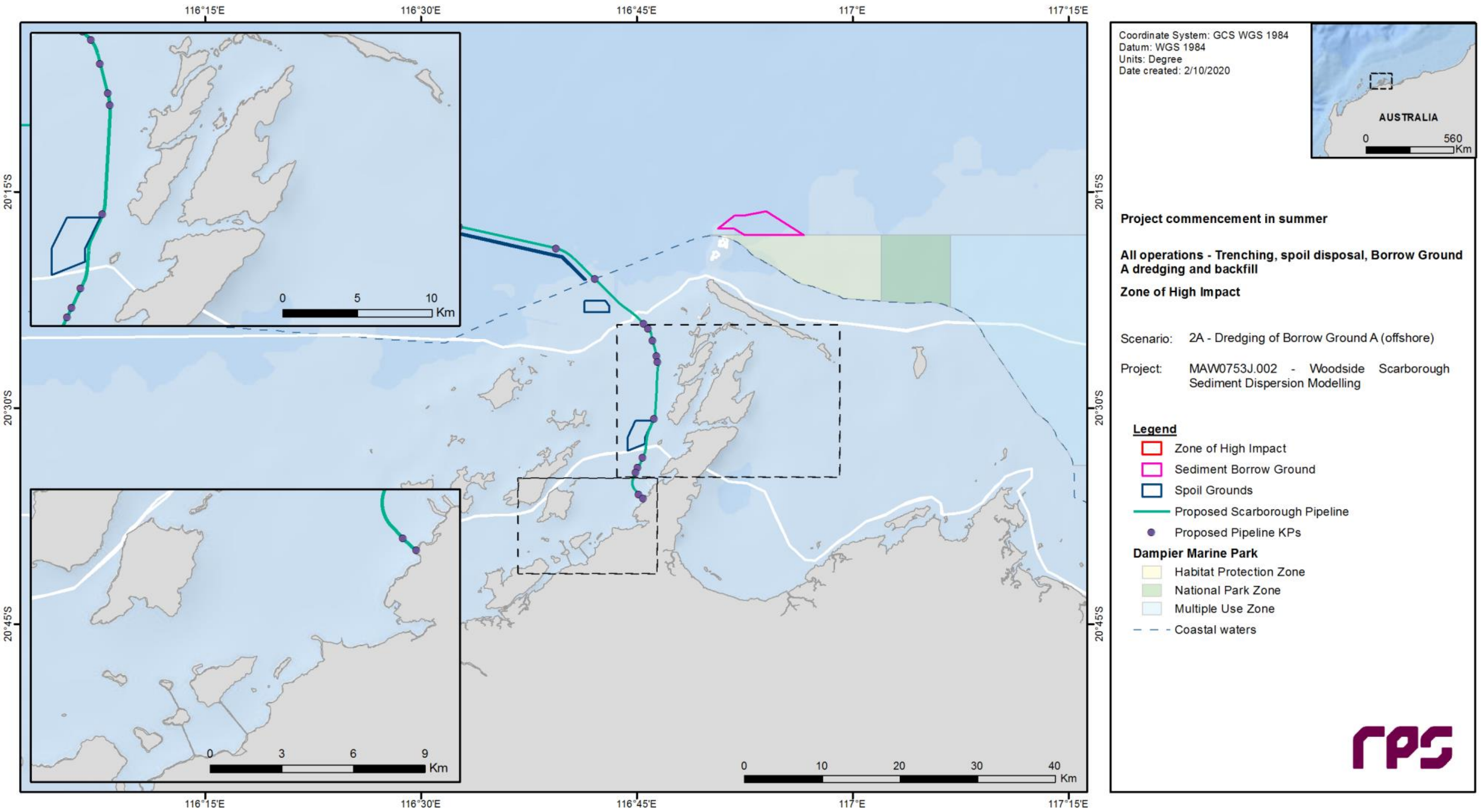

Figure 5.22 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the entire scenario duration (1st January 2017 to 21st November 2017).

5.3 Activities in Commonwealth Waters

To provide an indication of the characteristics of sediment plumes associated only with activities occurring – or directly related to those occurring – in Commonwealth waters, additional figures are presented in Sections B.1 (Scenario 1) and B.2 (Scenario 2) of Appendix B. These figures comprise overall percentile contours and overall management zone extents, and are representative of the following activities:

- Pipeline trenching and spoil disposal activities only beyond the State waters boundary.
- All borrow-ground dredging activities.
- All pipeline backfill activities (including those within State waters due to the direct correlation of backfill operations with borrow-ground dredging in Commonwealth waters).

It is emphasised that the intention of these outputs is to provide added context to the full-program outcomes described in the preceding sections. By design, the additional outputs exclude the cumulative effects of all dredging and disposal activities occurring within State waters. Therefore, while the influence of sediment plumes originating offshore and migrating to State waters is clear in the figures, the corresponding potential for influence on Commonwealth waters by plumes originating inshore is not fully considered.

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Appendix A: Additional Figures of Spatial Outcomes

A.1 Scenario 1: Dredging Operations Commencing during Winter, with Backfill Material Sourced from Borrow Ground A

A.1.1 Monthly Snapshots

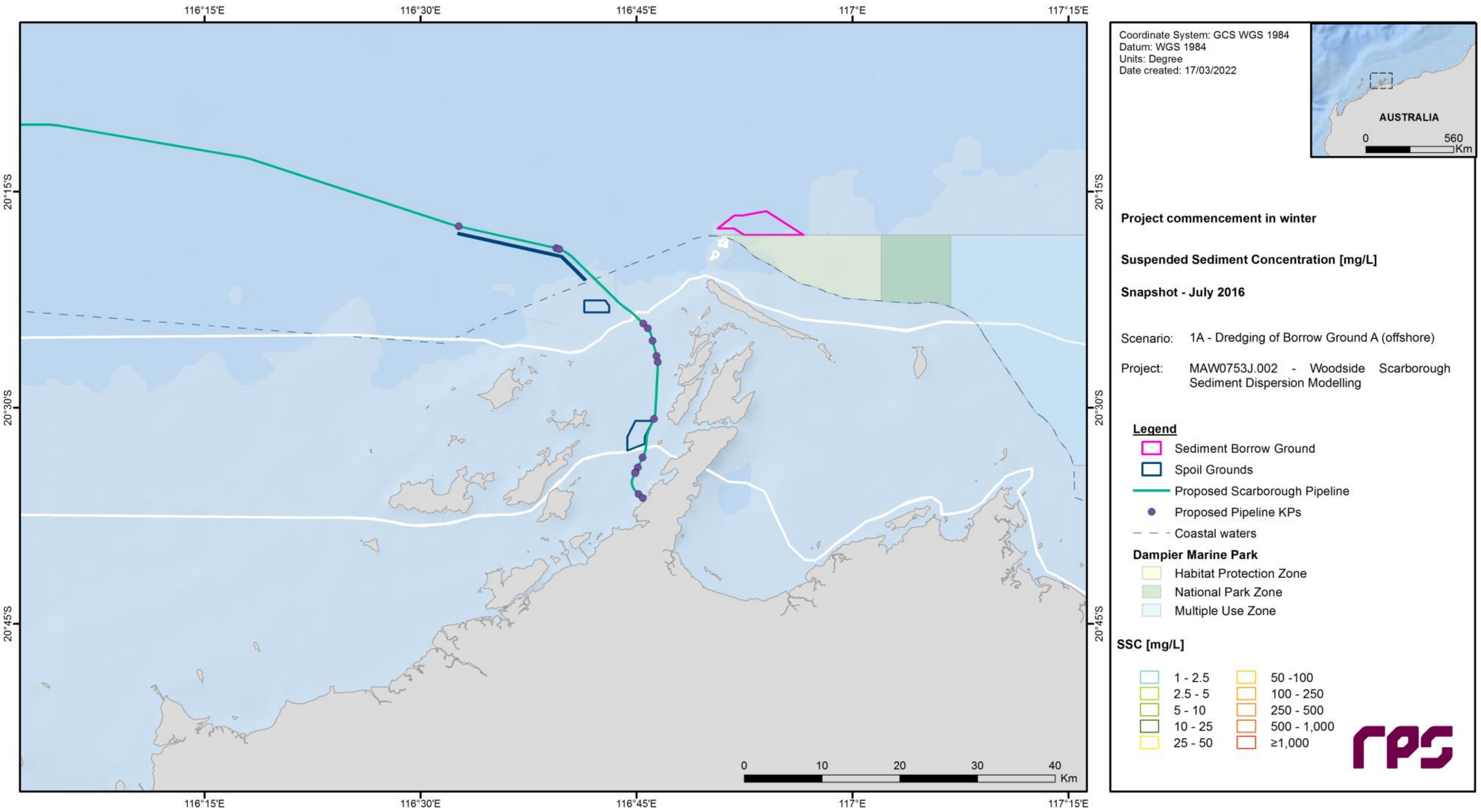

Figure A.1 Predicted instantaneous dredge-excess SSC on 1st July 2016.

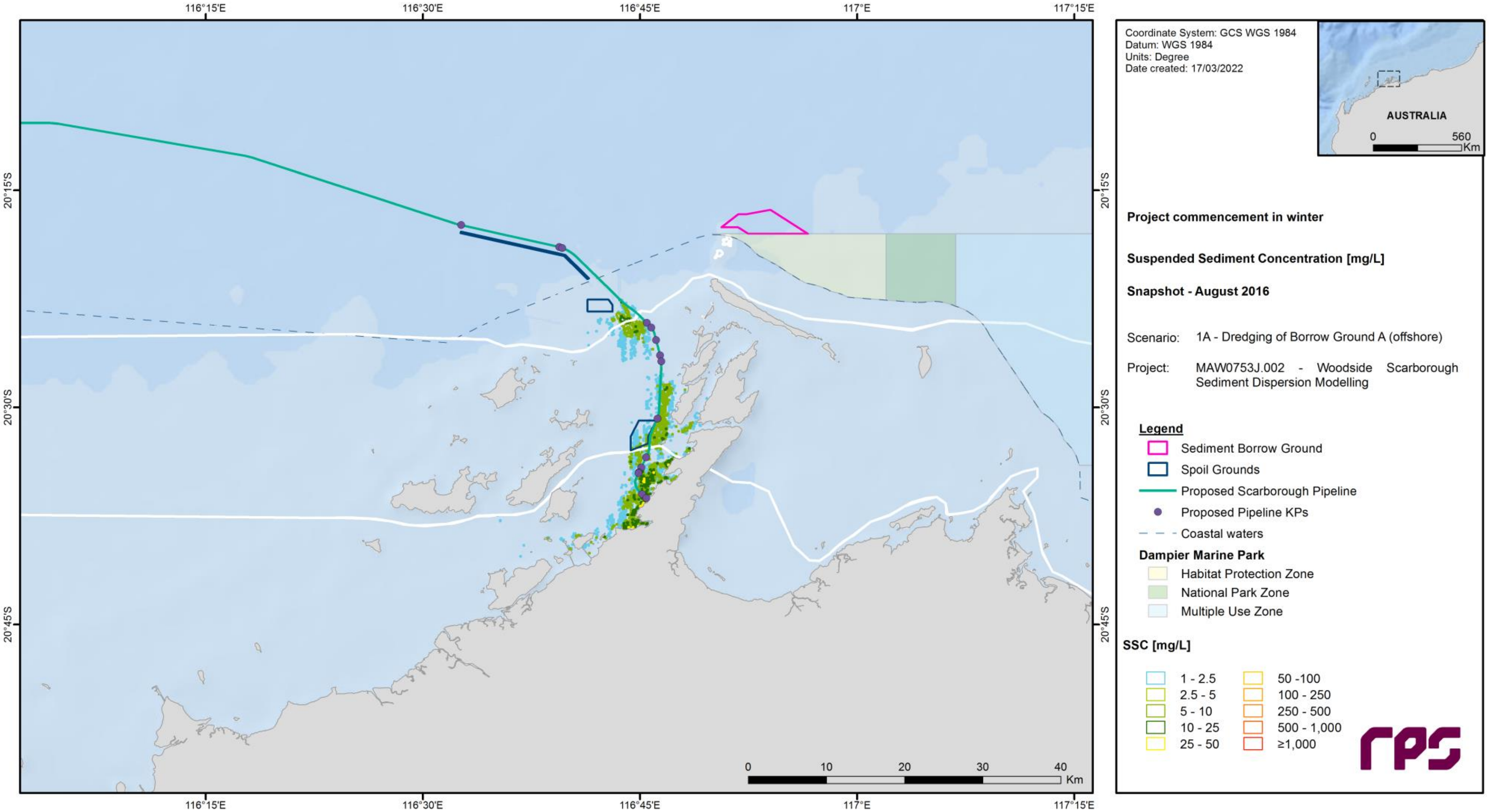

Figure A.2 Predicted instantaneous dredge-excess SSC on 1st August 2016.

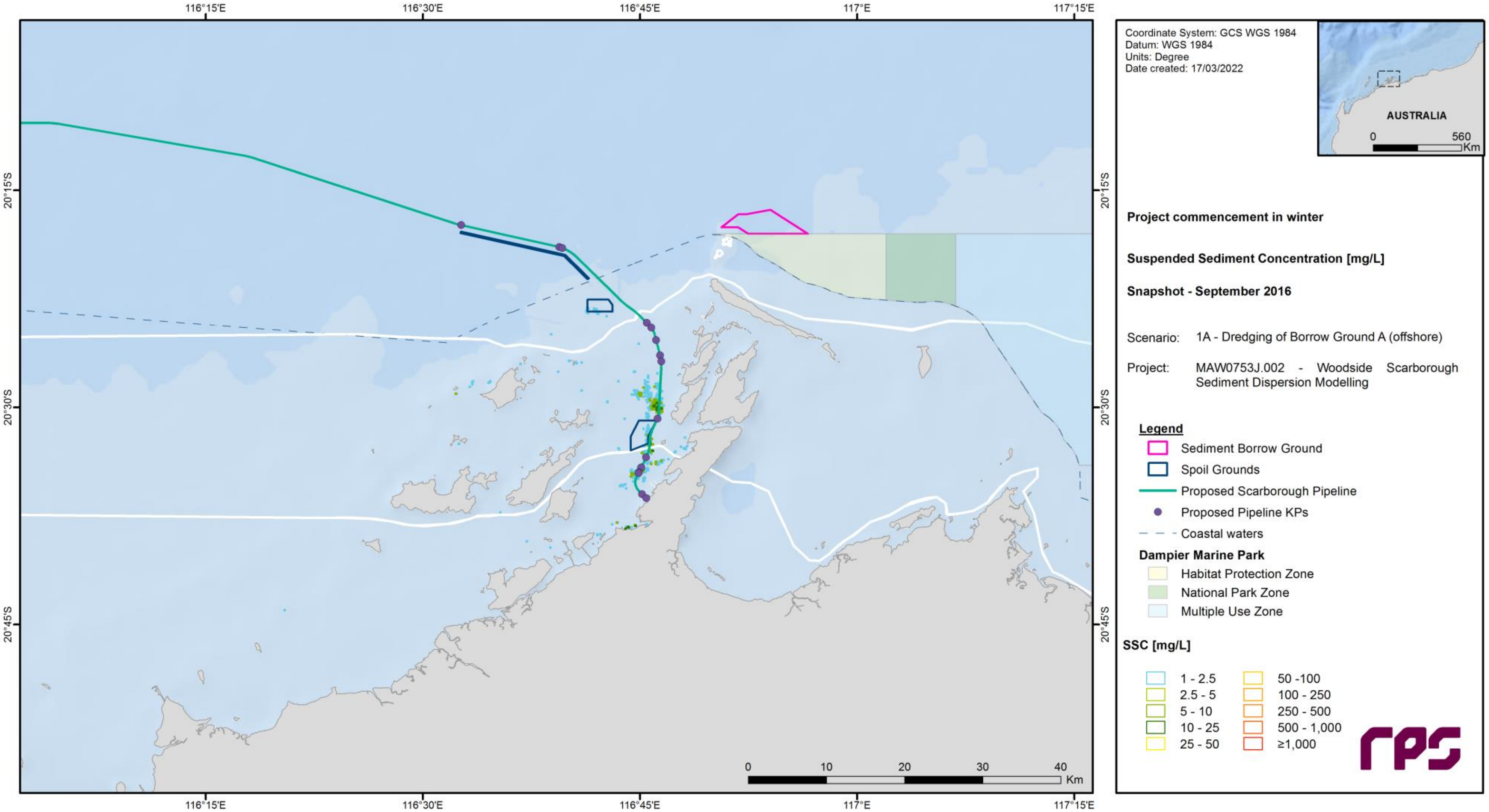

Figure A.3 Predicted instantaneous dredge-excess SSC on 1st September 2016.

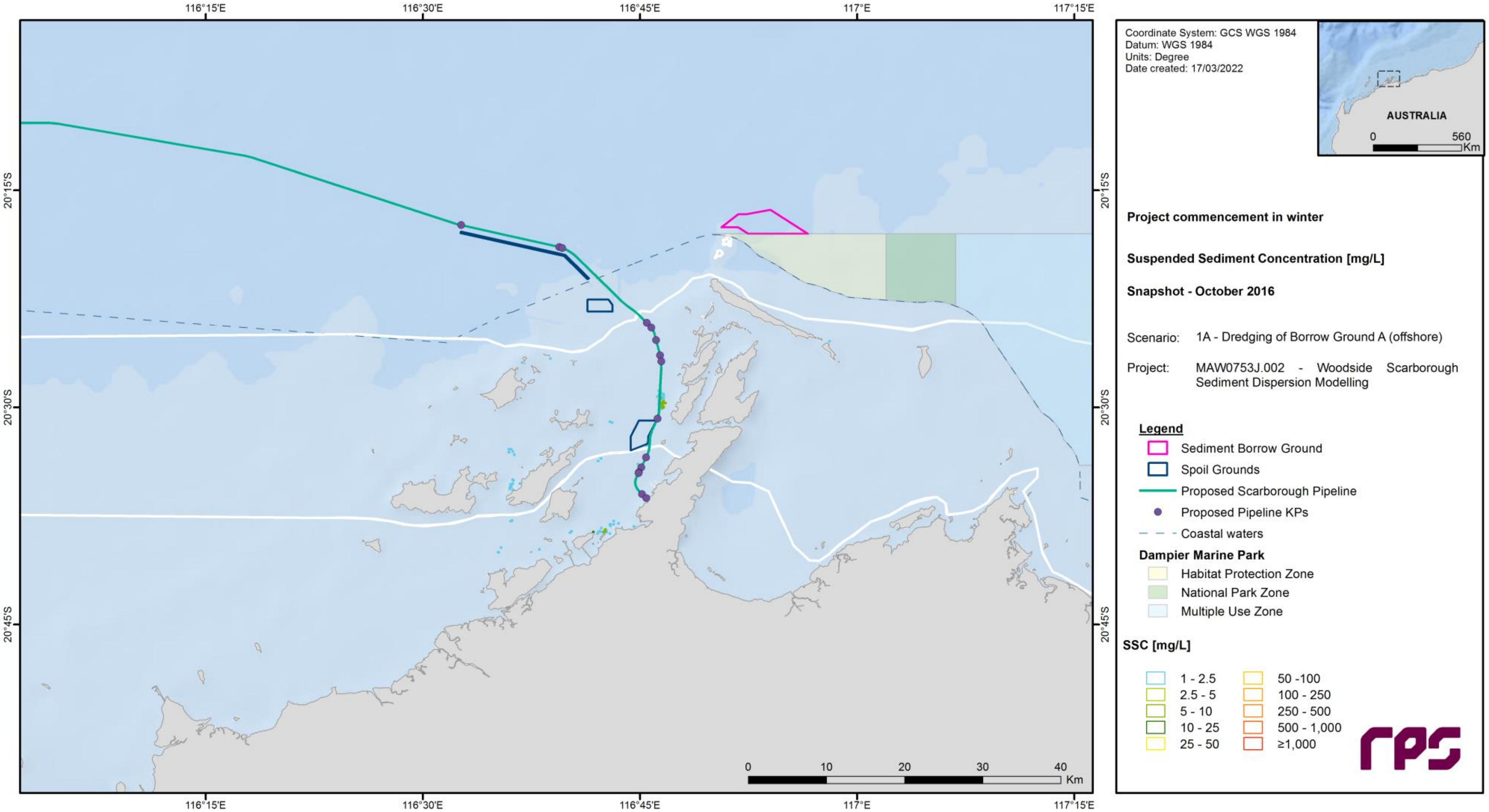

Figure A.4 Predicted instantaneous dredge-excess SSC on 1st October 2016.

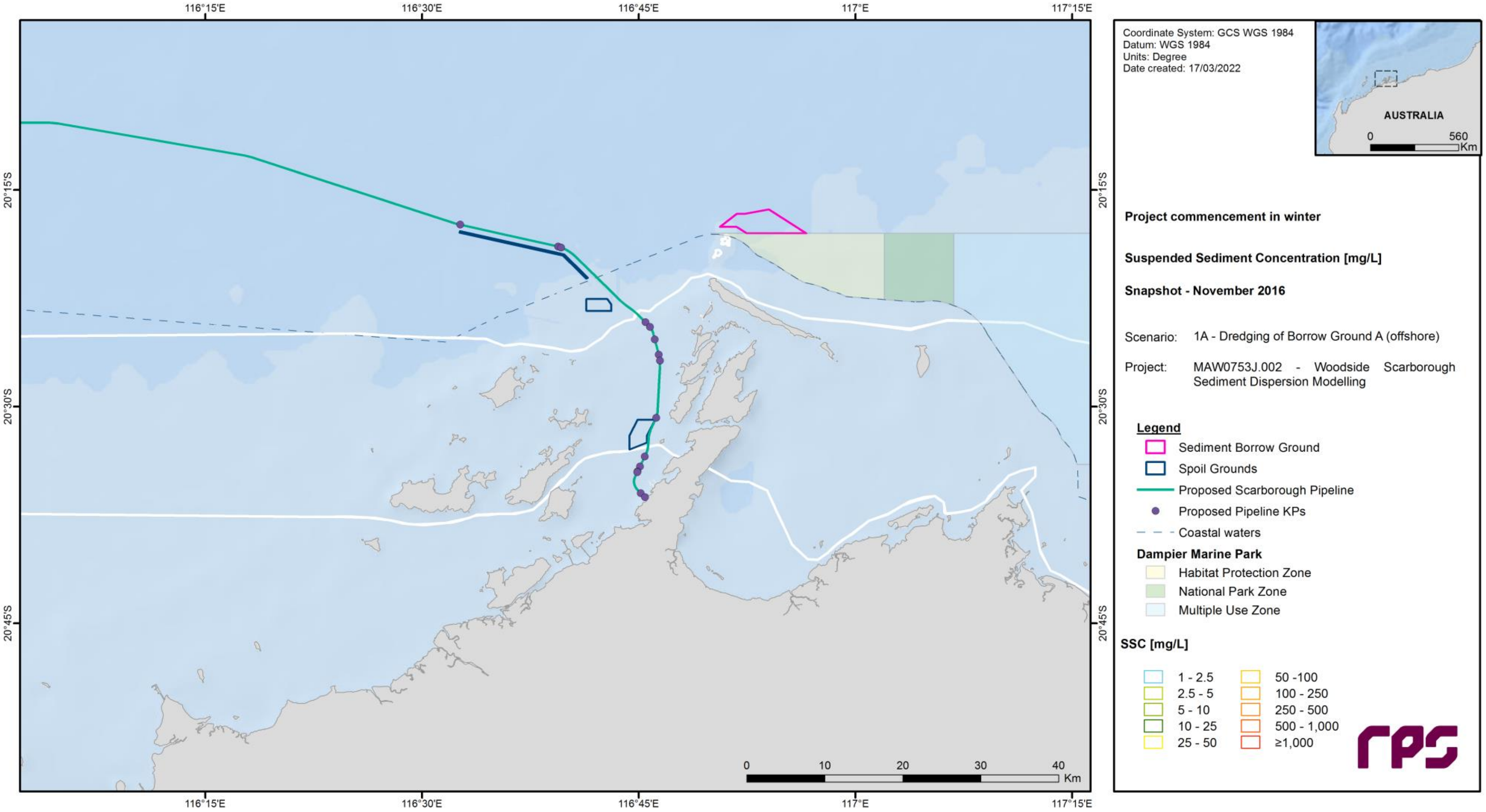

Figure A.5 Predicted instantaneous dredge-excess SSC on 1st November 2016.

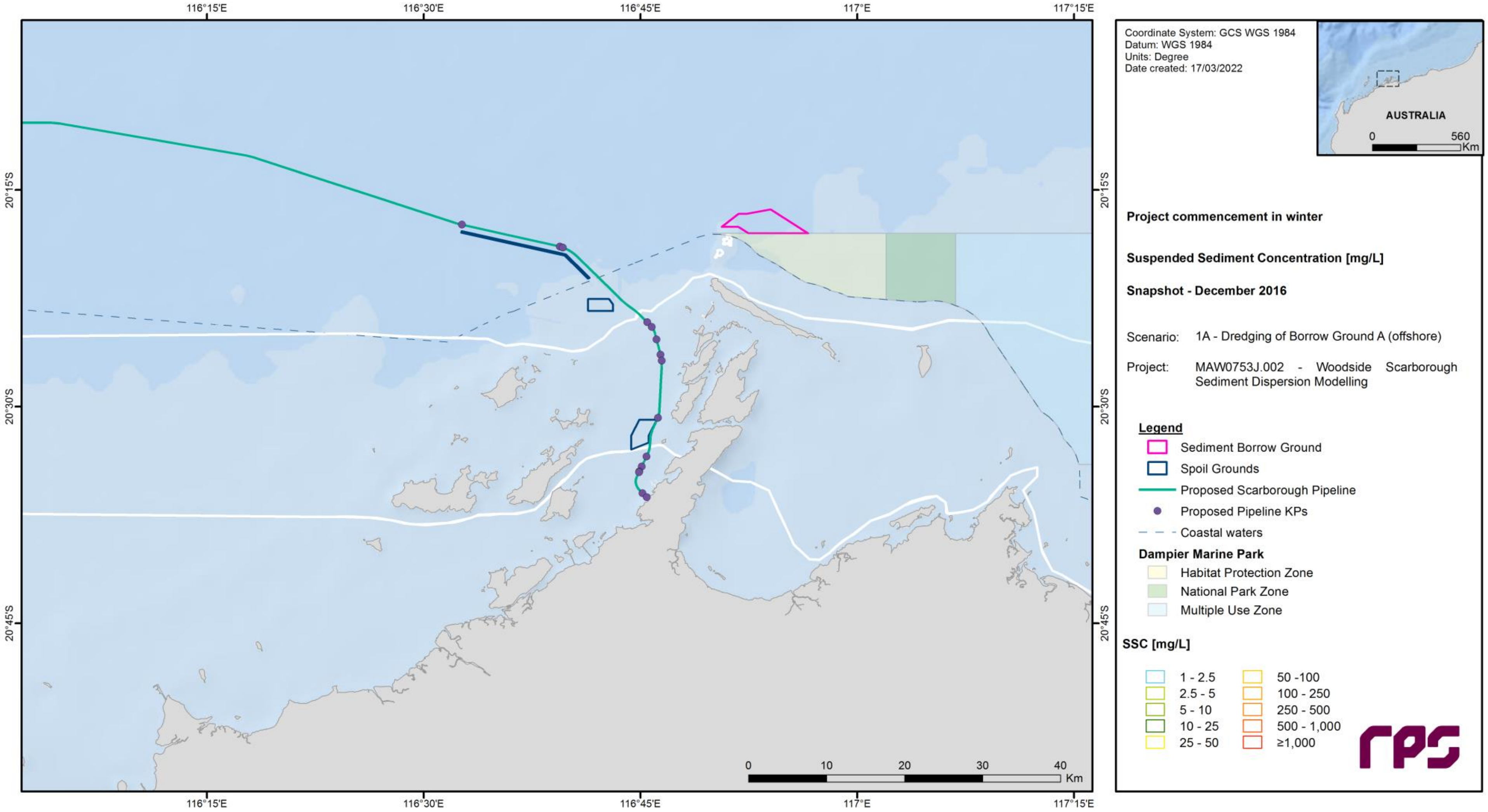

Figure A.6 Predicted instantaneous dredge-excess SSC on 1st December 2016.

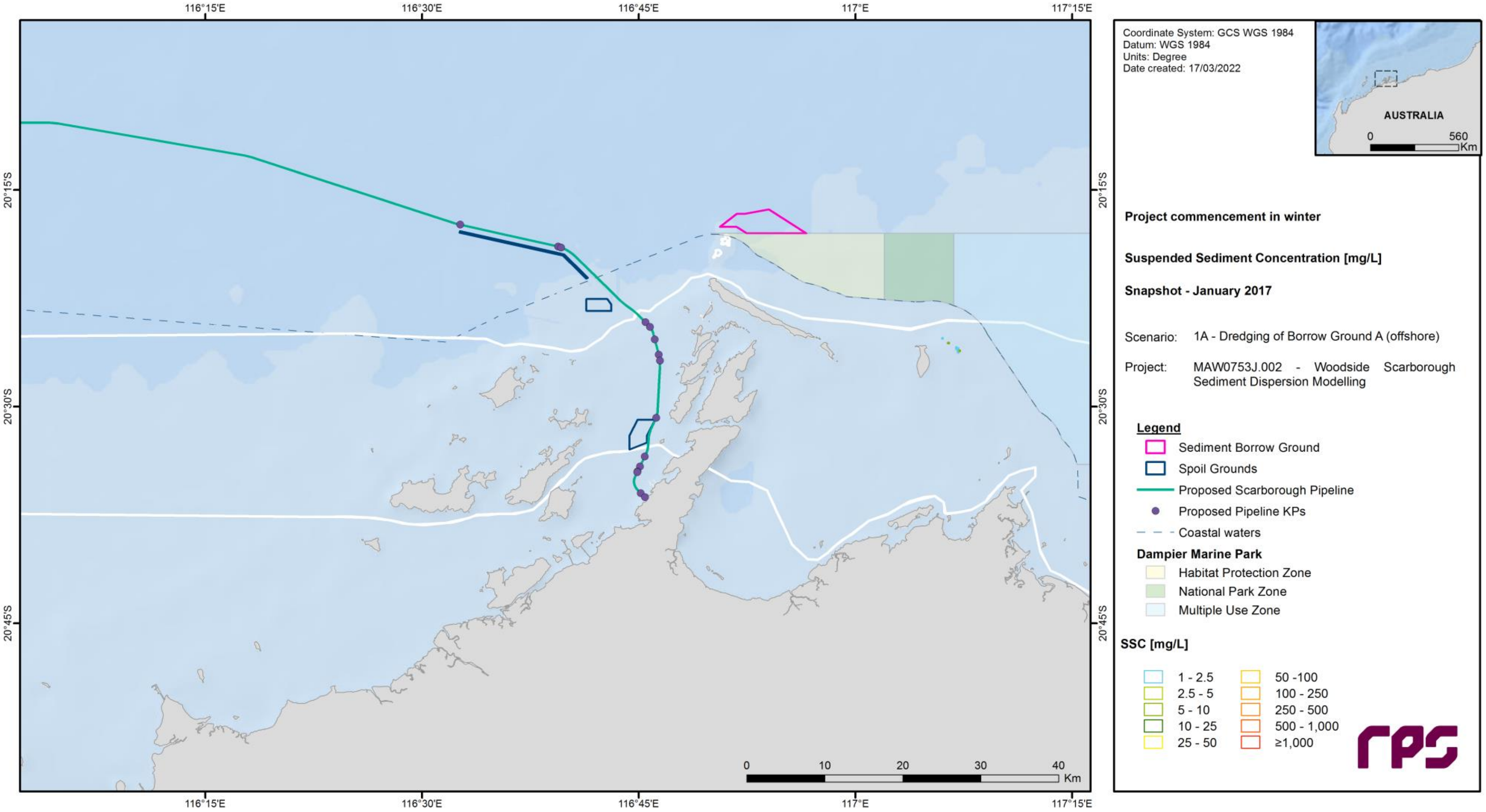

Figure A.7 Predicted instantaneous dredge-excess SSC on 1st January 2017.

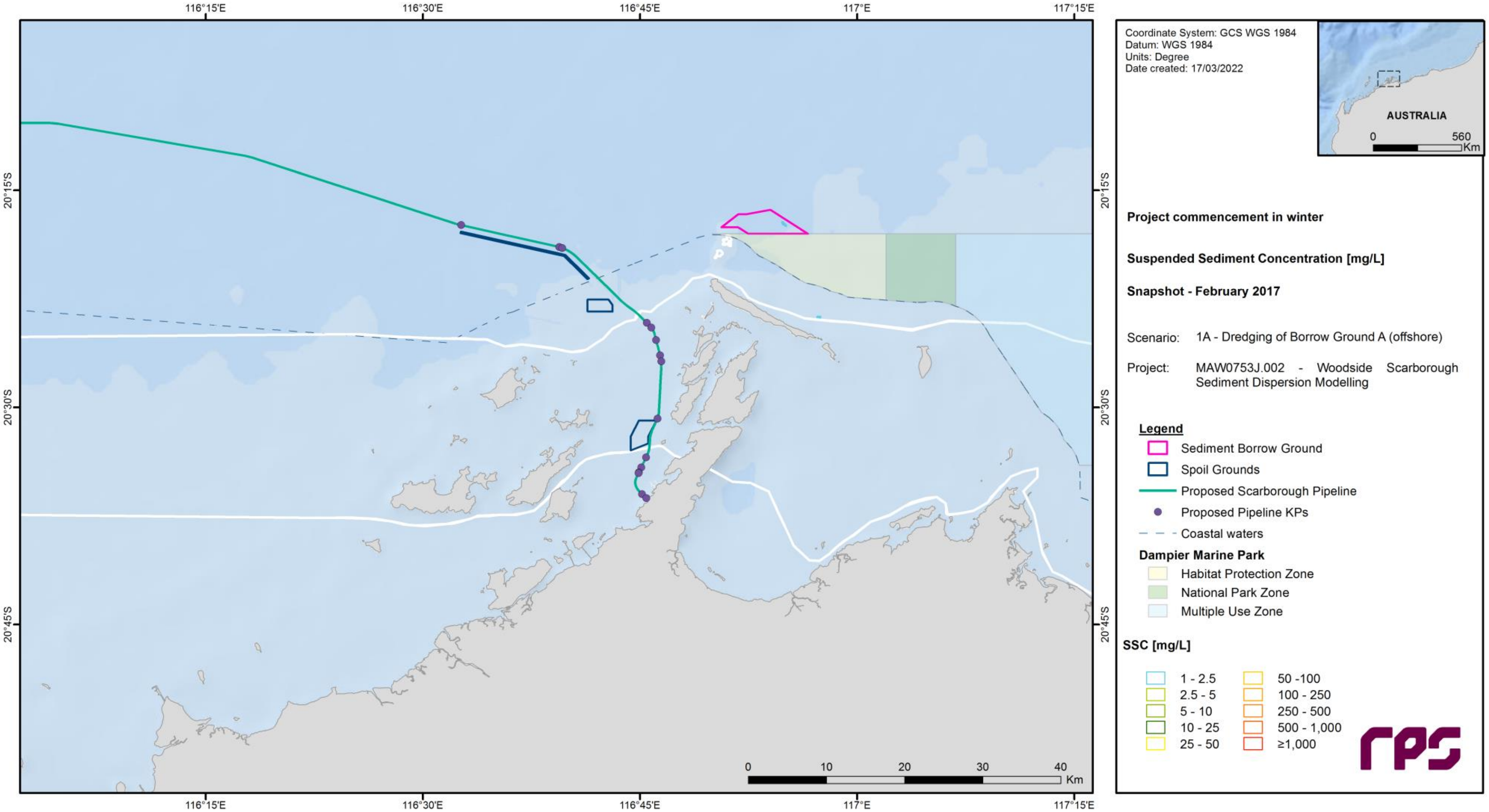

Figure A.8 Predicted instantaneous dredge-excess SSC on 1st February 2017.

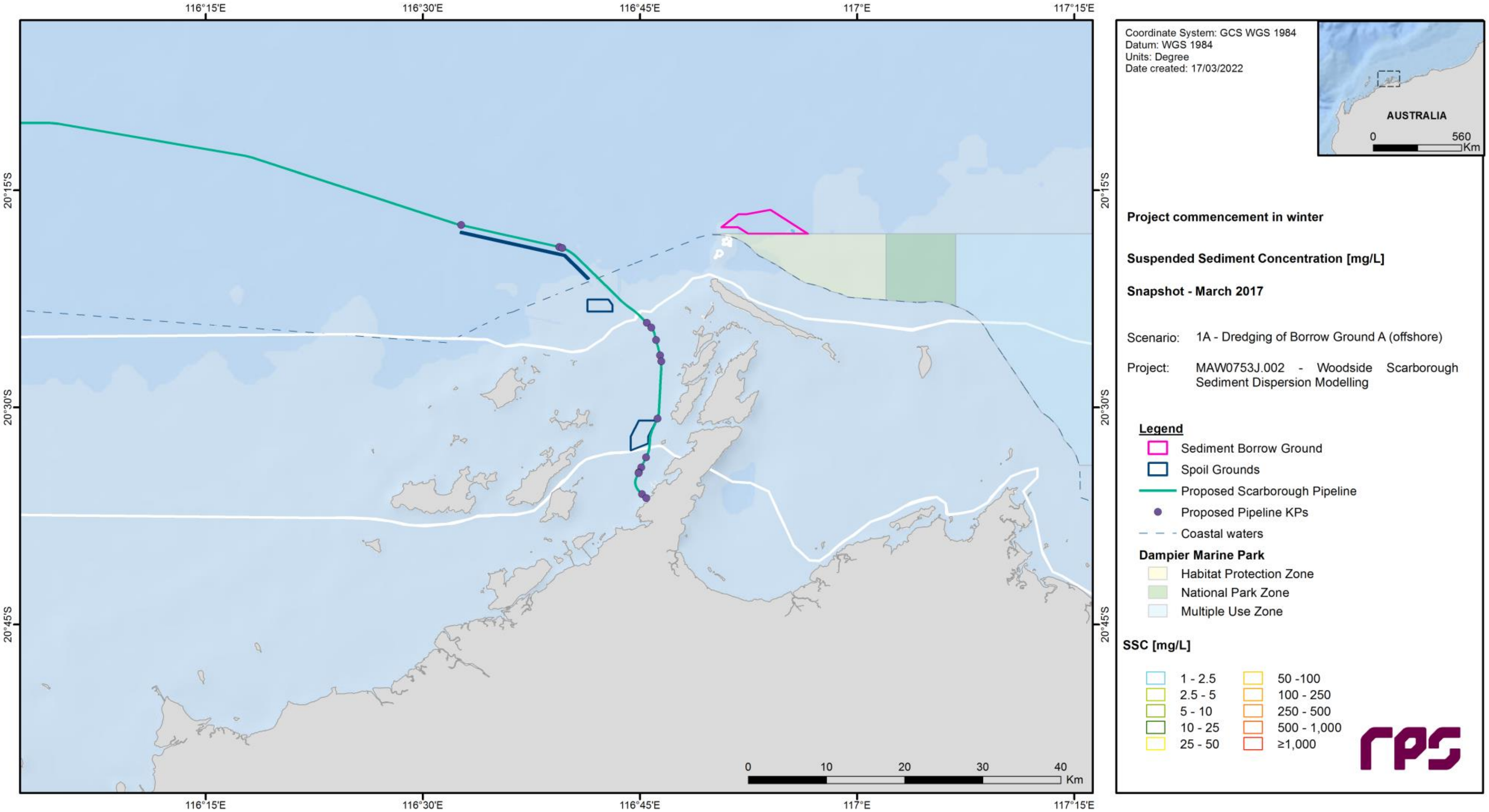

Figure A.9 Predicted instantaneous dredge-excess SSC on 1st March 2017.

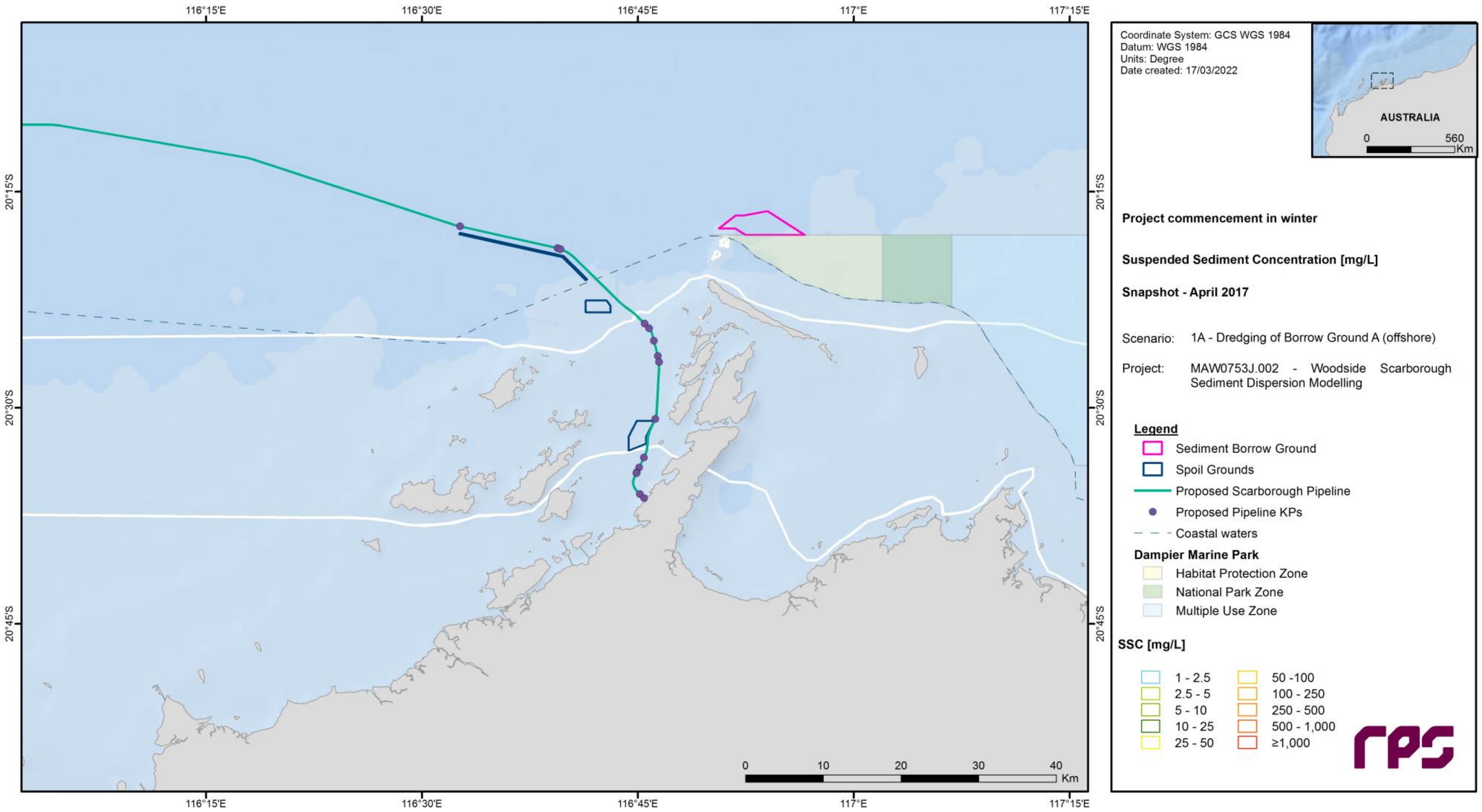

Figure A.10 Predicted instantaneous dredge-excess SSC on 1st April 2017.

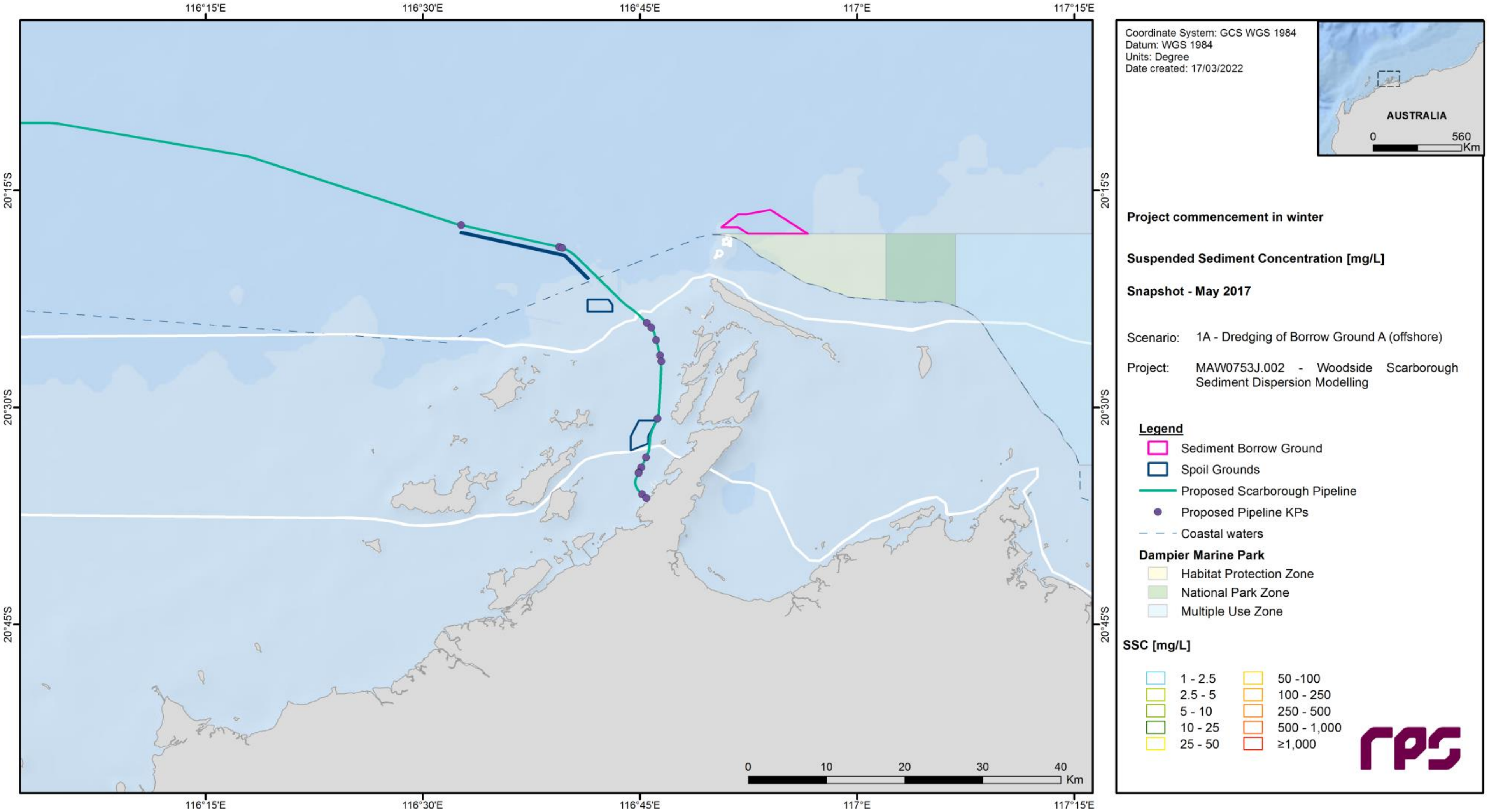

Figure A.11 Predicted instantaneous dredge-excess SSC on 1st May 2017.

A.2 Scenario 2: Dredging Operations Commencing during Summer, with Backfill Material Sourced from Borrow Ground A

A.2.1 Monthly Snapshots

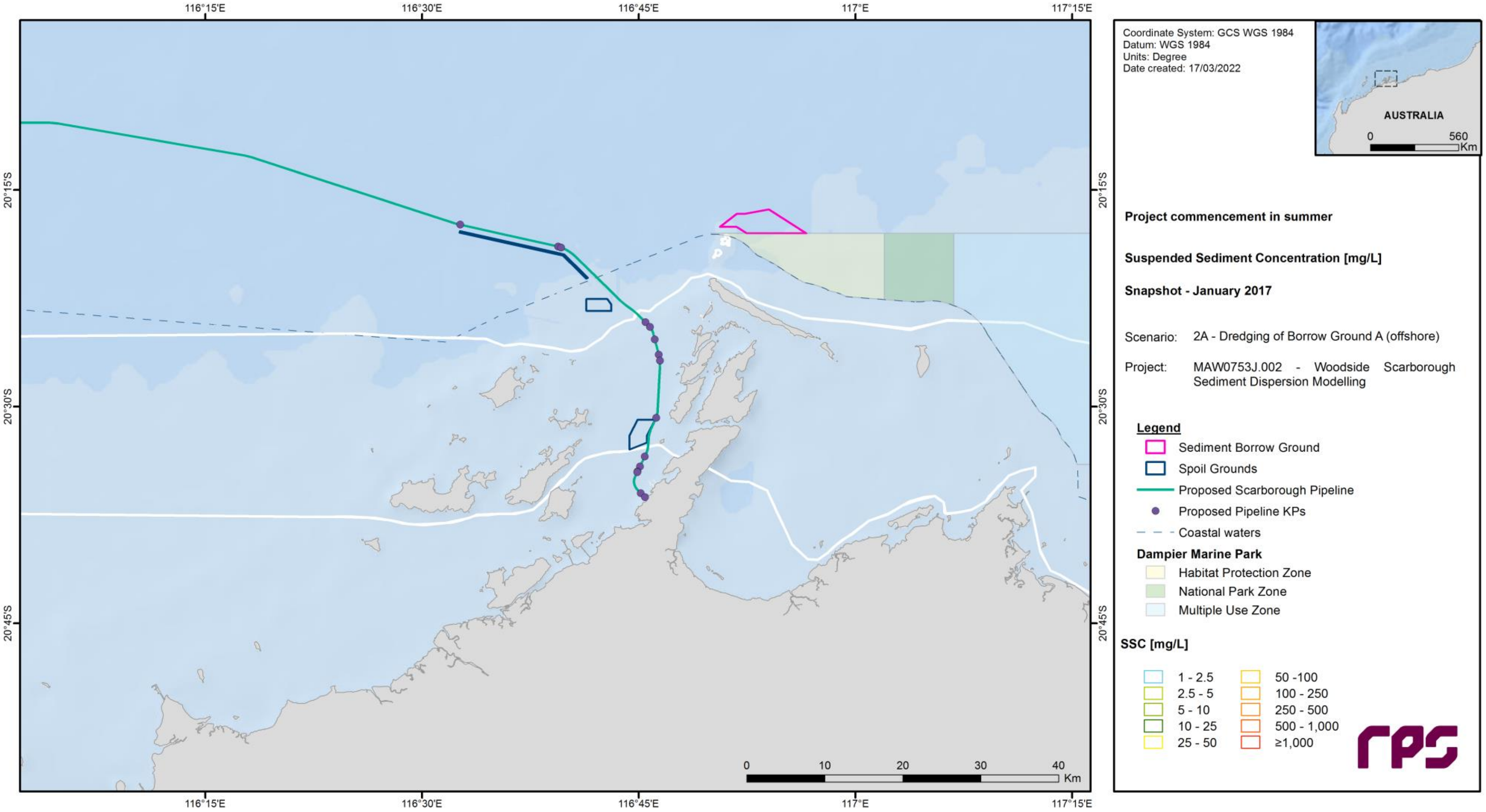

Figure A.12 Predicted instantaneous dredge-excess SSC on 1st January 2017.

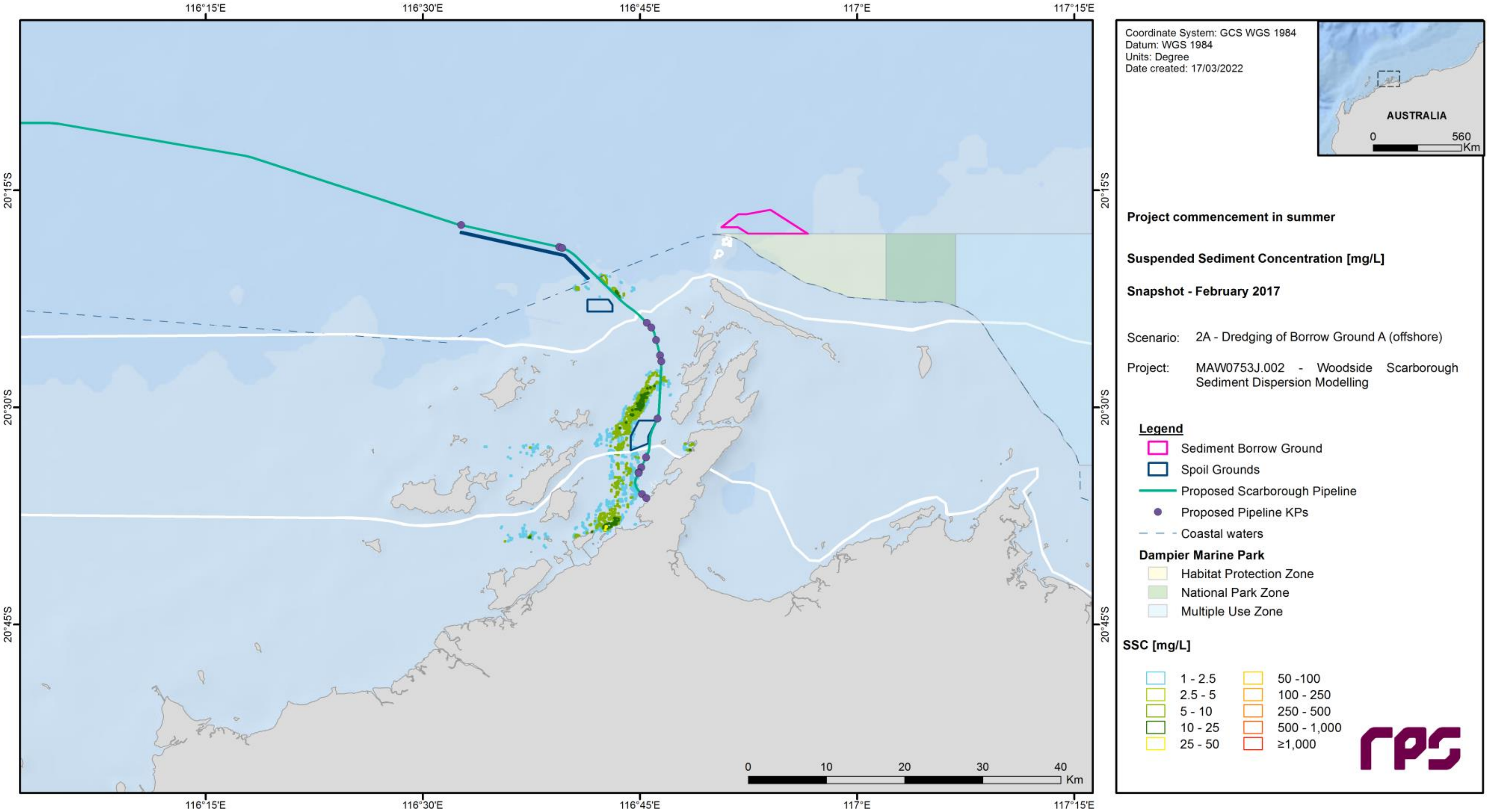

Figure A.13 Predicted instantaneous dredge-excess SSC on 1st February 2017.

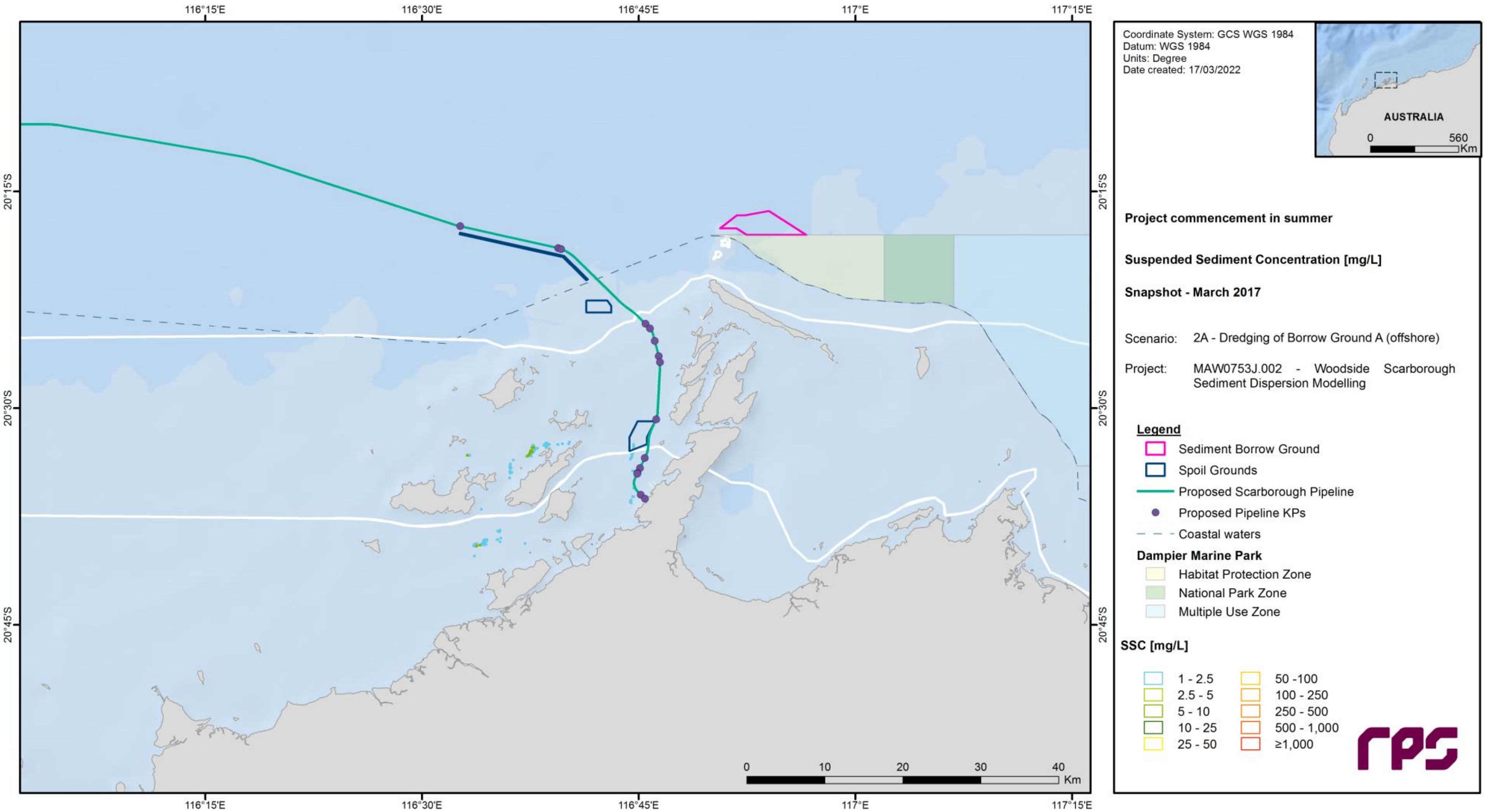

Figure A.14 Predicted instantaneous dredge-excess SSC on 1st March 2017.

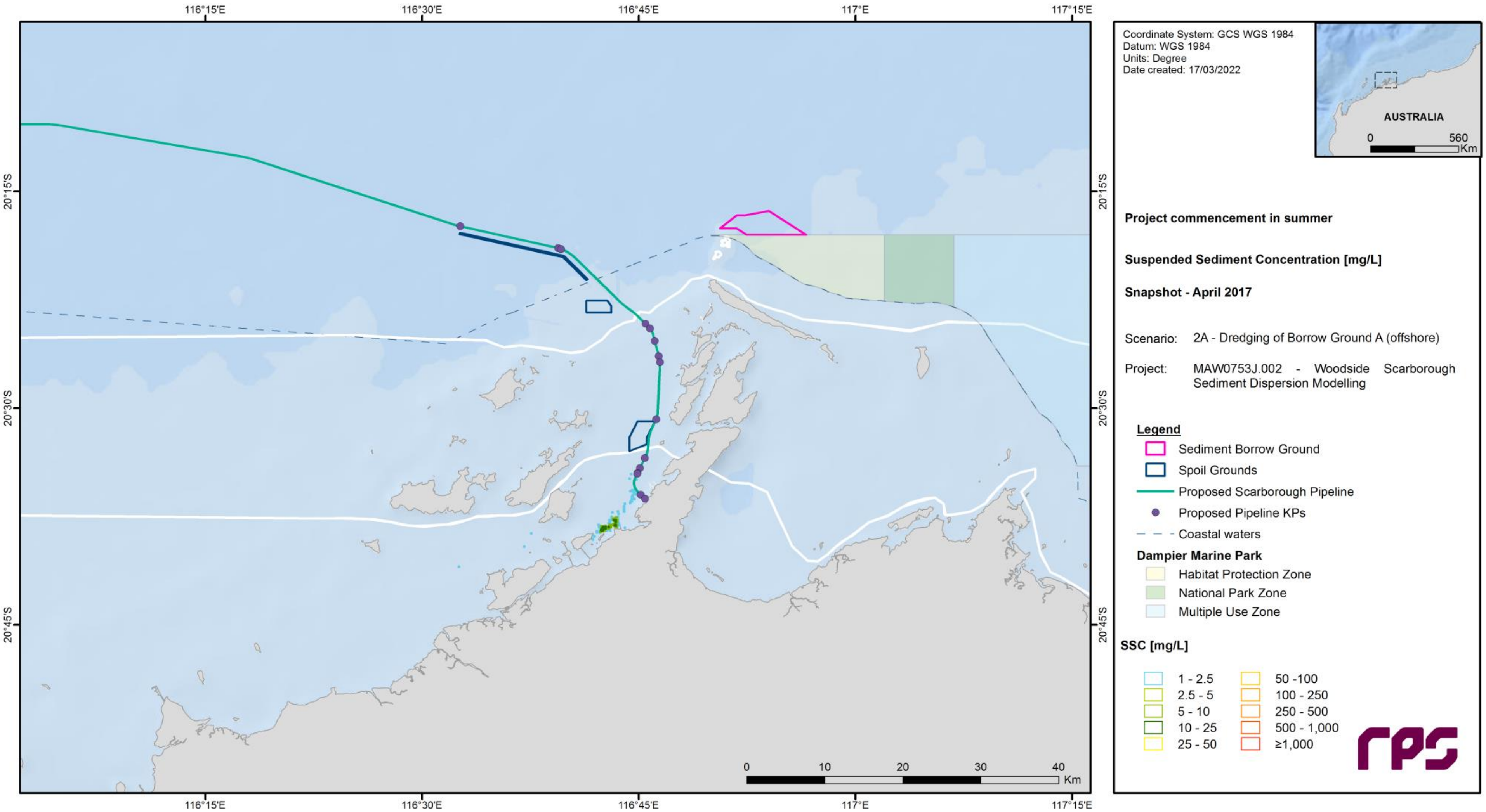

Figure A.15 Predicted instantaneous dredge-excess SSC on 1st April 2017.

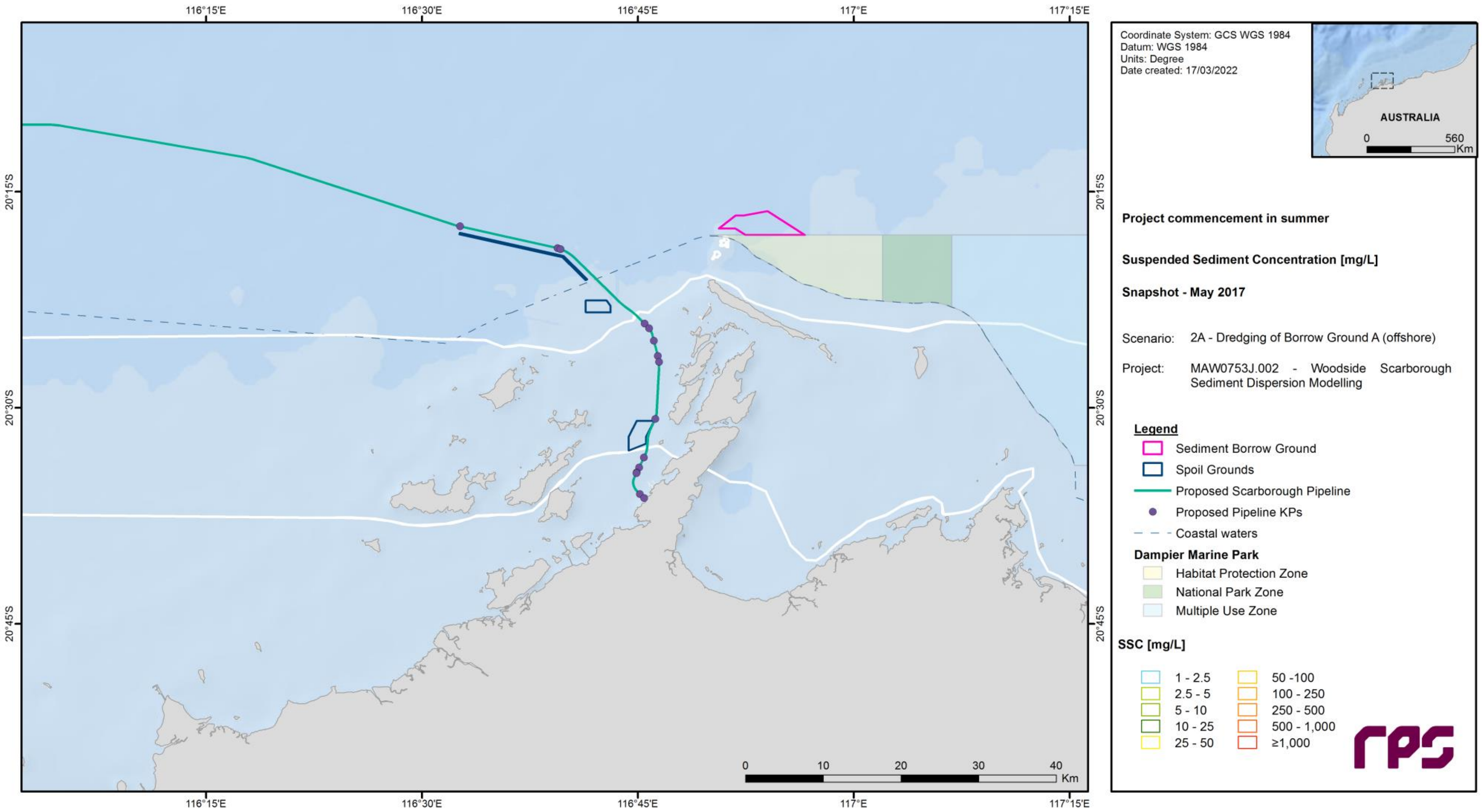

Figure A.16 Predicted instantaneous dredge-excess SSC on 1st May 2017.

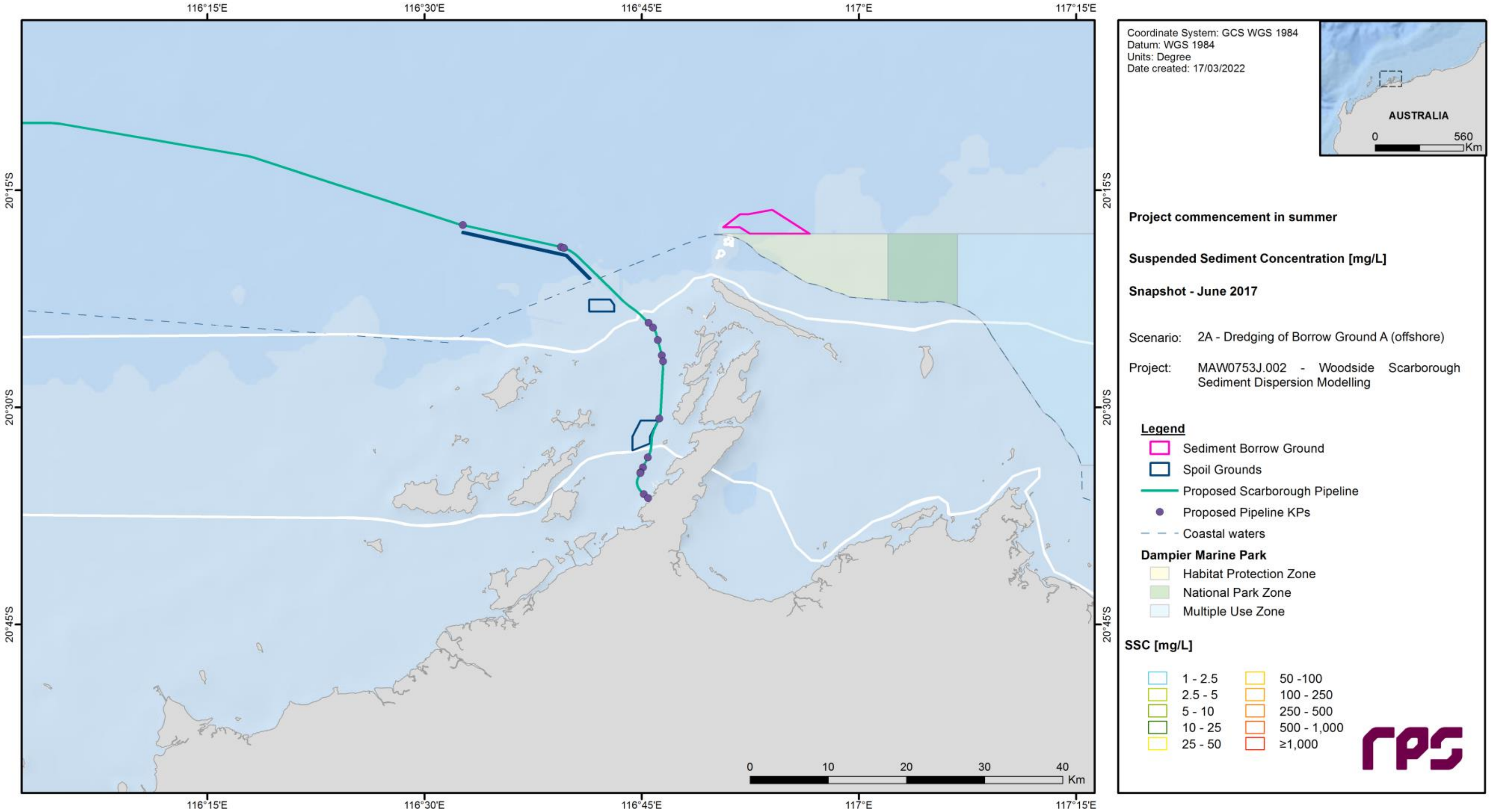

Figure A.17 Predicted instantaneous dredge-excess SSC on 1st June 2017.

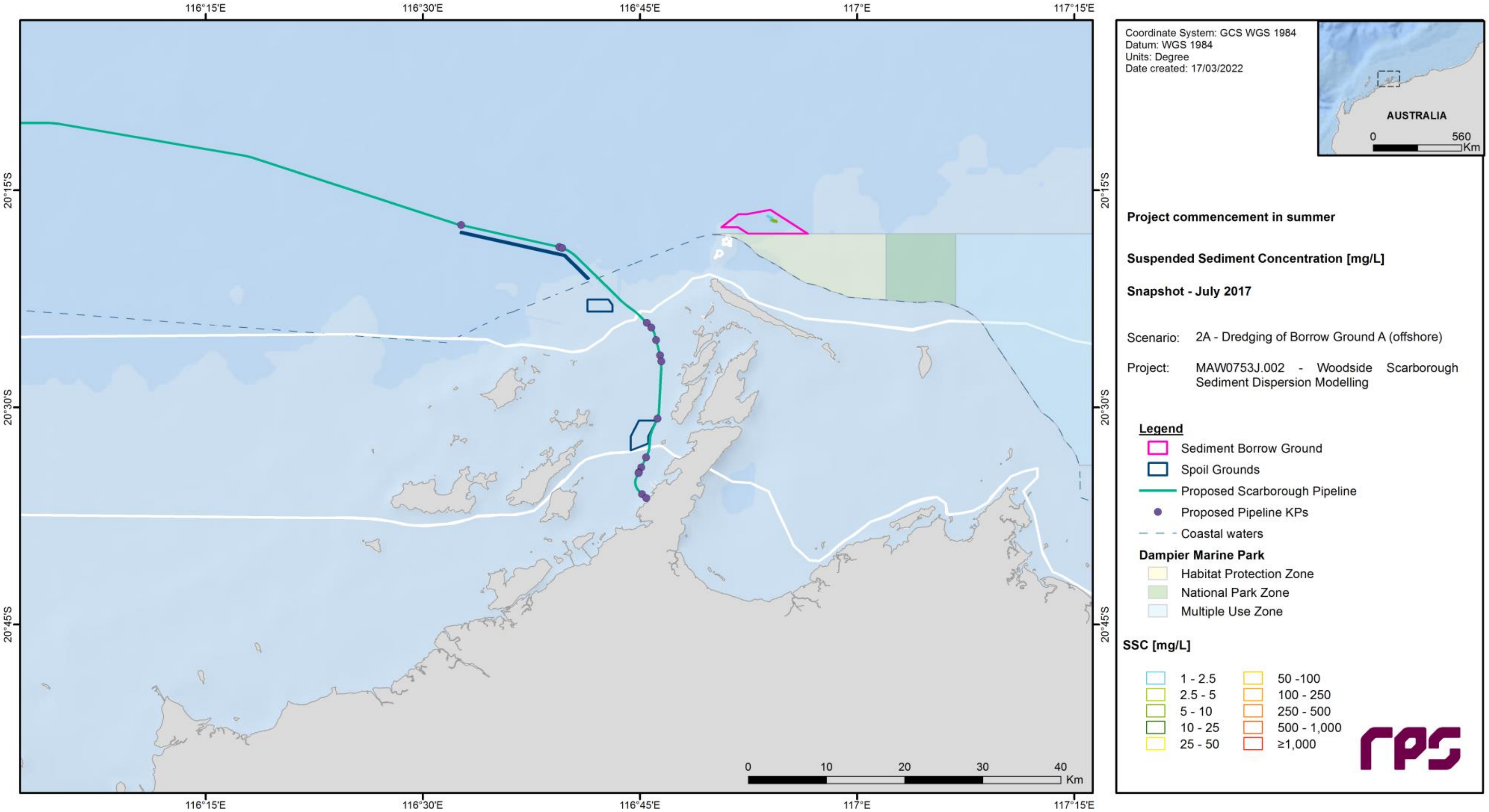

Figure A.18 Predicted instantaneous dredge-excess SSC on 1st July 2017.

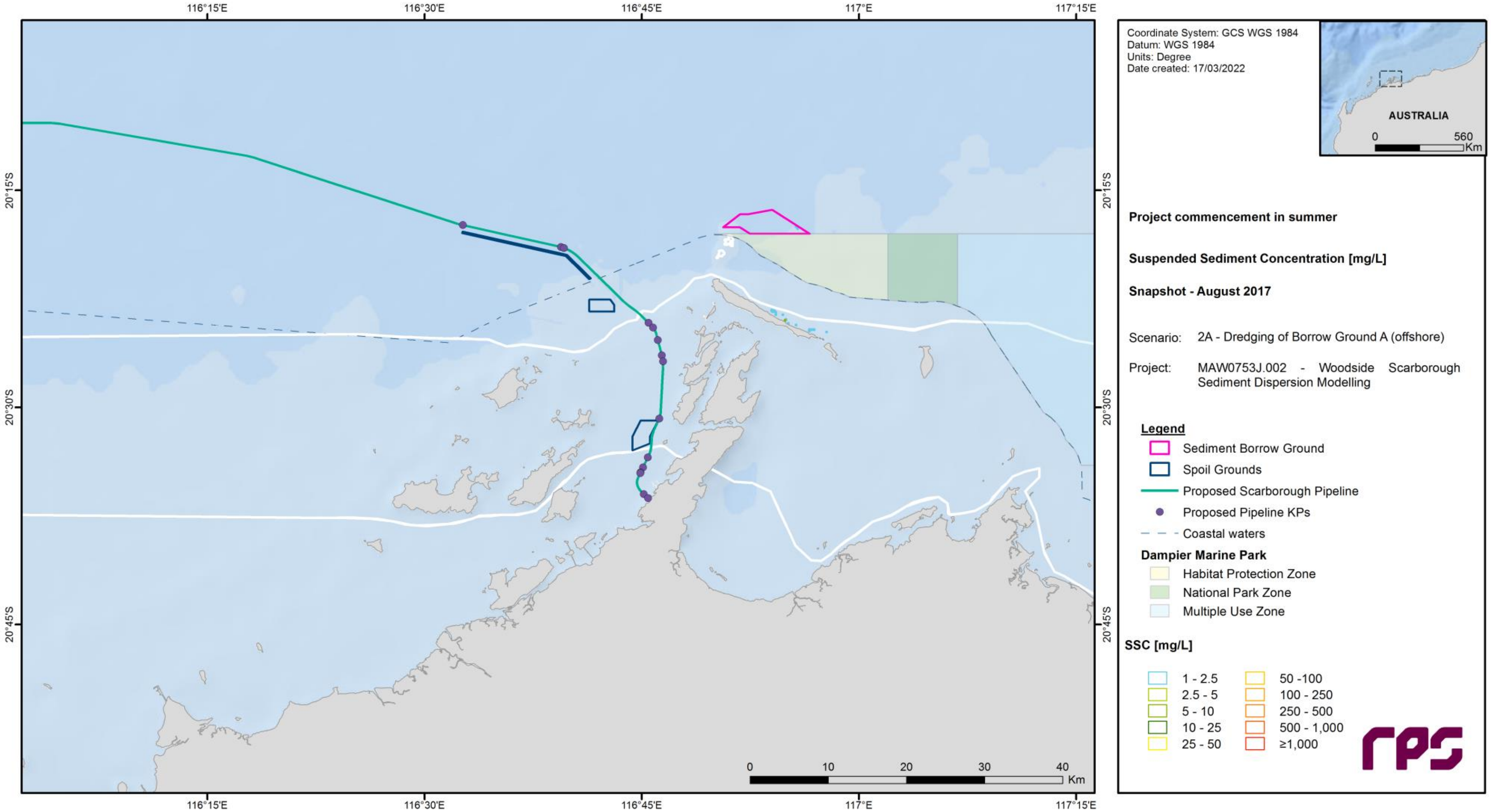

Figure A.19 Predicted instantaneous dredge-excess SSC on 1st August 2017.

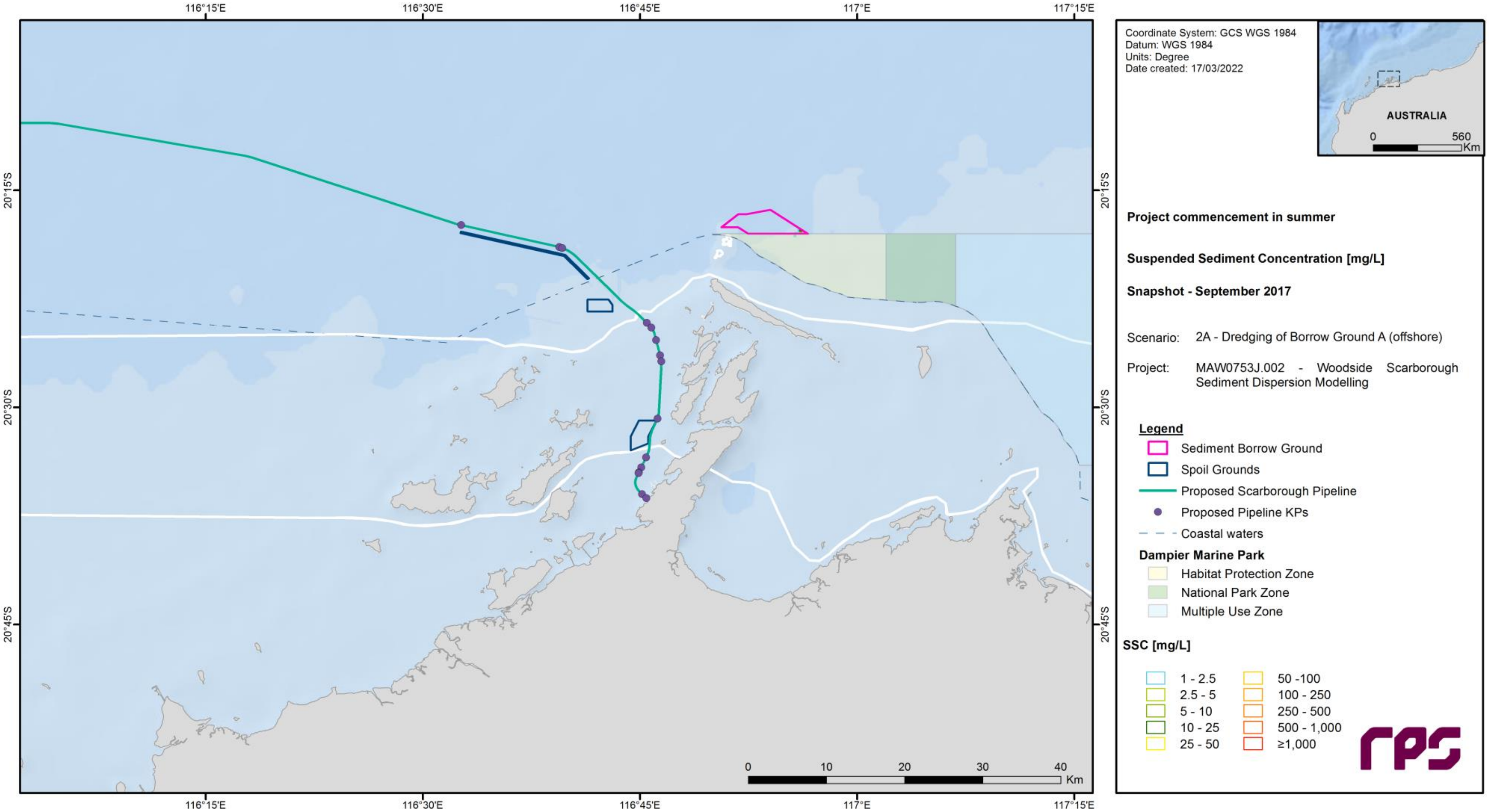

Figure A.20 Predicted instantaneous dredge-excess SSC on 1st September 2017.

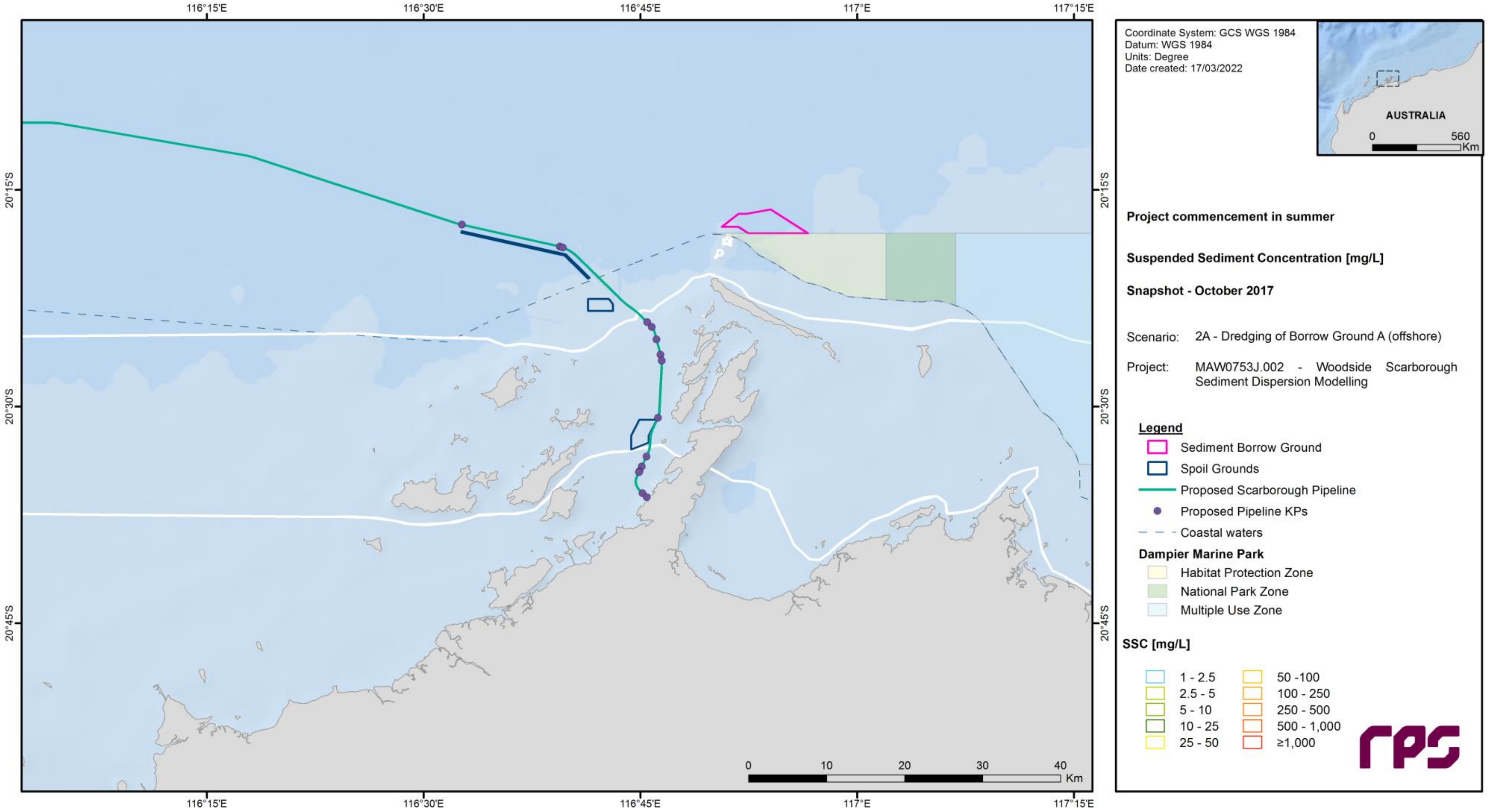

Figure A.21 Predicted instantaneous dredge-excess SSC on 1st October 2017.

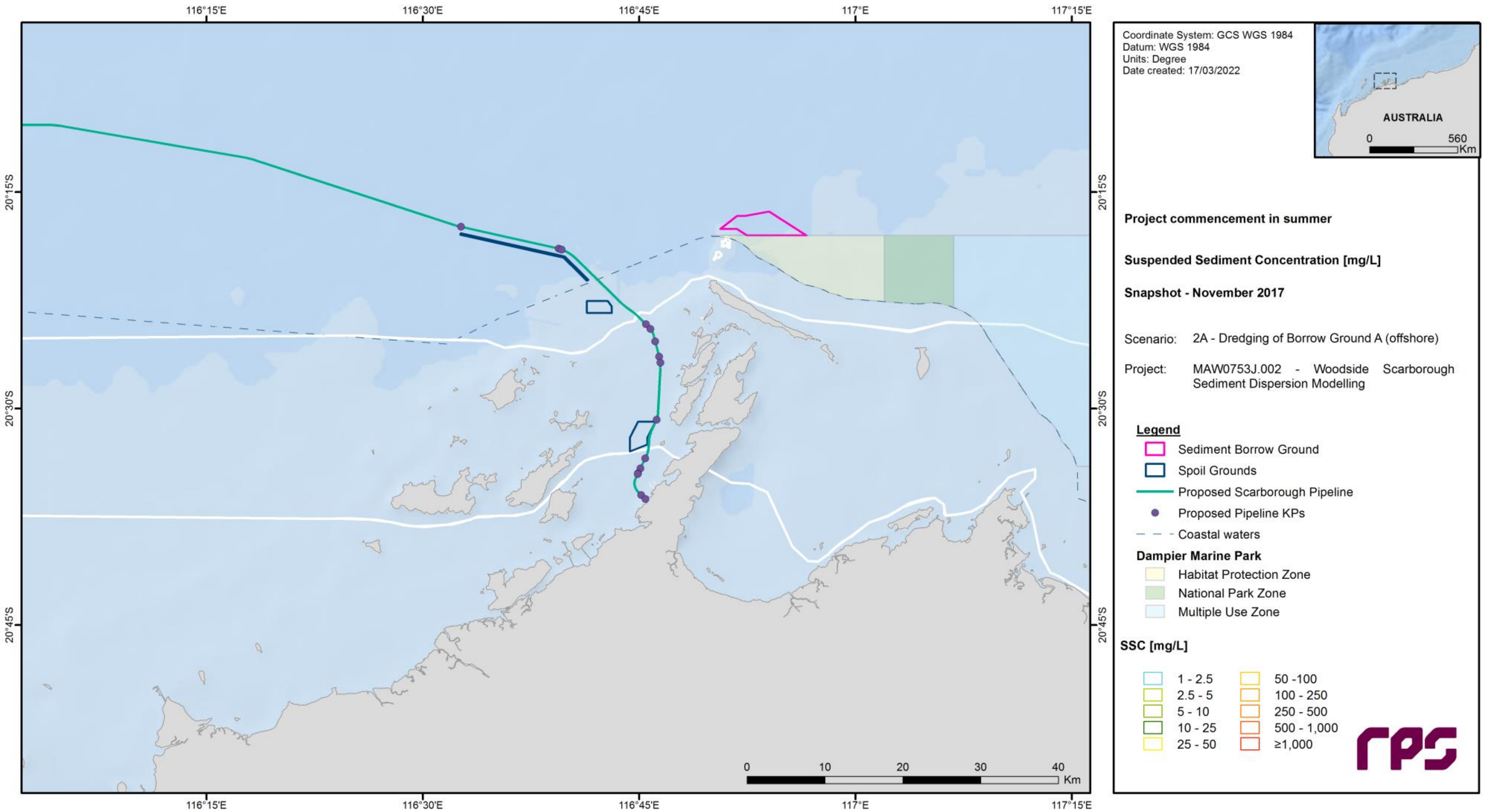

Figure A.22 Predicted instantaneous dredge-excess SSC on 1st November 2017.

Appendix B: Figures of Spatial Outcomes for Activities in Commonwealth Waters

B.1 Scenario 1: Project Commencement in Winter – Commonwealth Waters Activities Only

B.1.1 Overall Percentiles

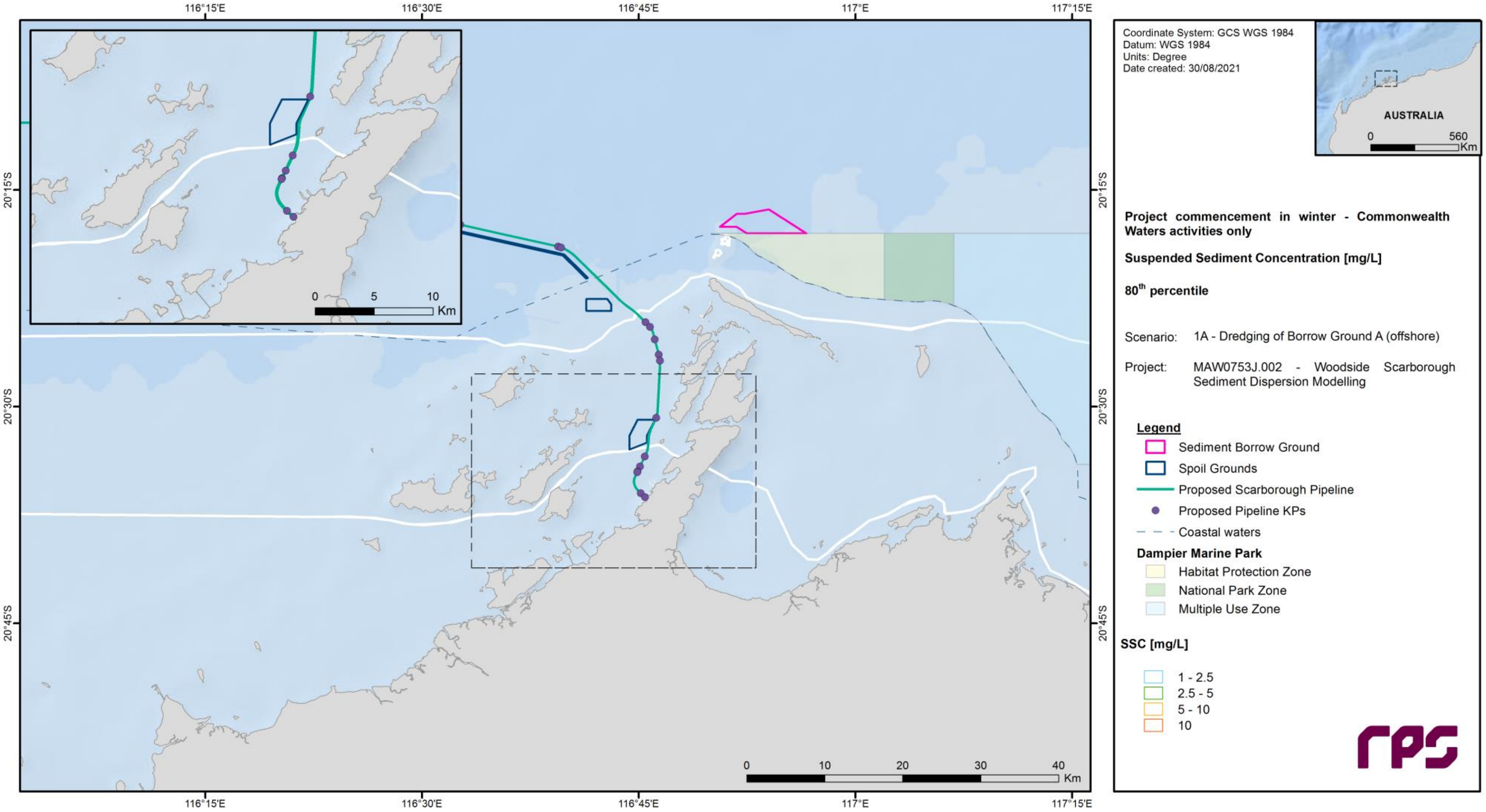

Figure B.23 Predicted 80th percentile dredge-excess SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

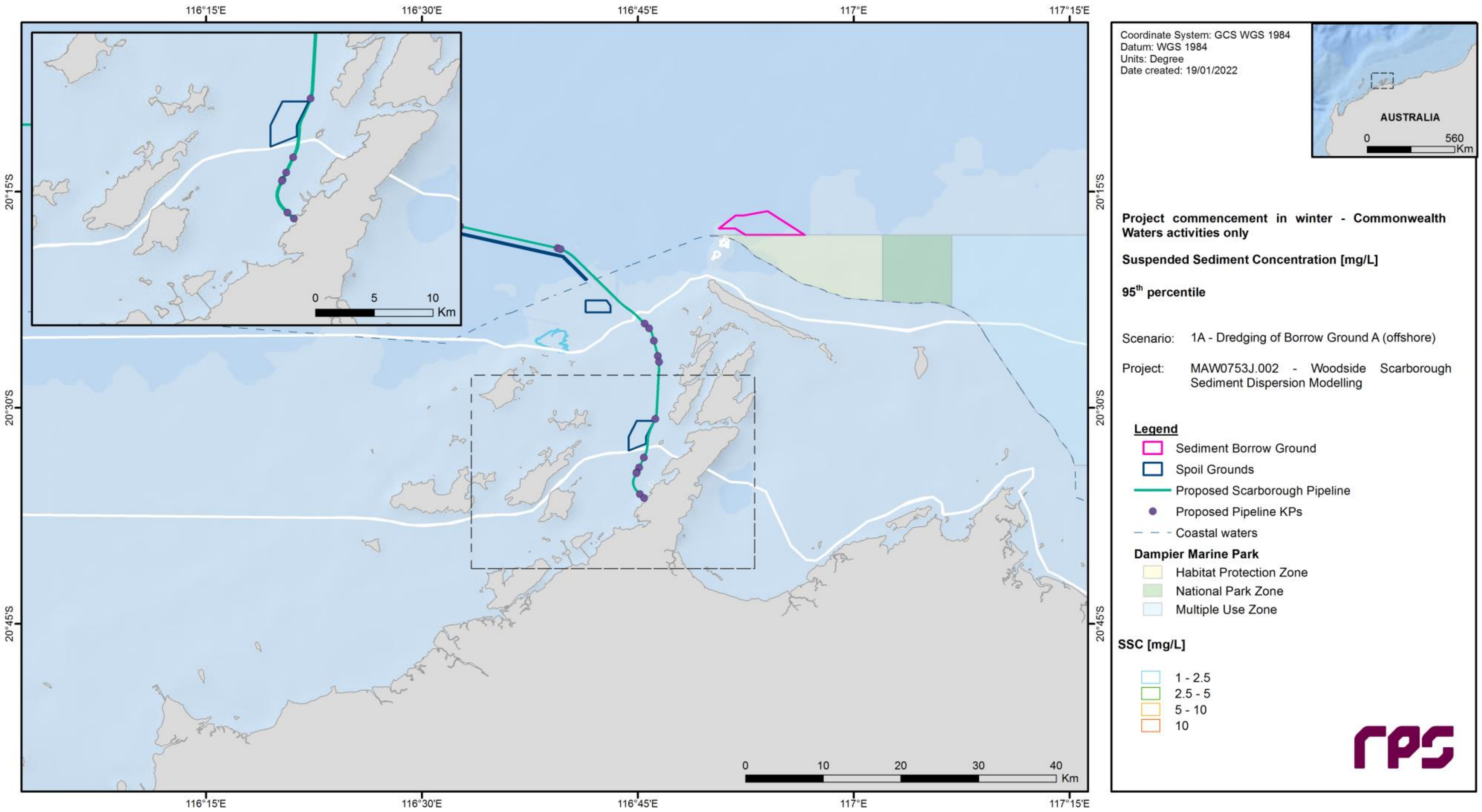

Figure B.24 Predicted 95th percentile dredge-excess SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

B.1.2 Overall Management Zones

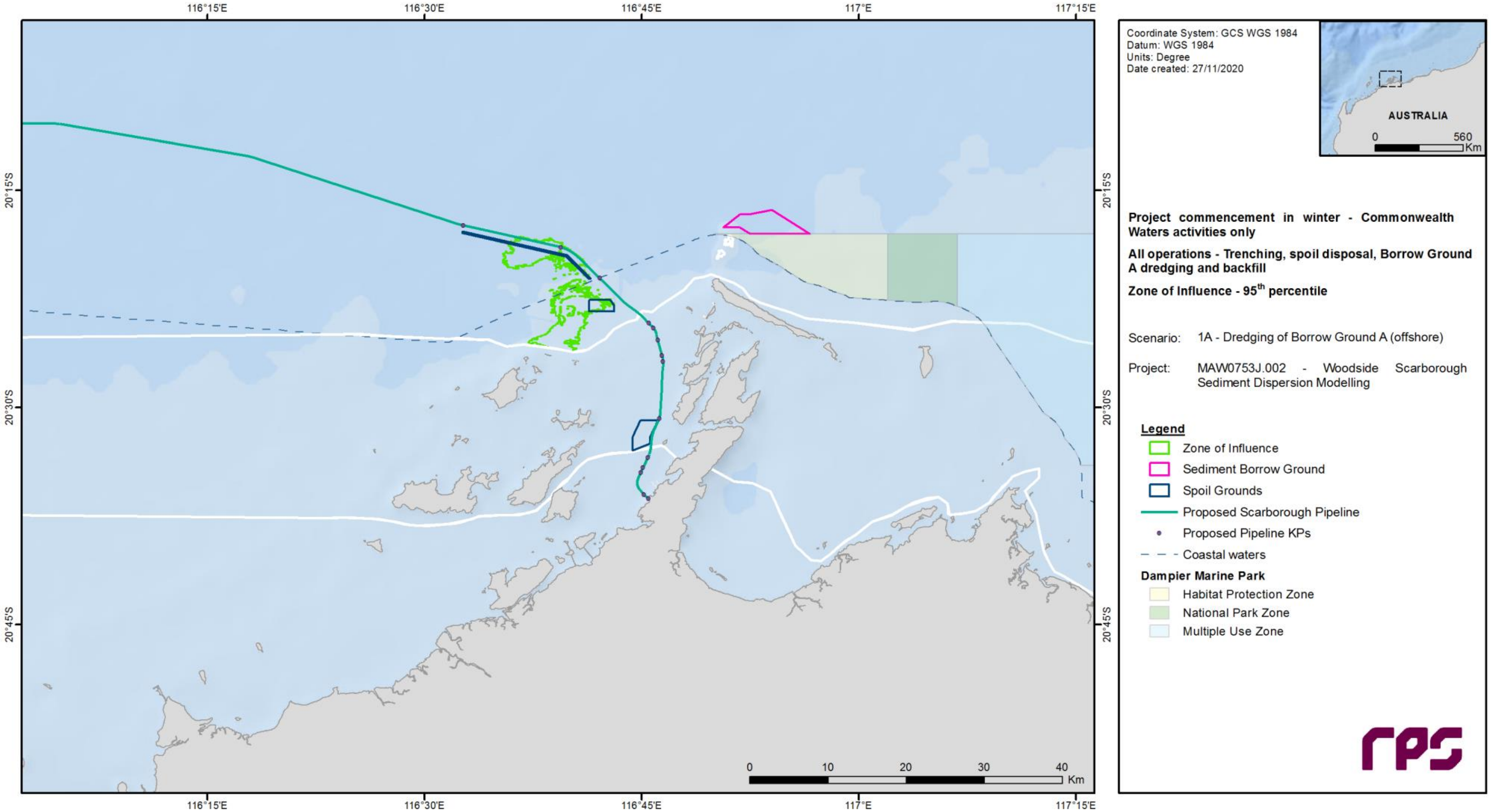

Figure B.25 Predicted 95th percentile Zone of Influence following application of the appropriate spatial thresholds in Table 4.2 to a 24-hour rolling average of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

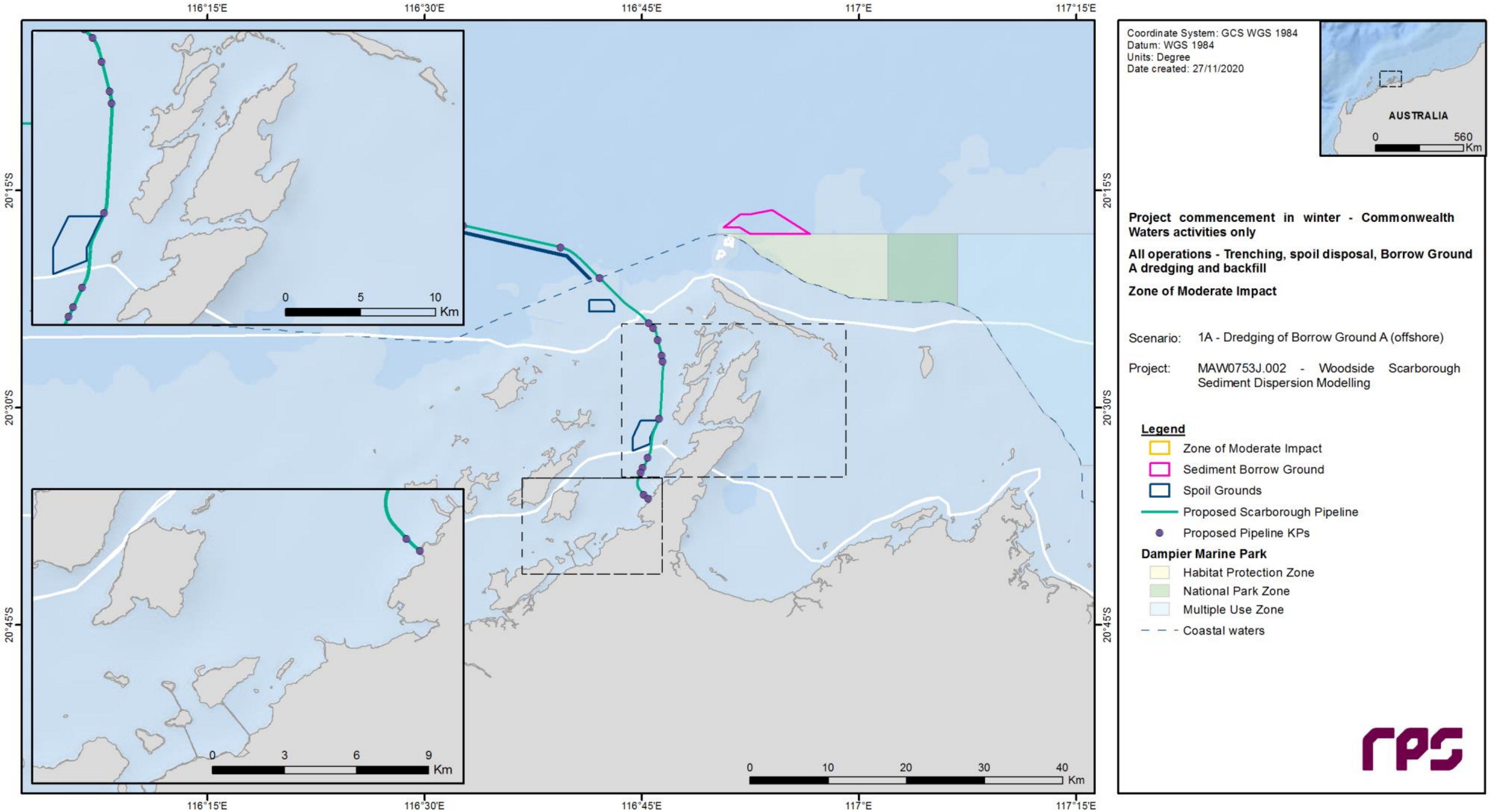

Figure B.26 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

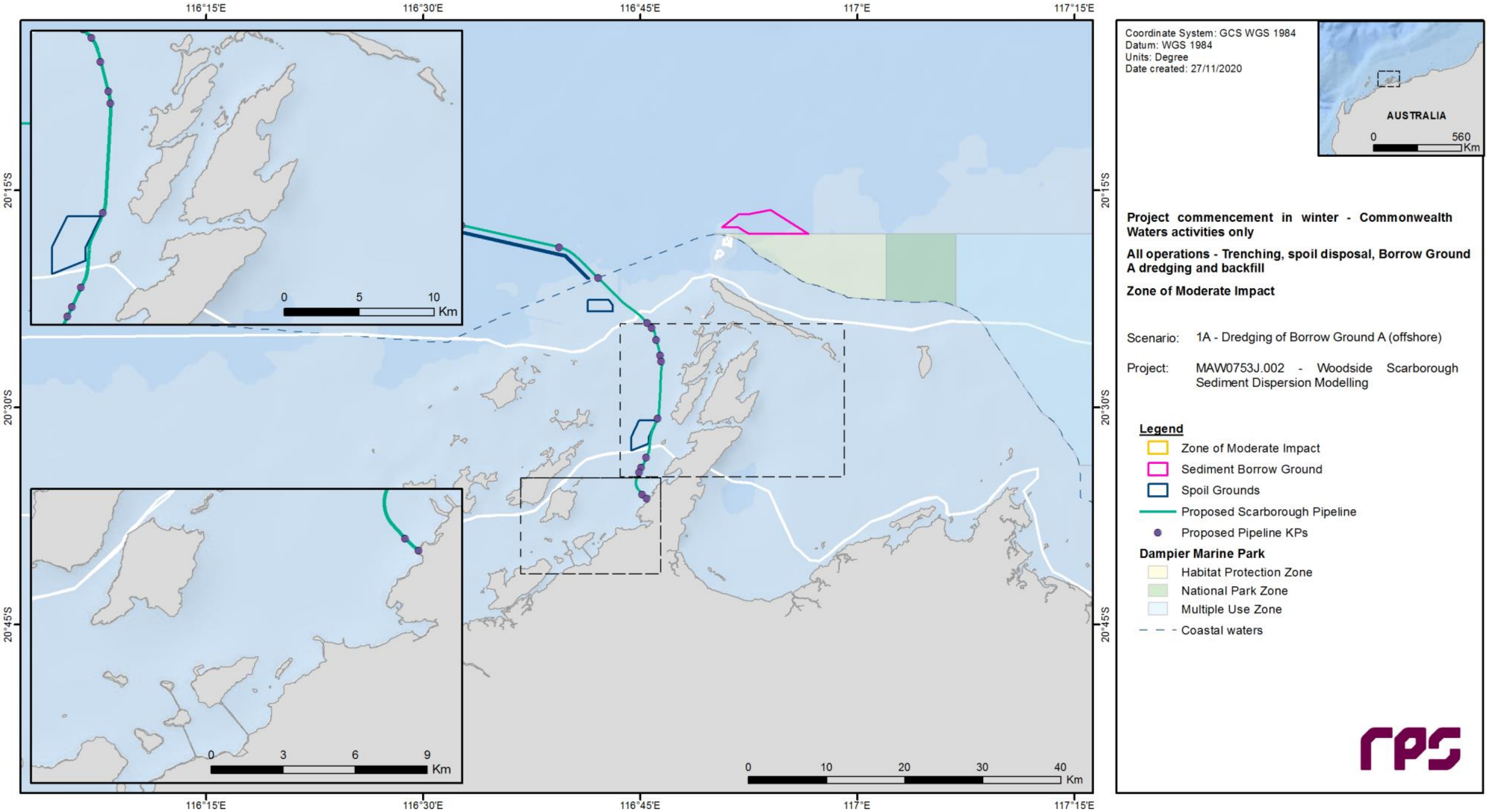

Figure B.27 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

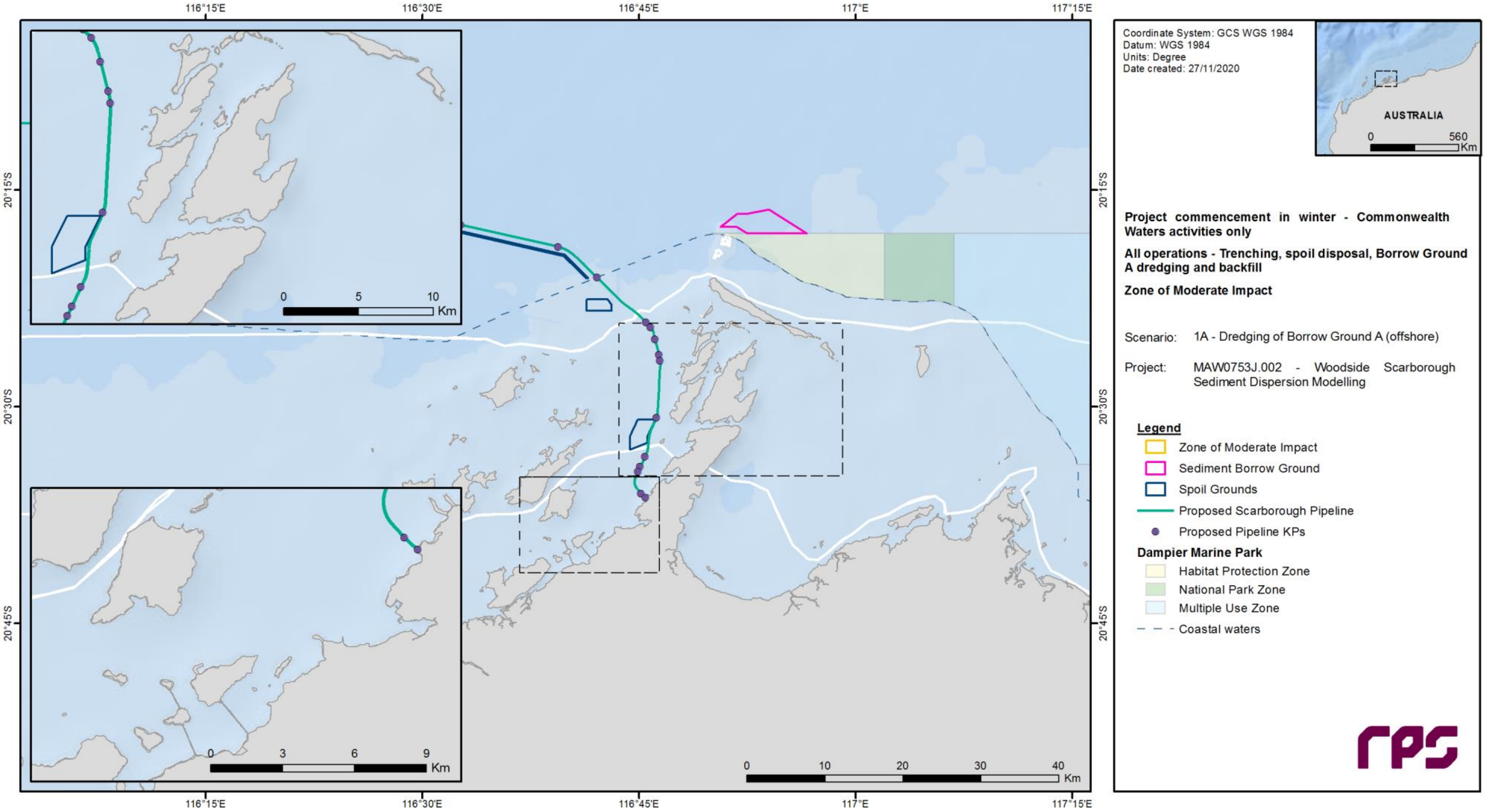

Figure B.28 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

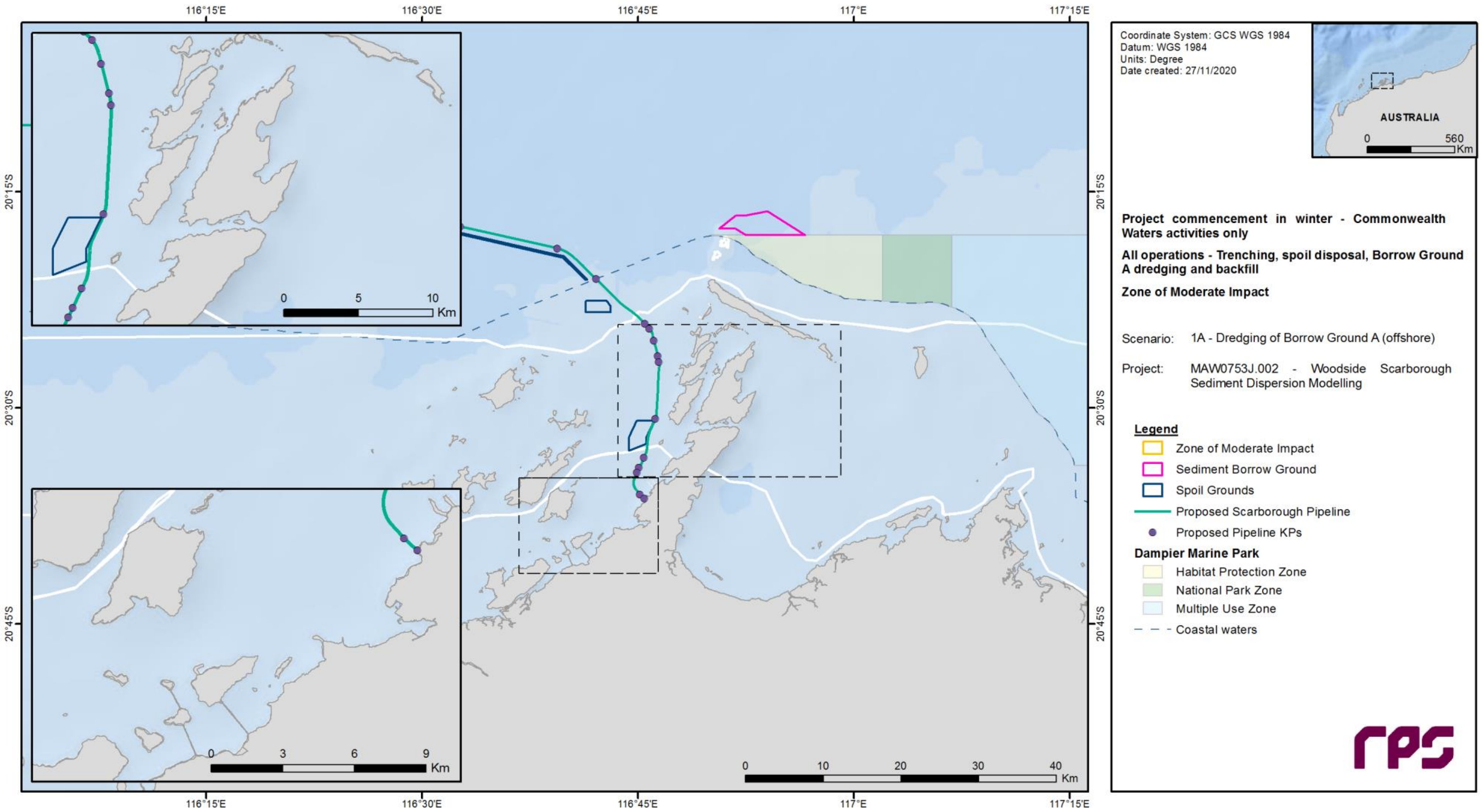

Figure B.29 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

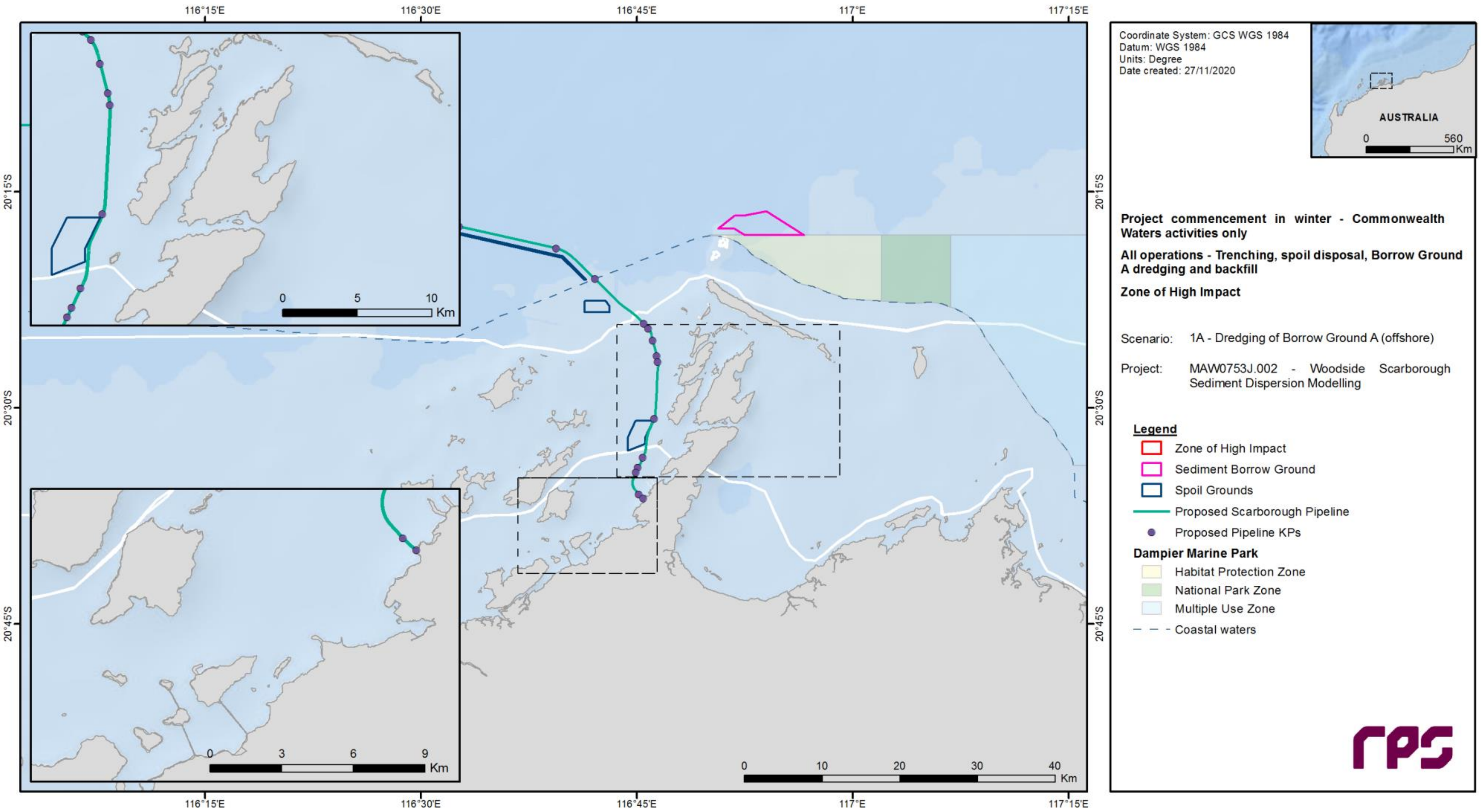

Figure B.30 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

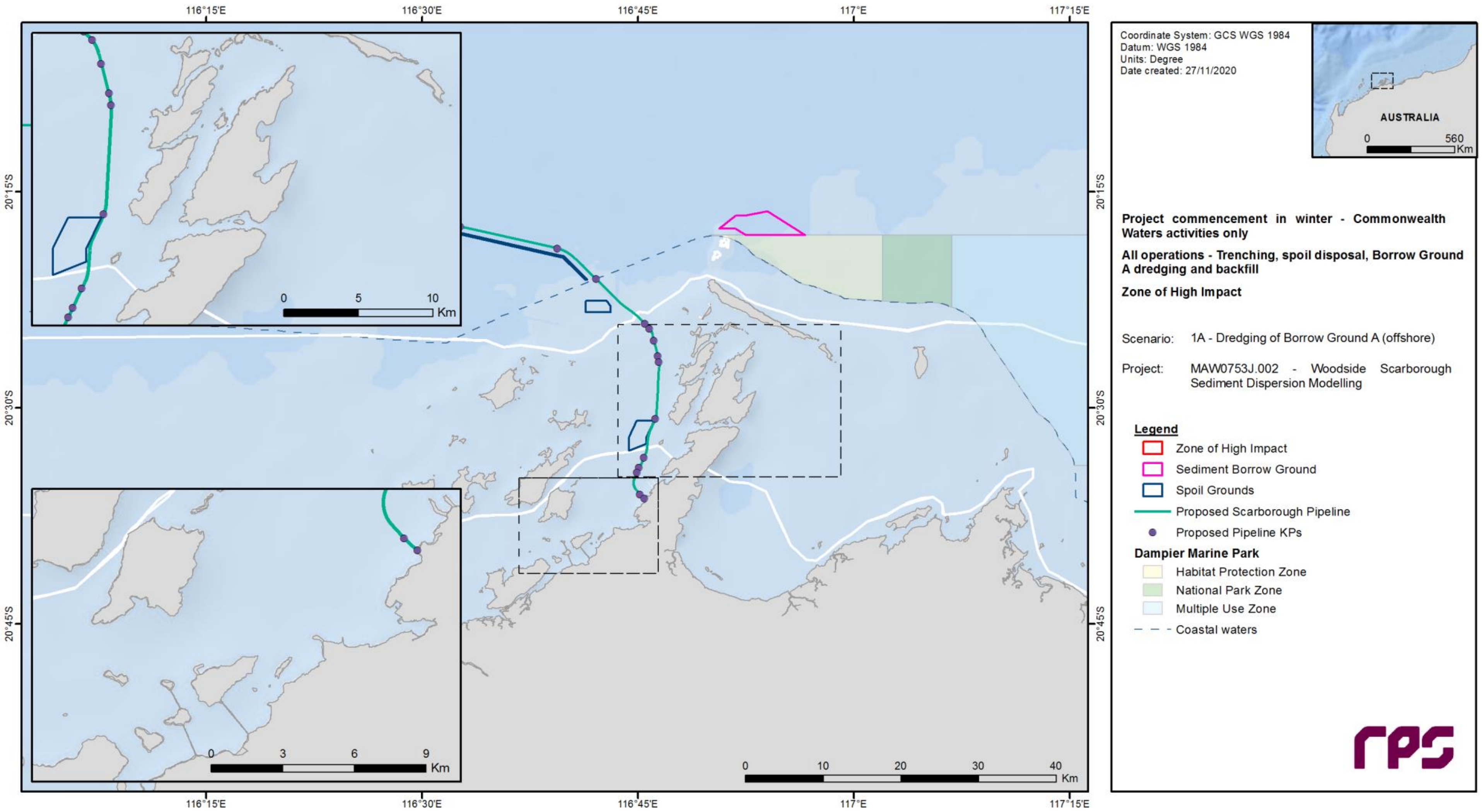

Figure B.31 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

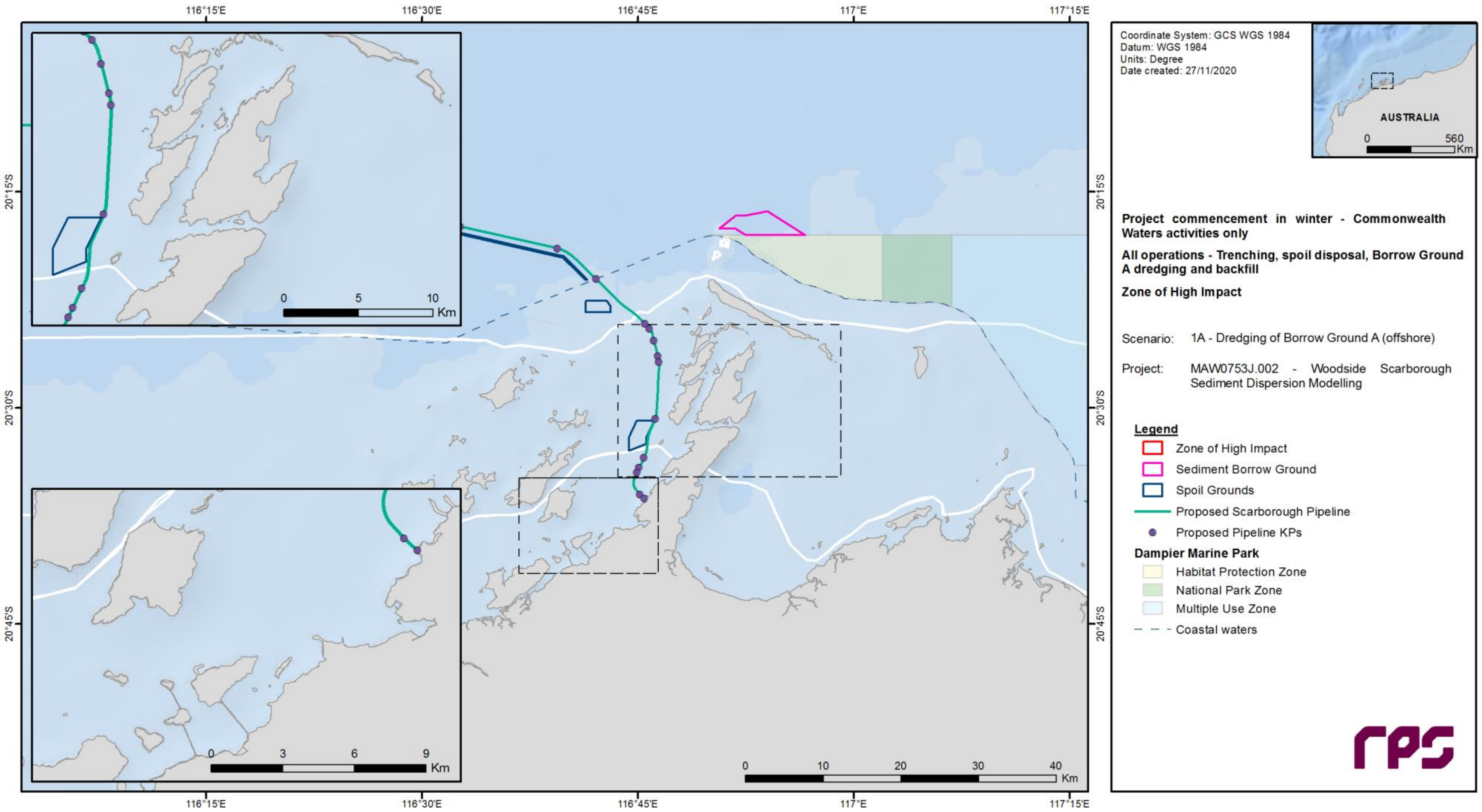

Figure B.32 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

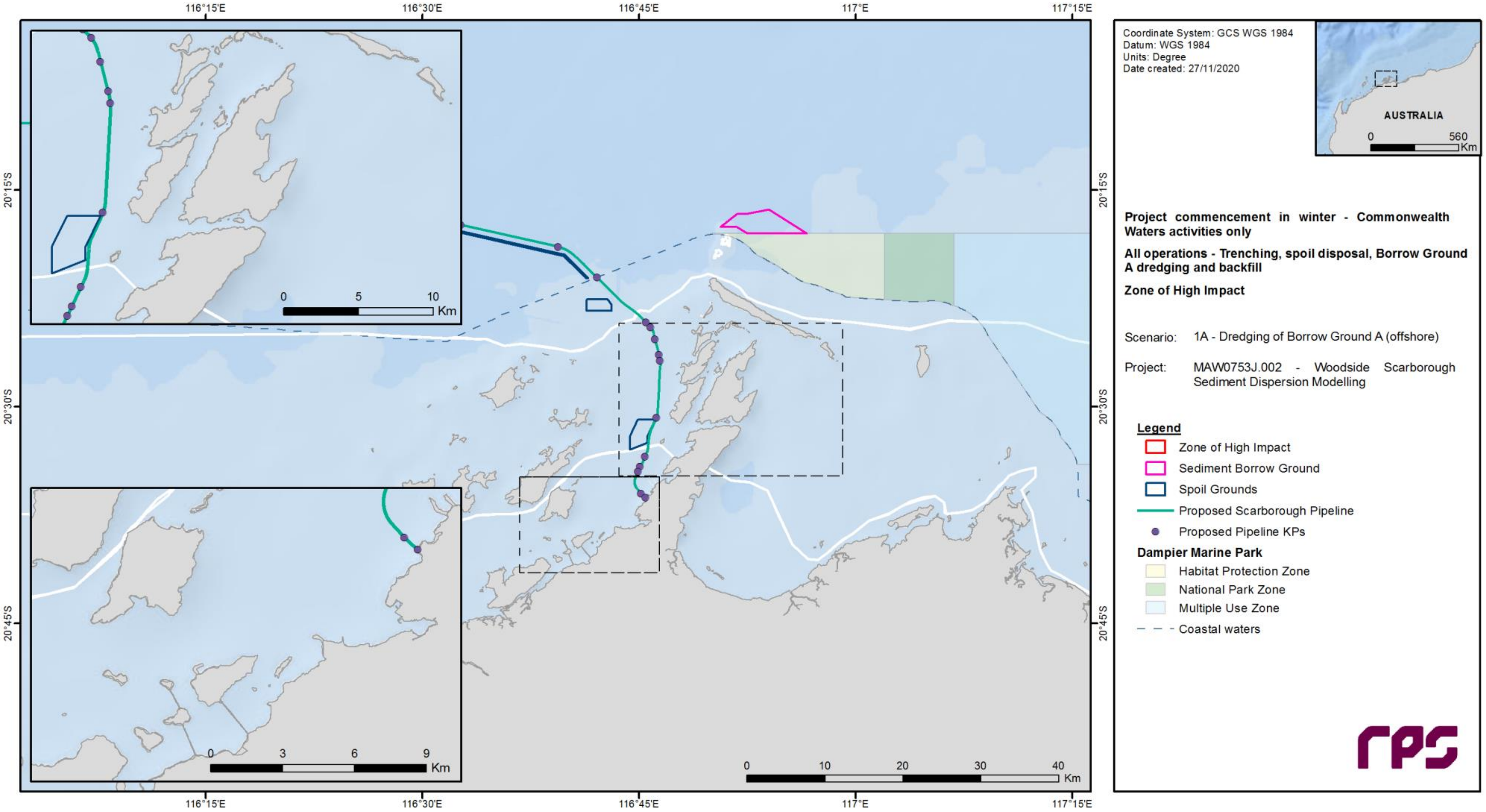

Figure B.33 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st August 2016 to 23rd May 2017).

B.2 Scenario 2: Project Commencement in Summer – Commonwealth Waters Activities Only

B.2.1 Overall Percentiles

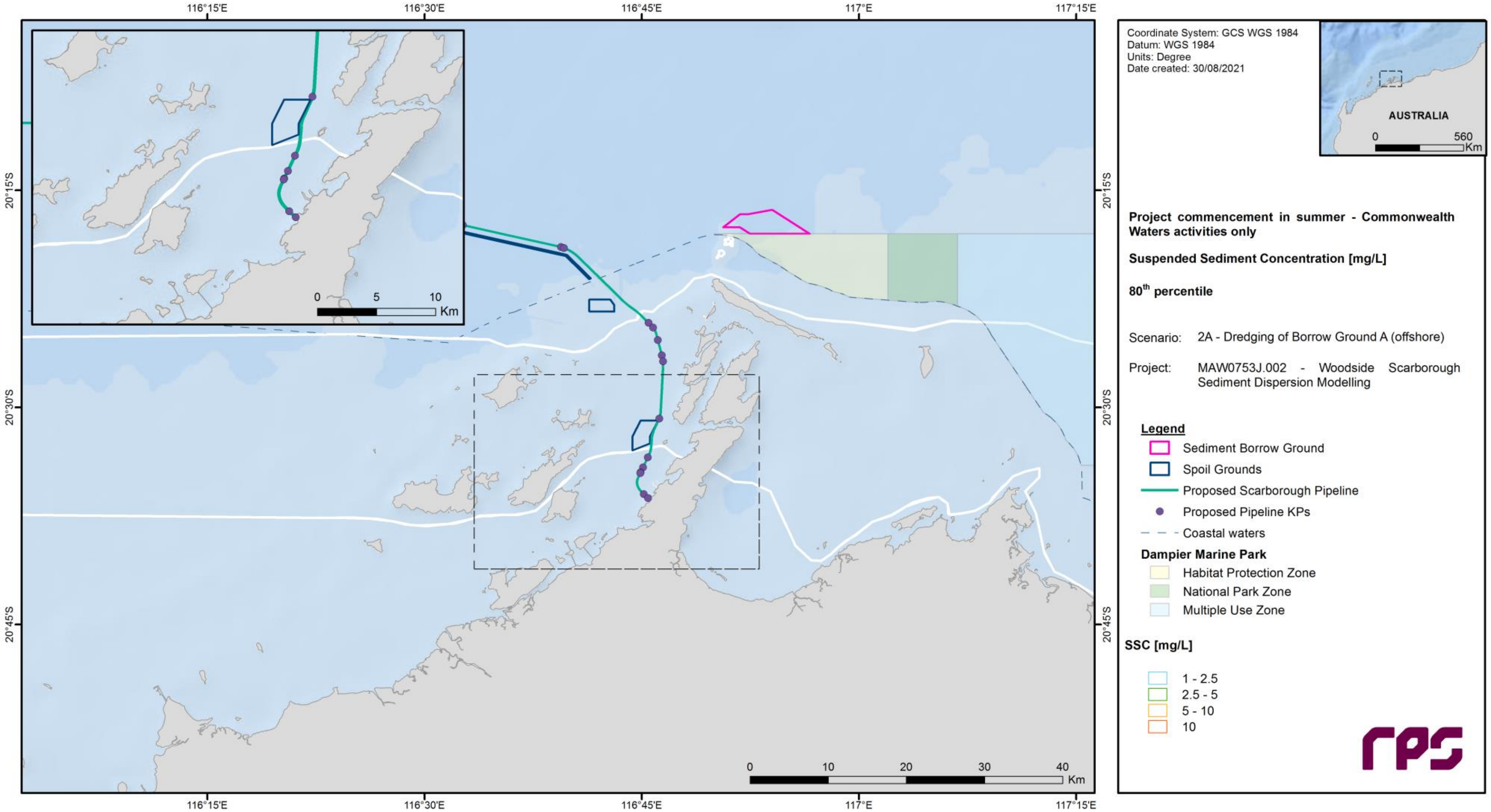

Figure B.34 Predicted 80th percentile dredge-excess SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

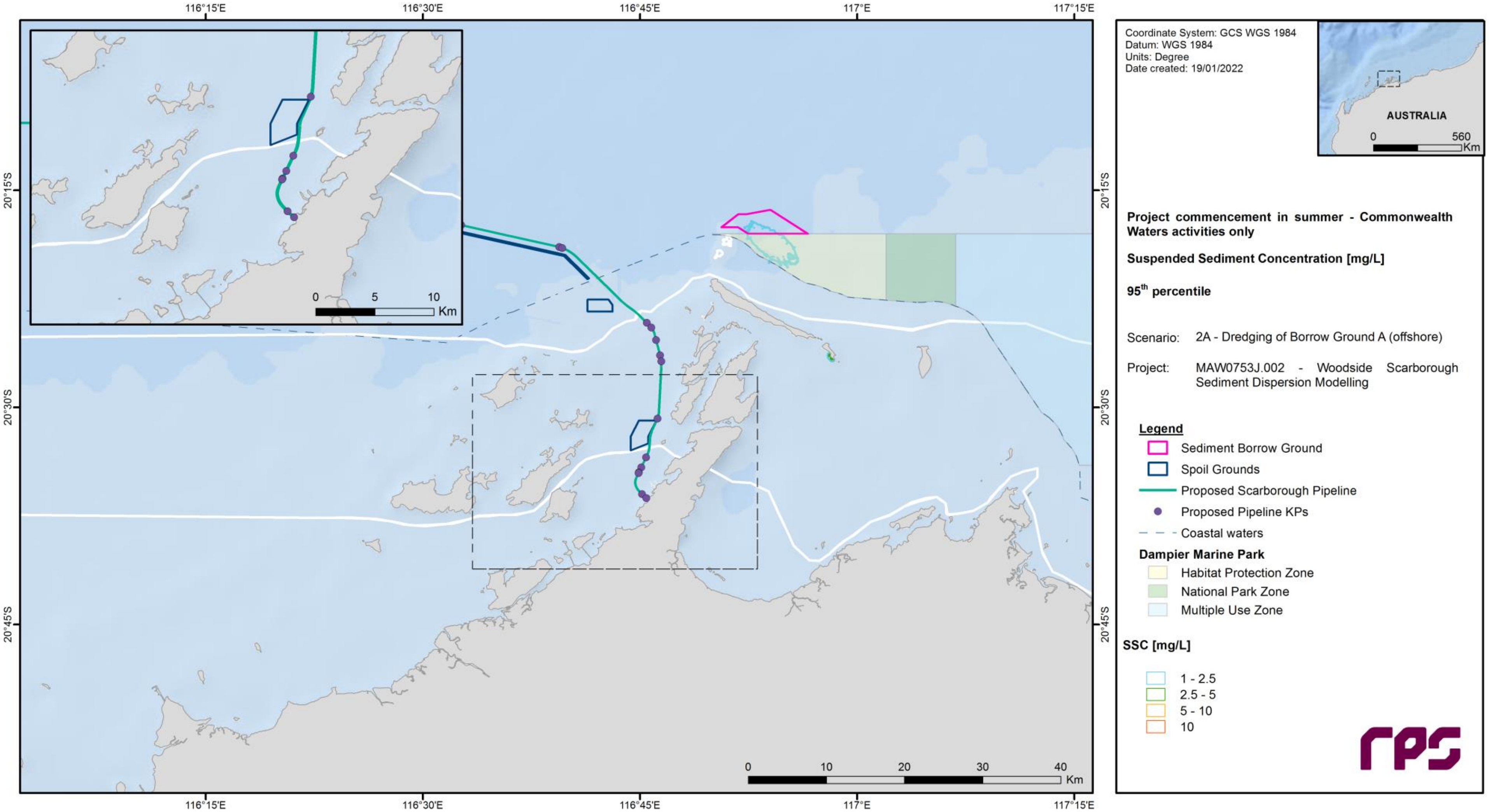

Figure B.35 Predicted 95th percentile dredge-excess SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

B.2.2 Overall Management Zones

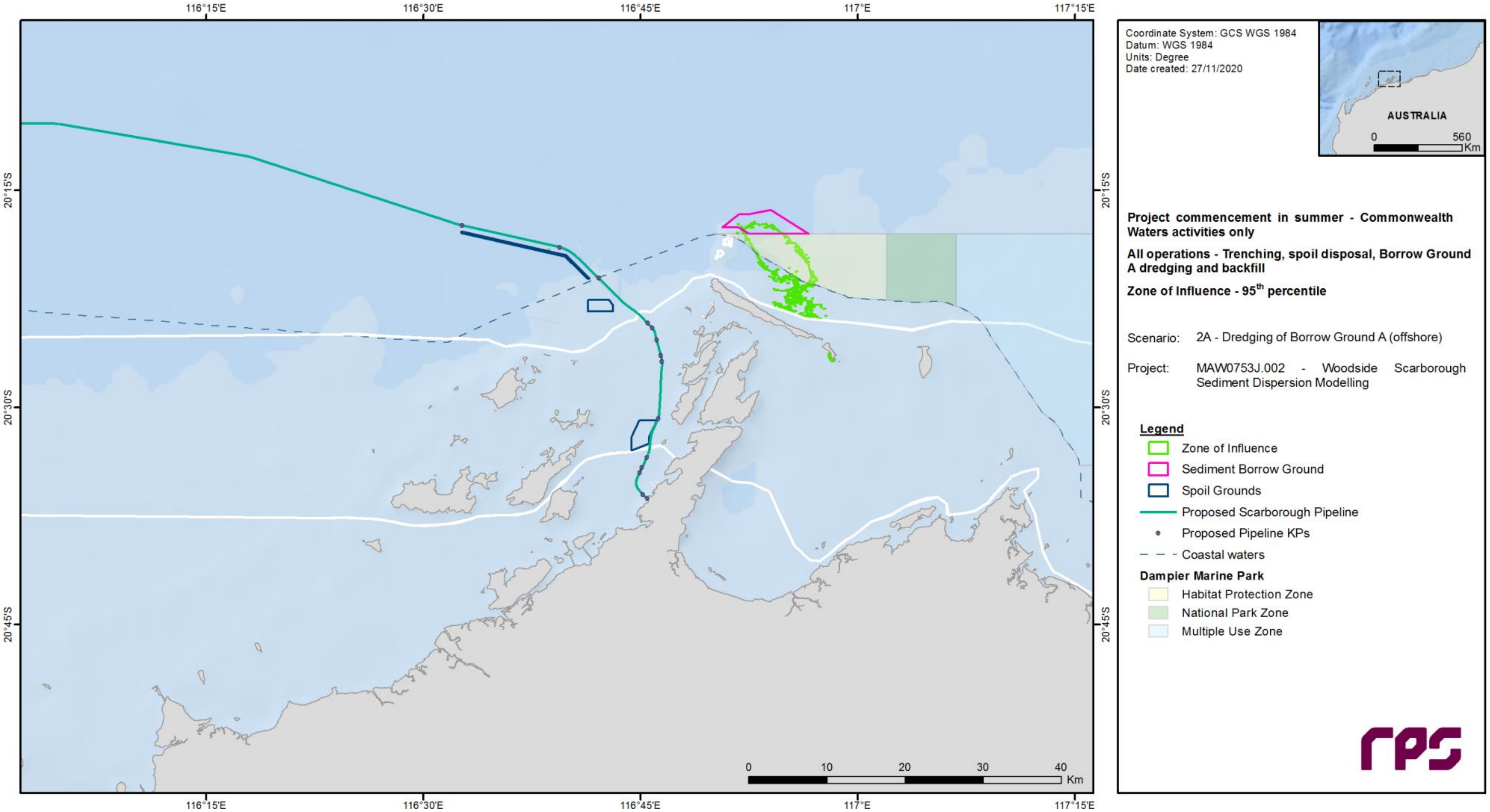

Figure B.36 Predicted 95th percentile Zone of Influence following application of the appropriate spatial thresholds in Table 4.2 to a 24-hour rolling average of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

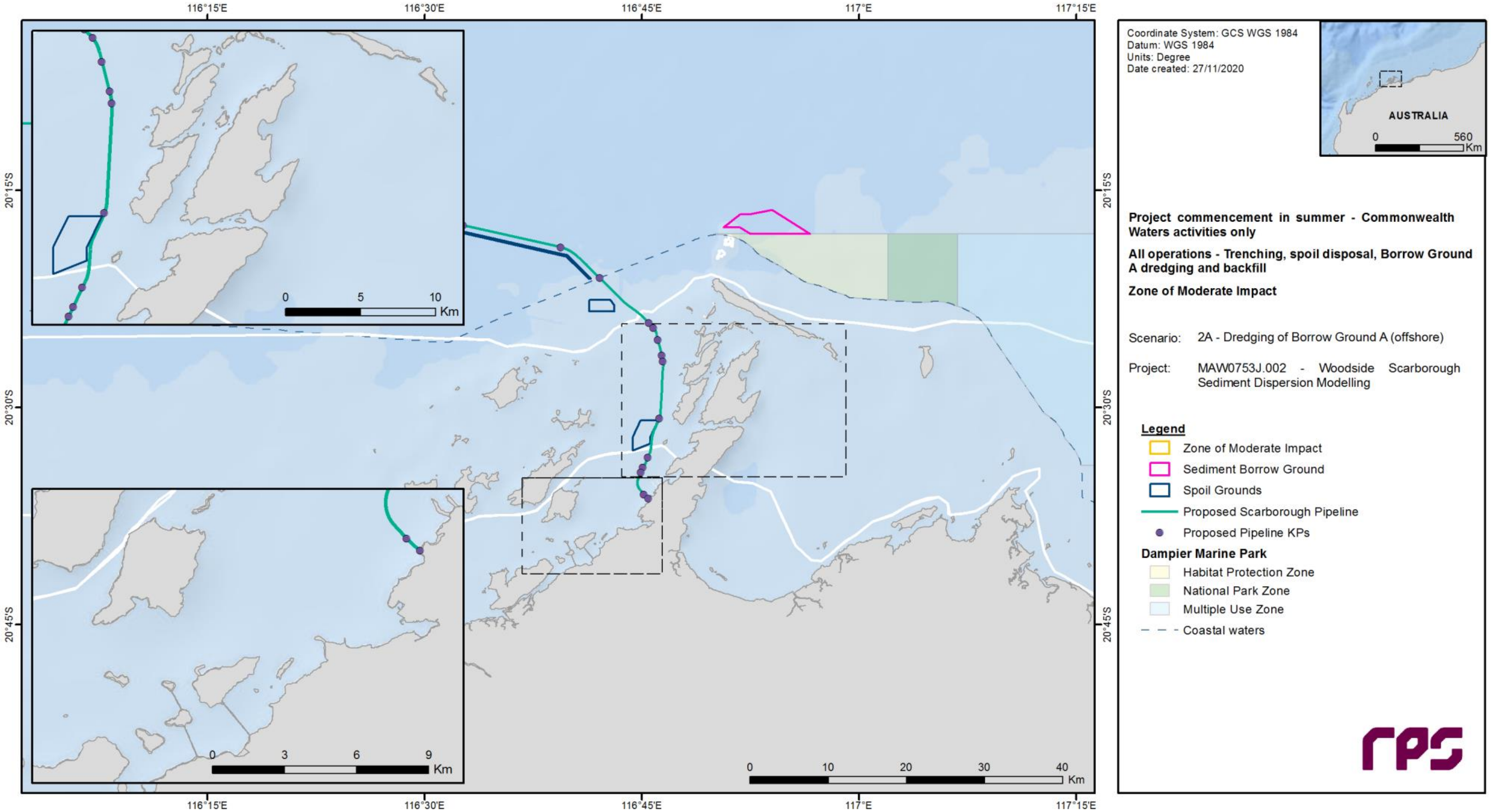

Figure B.37 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

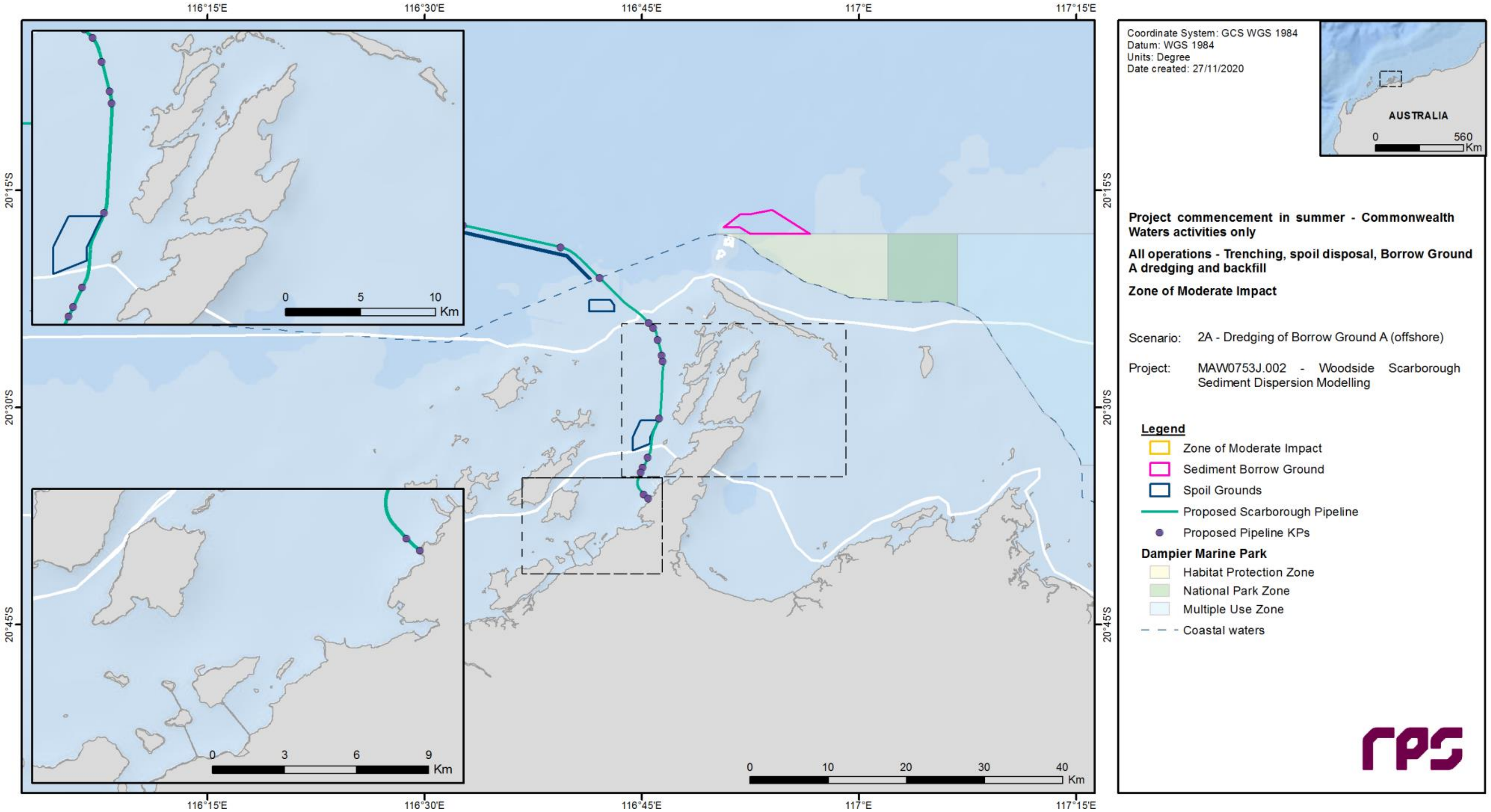

Figure B.38 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

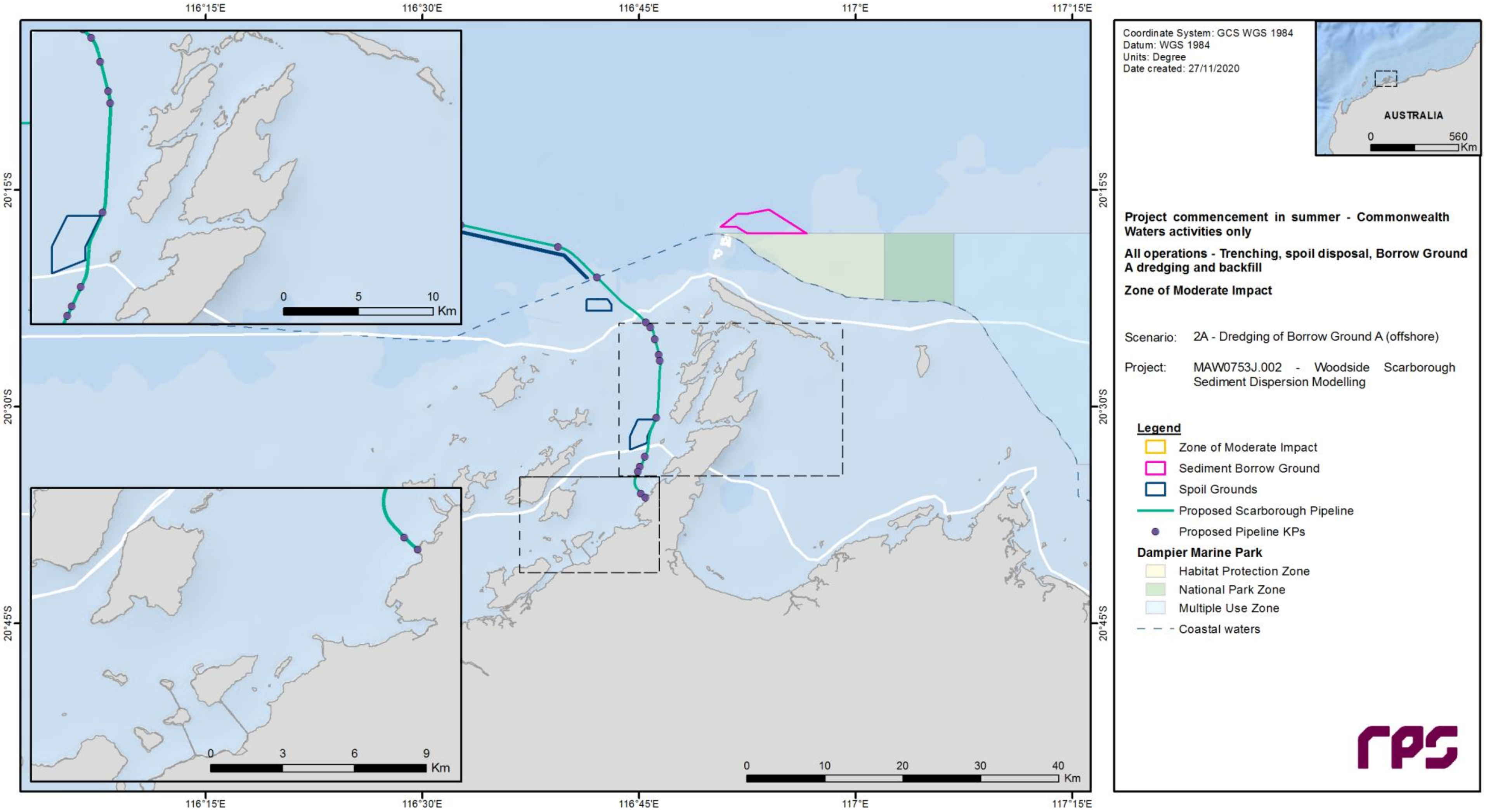

Figure B.39 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

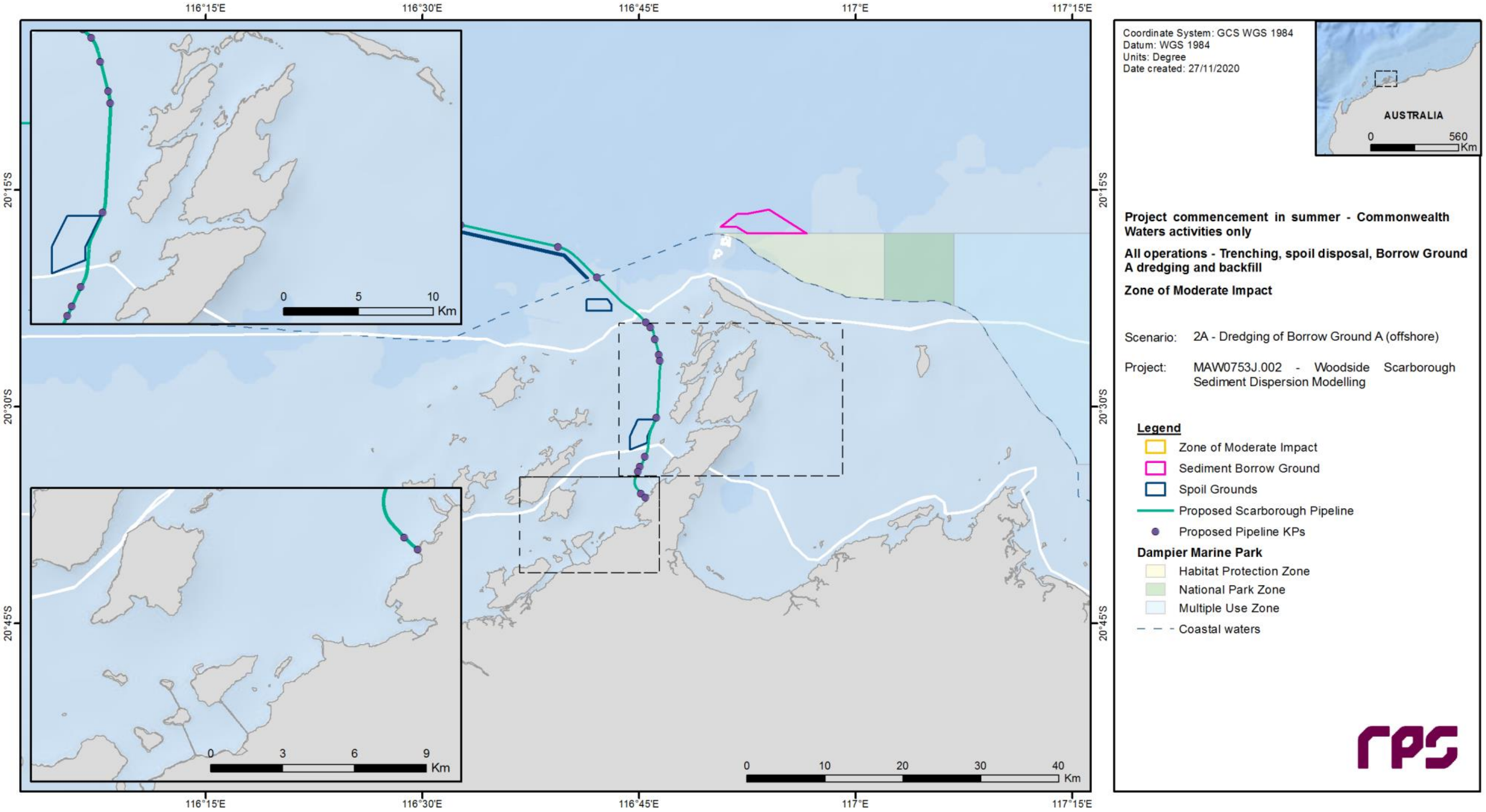

Figure B.40 Predicted Zone of Moderate Impact following application of the appropriate spatial thresholds in Table 4.3 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

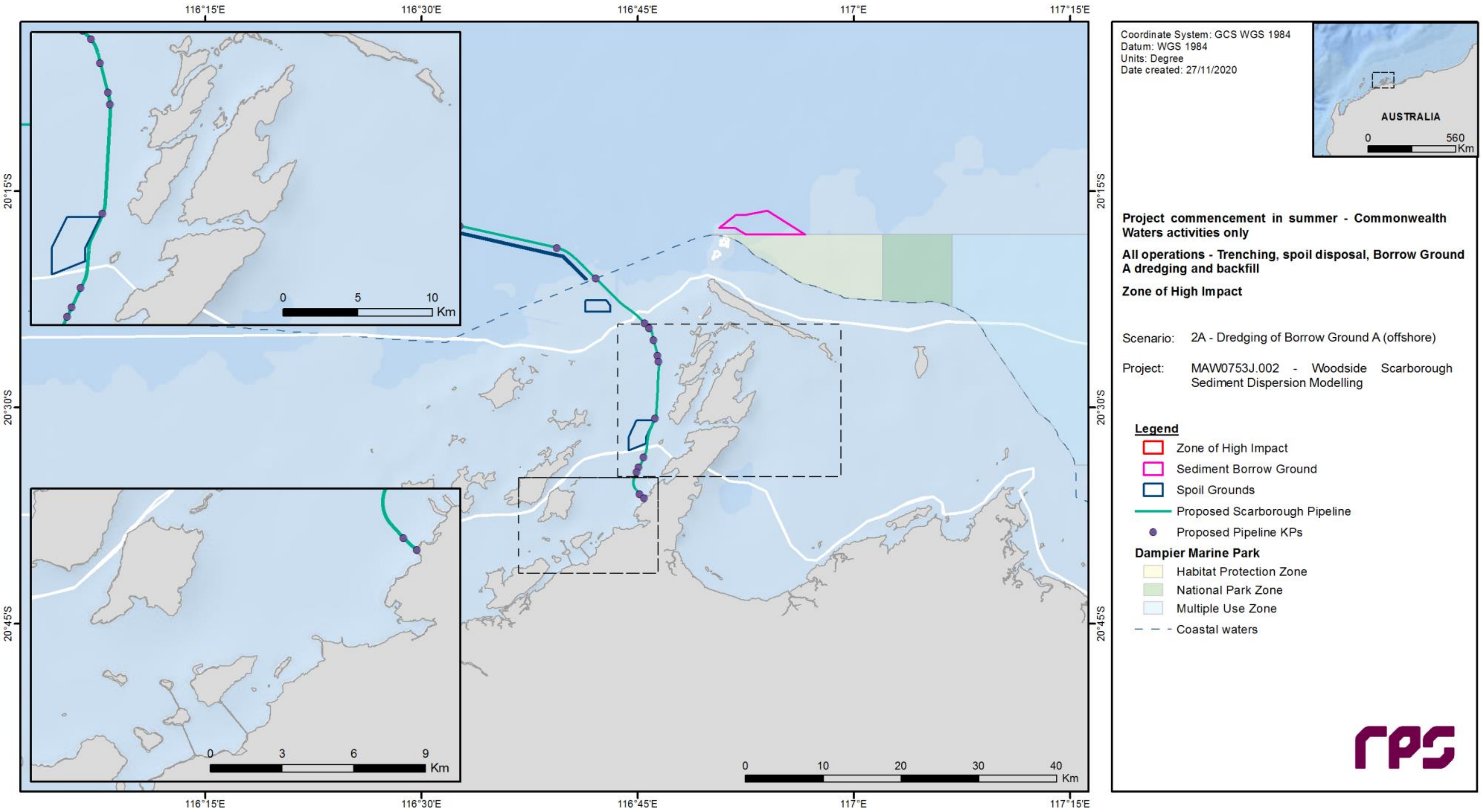

Figure B.41 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 3-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

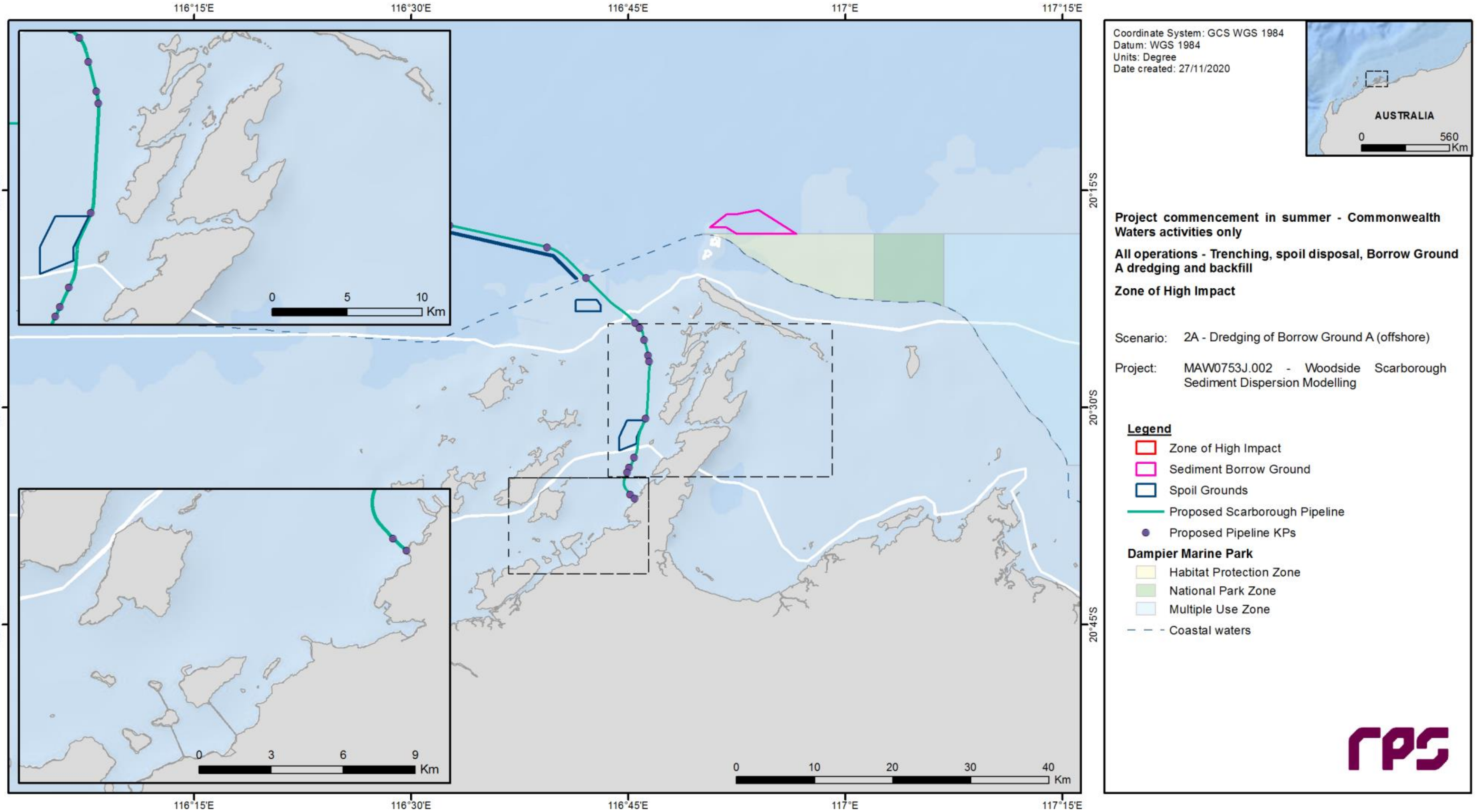

Figure B.42 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 7-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

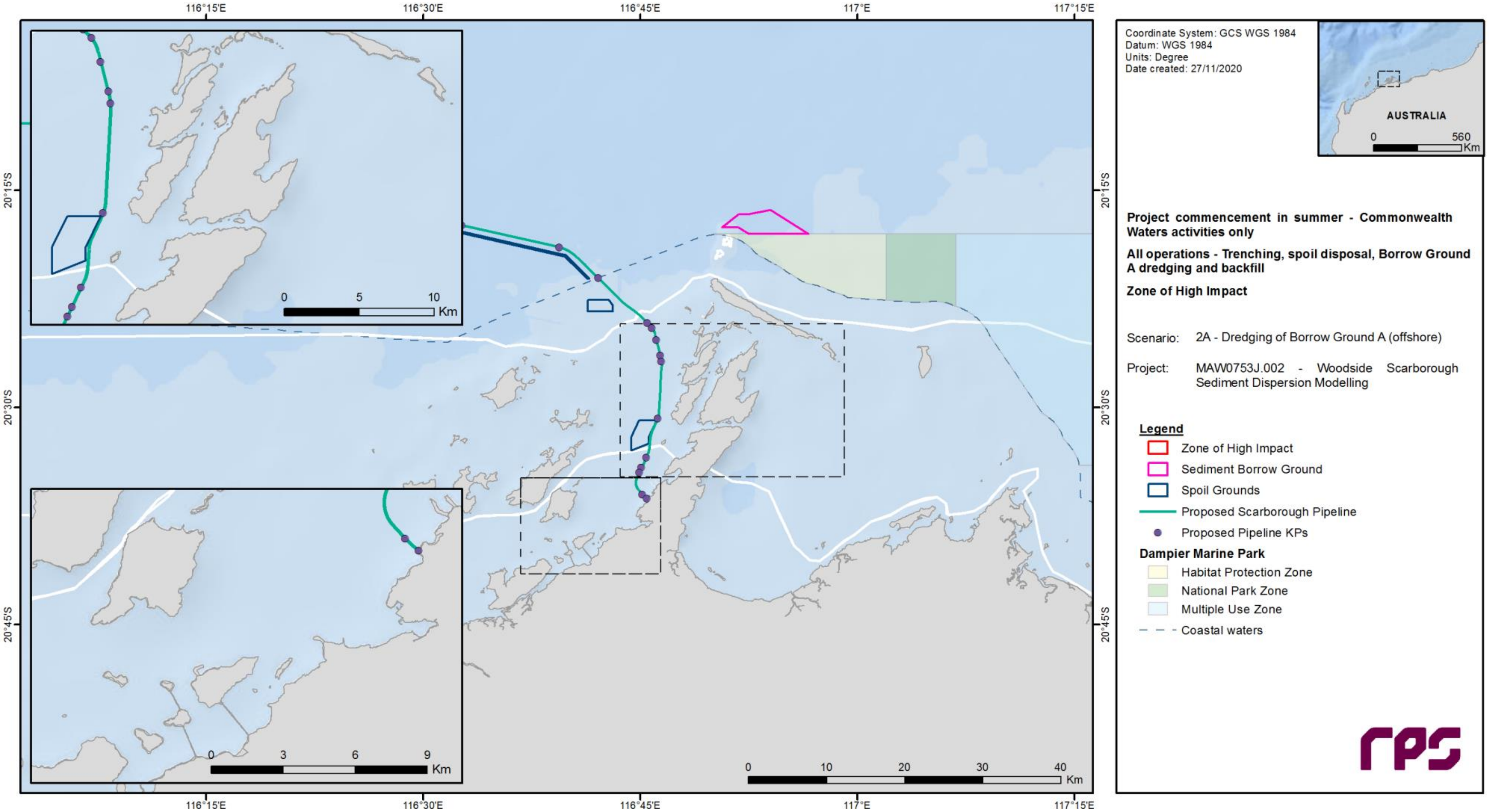

Figure B.43 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 10-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

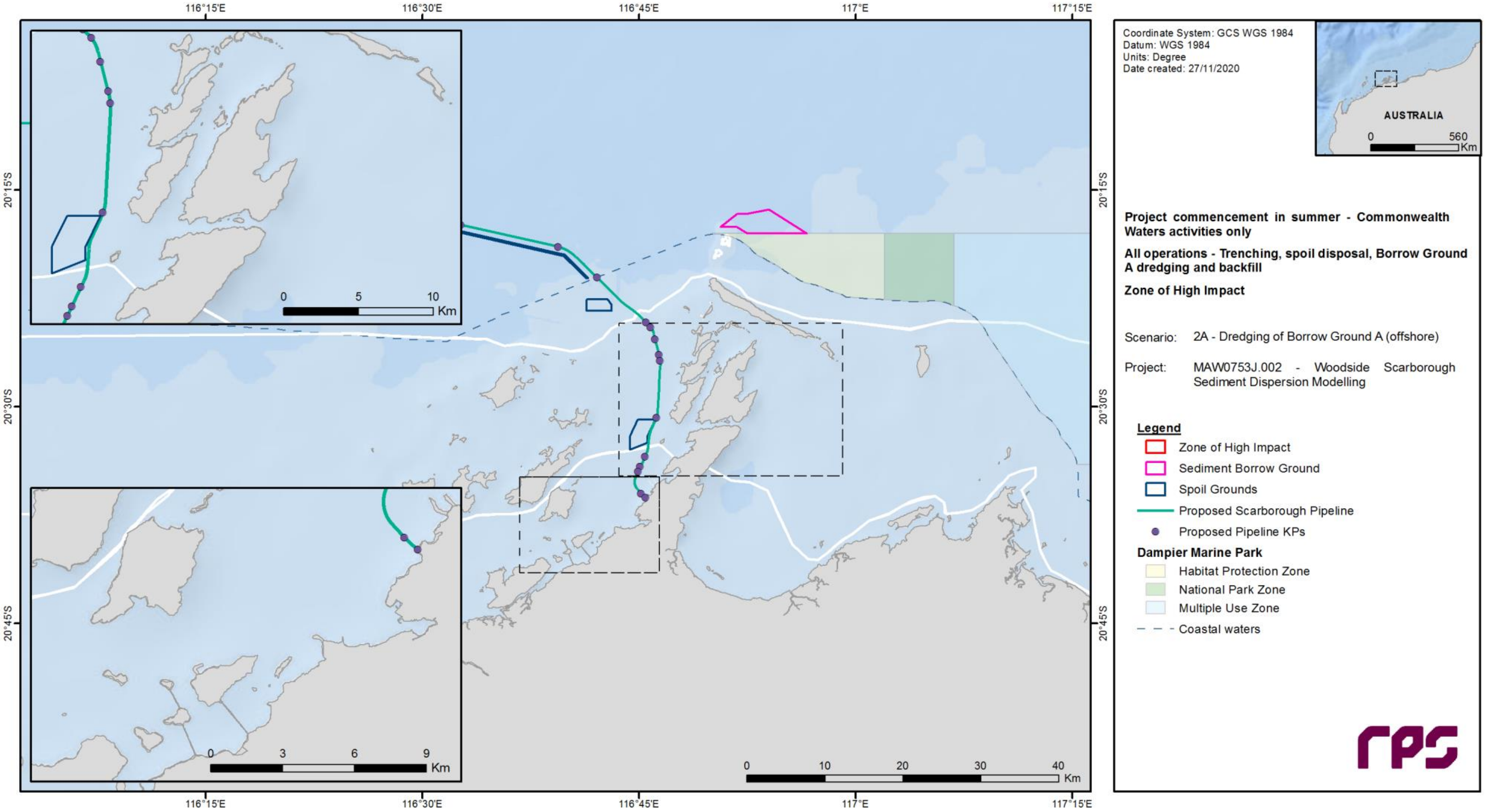

Figure B.44 Predicted Zone of High Impact following application of the appropriate spatial thresholds in Table 4.4 to 14-day (Zones A and B) and 28-day (Offshore) rolling averages of total (dredge and background) SSC throughout the duration of the relevant activities (1st February 2017 to 21st November 2017).

Appendix F

Sediment Transport Modelling Peer Review

Appendix F.1 Stage 1 Peer Review

Royal HaskoningDHV
Enhancing Society Together

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Date:	11 September 2020	Contact name:	Greg Britton
Your reference:		Telephone:	02 8854 5002
Our reference:	MALT-PA2463_peer review	Email:	greg.britton@rhdhv.com
Classification:	Project related		

Dear [redacted]

SCARBOROUGH PROJECT
SEDIMENT TRANSPORT MODELLING – STAGE 1, PEER REVIEW

I refer to the Scarborough Project sediment transport modelling peer review. As you know, the scope of the peer review consists of two stages; Stage 1: review of the appropriateness of the model inputs and process for the revised Scarborough dredge dispersion modelling study, and Stage 2: review of the outcomes of the modelling and in particular whether the interpretation and conclusions within the Dredging and Spoil Disposal Management Plan (DSDMP) are appropriate, with due consideration to dredging science and guidance.

I am writing to confirm the outcome of my Stage 1 peer review of the reports provided to me by Woodside Energy Ltd (Woodside). The reports I have examined are listed in **Attachment A**.

Following review of the reports, discussions were held with representatives of Woodside and RPS, the company undertaking the sediment transport modelling on behalf of Woodside, to discuss a number of review comments. These discussions lead to some revisions (updates) of the primary document examined in the peer review, namely the front end of MAW0753J.001-WEL Scarborough Dispersion Modelling – Rev C – Report. These updates were predominantly related to greater transparency of modelling inputs and assumptions within the modelling report, and confirmation that conservatism has been incorporated where uncertainty remains (e.g. source terms, particle size distributions). Specific updates included further information on model validation and the derivation of settlement rates, clarity of dredging volumes, additional information related to the derivation of modelled particle size distributions based on geotechnical data, and improved readability of the report with inclusion of additional figures. The finalised report at the conclusion of the peer review was Rev F.

I note that while a level of uncertainty will always exist with modelling studies, the uncertainty has been managed through detailed review of relevant information in the literature, extensive past project experience, adoption of well established models, adherence to suggested best practice as outlined in the

WAMSI Dredging Science Node reports and adoption of conservative values for input parameters where deemed necessary.

The approach taken regarding uncertainty is considered reasonable, noting also that there will be a tiered monitoring and management framework in place during execution of the project, as described in the DSDMP, which would enable timely management responses to measured field data where required.

In summary I am satisfied in regard to the modelling approach and the assumptions and input data as outlined in the front end of Rev F of the Dredge Dispersion Modelling Report

OUTLINE OF PEER REVIEWER

The peer review was carried out by Greg Britton. A brief biographical outline for Greg is provided below.

Greg is the Technical Director of Royal HaskoningDHV in Australia based in Sydney. He has a Bachelor of Civil Engineering (Hons I) and was awarded the UNSW University Medal. He has completed a Master of Engineering Science Degree specialising in coastal/maritime/water engineering.

He has 43 years professional experience in the investigation, design and documentation, planning, environmental assessment, and project management of coastal, estuary and maritime projects.

Greg has provided expert advice on coastal, maritime and environmental engineering to the NSW Land and Environment Court, NSW Supreme Court, Queensland Supreme Court, Federal Court of Australia and several Commissions of Inquiry. He has fulfilled the role of a Court Appointed Expert (CAE) in the NSW Land and Environment Court.

He has recently been appointed by the NSW Minister for Planning to the Sydney District and Regional Planning Panels as a Coastal Expert.

Greg is a long term member of an expert panel retained by the Commonwealth Department of Agriculture, Water and Environment (DAWE) to advise the Commonwealth on dredging, dredged material management and coastal engineering matters under the Commonwealth Environment Protection (Sea Dumping) Act 1981 and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

Greg was a member of the Independent Icythys Project Dredging Expert Panel (IDPEP) with a particular focus on hydrodynamics and sediment plume modelling. More recently he has been closely involved in the following relevant projects:

- Western Harbour Tunnel (Sydney Harbour) Dredging – hydrodynamic and sediment plume modelling;
- Middle Harbour Tunnel (Sydney) Dredging – hydrodynamic and sediment plume modelling; and
- Snowy 2.0 Pumped Hydro – hydrodynamic and sediment plume modelling (placement of very fine crushed rock into the two nearby reservoirs in the Kosciuszko National Park).

I trust the above satisfies your current requirements. Please contact me should you require any clarification or additional information.

Yours faithfully

Greg Britton
Technical Director

Attachment A to letter to Woodside Energy Ltd dated 11 September 2020
List of Reports examined in Peer Review

Document	Description
1. MAW0753J.001 - WEL Scarborough Dredge Dispersion Modelling - Rev C – Report, up to – Rev F - Report	Front end of the Scarborough Development Dredged Sediment Dispersion Modelling report, which is the primary document with regard to modelling inputs and assumptions for review.
2. RPS Scarborough Dredging Model Input Summary_30June2020	Excel spreadsheet with some further context/detail to support the dispersion modelling front end report. Many of the tables are reflected in the front end report with supporting context, however the summary of source terms tabs does include some addition breakdown with respect to the overflow calculations.
3. MSA275 Model Thresholds 20190110	Woodside Scarborough Dredging Threshold Levels for Model Interrogation report. This report provides the basis of the ecological thresholds selected for determination of the zone of influence, zone of moderate impact and zone of high impact.
4. Revised sediment transport modelling peer review - kick-off meeting	Scarborough Project Sediment Transport Modelling Peer Review – Kick off meeting presentation pack.
5. Pages from Scarborough DSDMP Rev 2_Project description	Contextual Project description, which has been extracted from revision 2 of the DSDMP. High level notes have been included where relevant throughout for consideration.
6. Schematic of dredging vs. rock placement	Schematic of nominal dredging and rock placement sections to help visualise the activity.

Appendix F.1 Stage 2 Peer Review

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Woodside Energy Ltd
Mia Yellagonga
Karlak, 11 Mount Street
PERTH WA 6000

Email: [redacted]

Date:	21 December 2020	Contact name:	Greg Britton
Your reference:		Telephone:	02 8854 5002
Our reference:	PA2463_Stage 2-20201120	Email:	greg.britton@rhdhv.com
Classification:	Project related		

Dear [redacted]

SCARBOROUGH PROJECT
SEDIMENT TRANSPORT MODELLING - STAGE 2, PEER REVIEW

I refer to the Scarborough Project sediment transport modelling peer review. As you know, the scope of the peer review consists of two stages; Stage 1: review of the appropriateness of the model inputs and process for the revised Scarborough dredge dispersion modelling study, and Stage 2: review of the outcomes of the modelling and in particular whether the interpretation and conclusions within the Dredging and Spoil Disposal Management Plan (DSDMP) are appropriate, with due consideration to dredging science and guidance.

The Stage 1 peer review was submitted in my letter dated 11 September 2020.

I am now writing to confirm the outcome of my Stage 2 peer review of the reports provided to me by Woodside Energy Ltd (Woodside). The reports I initially examined in the Stage 2 peer review are listed below.

- MAW0753J.002 – Scarborough Development Dredged Sediment Dispersion Modelling – Rev 0 – 2 October 2020, prepared RPS; and
- Chapter 6 of Scarborough Dredging and Spoil Disposal Management Plan, Draft Revision 3, October 2020, prepared by Woodside.

The modelling report follows accepted practice involving definition of ecological zones and determination of three management zones of influence and impact based on predictions of suspended sediment concentration (SSC) due to the works and certain water quality thresholds (criteria) for SSC. The threshold SSC to define the management zones differ between the ecological zones, reflecting the different ecology within each zone.

Following review of the modelling report, discussions were held with representatives of Woodside to discuss a number of review comments. These discussions led to some revision (updates) of the modelling report. The updates were predominantly related to provision of additional references to support statements in the report, justification of the adopted background water quality data, provision of modelling outputs at more frequent intervals during the proposed works, and greater graphical representation of model outputs to aid understanding and interpretation.

The finalised modelling report at the conclusion of the Stage 2 peer review was Rev 1, 30 November 2020. The finalised report is considered a suitable basis to inform the DSDMP.

The initial review of Chapter 6 of the DSDMP Draft Rev 3, conducted prior to finalisation of the modelling report, led to minor editorial suggestions only.

An updated version of Chapter 6 of the DSDMP (Rev 3, 20 November 2020) was further reviewed following finalisation of the modelling report. The interpretation and conclusions within Chapter 6 are based on the finalised modelling report, which is considered a suitable basis as noted above. The interpretation and conclusions are considered appropriate, with due consideration to dredging science and guidance.

OUTLINE OF PEER REVIEWER

The peer review was carried out by Greg Britton. A brief biographical outline for Greg is provided below.

Greg is the Technical Director of Royal HaskoningDHV in Australia based in Sydney. He has a Bachelor of Civil Engineering (Hons I) and was awarded the UNSW University Medal. He has completed a Master of Engineering Science Degree specialising in coastal/maritime/water engineering.

He has 43 years professional experience in the investigation, design and documentation, planning, environmental assessment, and project management of coastal, estuary and maritime projects.

Greg has provided expert advice on coastal, maritime and environmental engineering to the NSW Land and Environment Court, NSW Supreme Court, Queensland Supreme Court, Federal Court of Australia and several Commissions of Inquiry. He has fulfilled the role of a Court Appointed Expert (CAE) in the NSW Land and Environment Court.

He has recently been appointed by the NSW Minister for Planning to the Sydney District and Regional Planning Panels as a Coastal Expert.

Greg is a long term member of an expert panel retained by the Commonwealth Department of Agriculture, Water and Environment (DAWE) to advise the Commonwealth on dredging, dredged material management and coastal engineering matters under the Commonwealth Environment Protection (Sea Dumping) Act 1981 and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

Greg was a member of the Independent Icythys Project Dredging Expert Panel (IDPEP) with a particular focus on hydrodynamics and sediment plume modelling. More recently he has been closely involved in the following relevant projects:

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- Middle Harbour Tunnel (Sydney) Dredging – hydrodynamic and sediment plume modelling; and
- Snowy 2.0 Pumped Hydro – hydrodynamic and sediment plume modelling (placement of very fine crushed rock into the two nearby reservoirs in the Kosciuszko National Park).

I trust the above satisfies your current requirements. Please contact me should you require any clarification or additional information.

Yours faithfully

Greg Britton
Technical Director
Water

Appendix G

Water Quality Thresholds

Woodside Scarborough Trunkline Dredging

Image from Woodside (www.woodside.com.au)

11 March 2022

Water Quality Thresholds

Report to Advisian Pty Ltd

From

MScience Pty Ltd

Woodside Scarborough Trunkline Dredging

Water Quality Thresholds

Document Information

REPORT NO.	MSA275R02
DATE	March 9, 2022
CLIENT	Advisian Pty Ltd
USAGE	This report is provided for use as an appendix to the Woodside Scarborough Dredging and Spoil Disposal Management Plan.
KEYWORDS	Water quality, thresholds, dredging, benthos
CITATION	MScience 2022. Woodside Scarborough Trunkline Dredging: Water Quality Thresholds. Unpublished report MSA275R02 to Advisian Pty Ltd , Perth Western Australia, pp22

Version History

Version/Date	Issued as	Author	Approved
1/10.01.2019	Issued for use by Woodside	JAS	CWS
2/09.03.2022	Issued for review by Woodside	JAS	IJP
3/11.03.2022	Issued as final		JAS

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Table 2: Depth light and turbidity at two sites monitored in late October 2016. 3

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Table 4: Thresholds for the boundary from ZoI to ZoMI in the Offshore zone. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoMI. 8

Table 5: Thresholds for the boundary from ZoI to ZoMI in Zone B for coral/mixed community. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoMI. 8

Table 6: Thresholds for the boundary from ZoI to ZoMI in Zone A for the coral/mixed community. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoMI. 9

Table 7: Thresholds for the boundary from ZoMI to ZoHI in the Offshore zone. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoHI. 10

Table 8: Thresholds for the boundary from ZoMI to ZoHI in Zone B. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoHI. 10

Table 9: Thresholds for the boundary from ZoMI to ZoHI in Zone A. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoHI. 11

1 EXECUTIVE SUMMARY

This report has been prepared to provide technical data to aid with the environmental assessment of the impacts of dredging by Woodside Energy Limited (Woodside) to construct a trunkline for the Scarborough Project. The report provides a set of water quality thresholds to indicate levels of deterioration in water quality that might cause varying degrees of impact on benthic biota. When applied to predictions of water quality derived from a model of dredging impacts, those criteria have been used to predict the extent of three zones of impact around the dredging and disposal operations.

This revision of the document includes consideration of:

- guidance published by researchers and regulators in the period following the thresholds' initial derivation;
- updated project information; and
- provides a more detailed explanation of the basis of calculations used.

Thresholds have been derived from an extensive series of studies undertaken on behalf of the Western Australian Marine Science Institute (WAMSI) to provide a capacity for better prediction of the effects of dredging on the marine communities off Western Australia's Pilbara coast. The final report of that study, synthesising a mass of data from the literature, past monitoring around dredging and empirical studies, has been used to provide guideline water quality thresholds which have been adapted to the local environment in which the Scarborough trunkline dredging will occur. In addition, thresholds suggested have been contrasted to studies around actual or potential dredging in similar environments from the western Pilbara and Kimberley marine areas.

This document lists sets of thresholds expressed as suspended sediment concentrations and daily light integrals to define three zones of potential impact within three ecological zones. Calculations are set out in detail and notes provided on the use of these calculations to interrogate sediment dispersion modelling outcomes in predicting the marine environmental impacts of the Scarborough trunkline.

2 INTRODUCTION

2.1 Background

The Scarborough gas resource is located in the Carnarvon Basin, approximately 375 km west-north-west of the Burrup Peninsula in Western Australia. The Scarborough gas resource will be developed through a phased development drilling program, which will be tied back to a semi-submersible floating production unit (FPU) moored in 950 m of water close to the Scarborough field. The offshore facility will be connected by an approximately 430 km trunkline to a second LNG train (Pluto Train 2) at the existing Pluto LNG onshore facility in Dampier, Western Australia.

Dredging for the Project consists of two main activities:

- Trenching from the shore crossing in Mermaid Sound to offshore, with disposal of spoil in spoil grounds A/B, 2B and 5A (Figure 1);
- Borrow ground dredging and subsequent placement of sand backfill in trench post installation of trunkline.

To evaluate the potential effects of dredging and disposal of spoil on the surrounding marine environment the environmental impact assessment included a numerical model of the effects of dredging in elevating concentrations of suspended sediments in the water column. When interrogated against a set of thresholds of water quality expected to cause increasing levels of stress or mortality to sensitive benthic organisms, that model provided a spatial prediction of the location of zones with three levels of impact. Further information on modelling and the derivation of those zones may be found in the Dredging and Spoil Disposal Management Plan (Woodside 2022) for which this document forms a supporting appendix.

The purpose of this document is to provide the water quality thresholds against which Woodside's sediment dispersion model can be interrogated to predict impact zones. The document has been updated from its original form to revisit the water quality threshold development to:

- relate the process by which those criteria were derived to guidance published by researchers and regulators in the period following their initial derivation;
- address updated project information; and
- provide a more detailed explanation of the basis of calculations used.

2.2 Structure of this Document

The document lists:

- The background to this study;
- Methods and data sources used to derive thresholds;
- An appendix containing the thresholds and calculations used to derive them.

The document is current as at the date on the cover page and is referenced as Version 3 (Documents with a lower version number are superseded by this document).

3 POTENTIAL IMPACT ZONES

Consideration of marine environmental stresses has been structured into a series of zones, as recommended by the Western Australian Environmental Protection Authority's guidance on dredging management (WAEPA 2021). For impact predictions, zones include three levels of potential impact:

Zone of Influence: an area where environmental quality is affected by dredging, but without detectable effects to biota;

Zone of Moderate Impact: an area in which dredging may cause sub-lethal impacts on benthic biota which will be recovered within five years of the cessation of dredging; and a

Zone of High Impact: an area where benthic communities suffer serious or irreversible impacts from diminished environmental quality derived from dredging effects.

The focus of the plume dispersion modelling undertaken was to predict the location of the above zones around the dredging based on water quality thresholds alone: i.e. areas where water quality thresholds are exceeded irrespective of whether the relevant sensitive benthic communities exist within that area. That modelling exercise has been reported in the body of the Dredging and Spoil Disposal Management Plan (Woodside 2022). Prediction of the area included in each of these zones was undertaken by using a set of water quality thresholds to interrogate the results of a model predicting the intensity, duration and frequency (IDF) of suspended sediment concentrations caused by the impacts of dredging and metocean conditions. The purpose of this document is to describe how those thresholds were developed.

4 ECOLOGICAL ZONES

Early studies of the ecology of Mermaid Sound recognised that water quality varied routinely between the waters within a few kilometres of shore and those further offshore (Forde 1985; Simpson 1988). Inshore waters were observed to be substantially more turbid than waters offshore and the turbid inshore zone was larger (i.e. stretched further offshore) and more pronounced in summer months.

Studies undertaken as baselines for Woodside's Pluto LNG Foundation project used a variety of investigations over 14 months to establish a series of management zones which reflected this natural variation in water quality and how that might relate to the likely impacts of dredging (MScience 2010). Zone A and B of that project occupied waters close to shore and typical of the higher turbidity zones defined in the earlier studies. Pluto Zone A was a subset of Pluto Zone B defined by its proximity to the most sustained area of dredging and predicted as a site which would see consistent water quality impacts during dredging. Zone C of the Pluto LNG Foundation study was an area with turbidity elevations from nearshore sediment resuspension, but at lesser levels than Zone B. While the Offshore zone was one with generally low turbidity and rare occurrence of For the current study, Pluto LNG Foundation management zones A and B are aggregated to be Scarborough ecological zone A, and Pluto management zone C (Inner and Outer) is denoted as Scarborough ecological zone B, while the Offshore zone remains the same (Figure 1). Exact boundaries of these zones will vary seasonally and with weather events, however, they are sufficiently indicative of turbidity levels to meet the requirements established in the WAEPA guidance for predictive uncertainty (see Section 3.4.3 of WAEPA 2021).

5 DATA SOURCES

Recommendations for generic water quality thresholds have been drawn from the outcome of an extensive study of the mechanisms and thresholds of water quality impacts on Western Australian tropical and sub-tropical benthos. The details of that study may be found in a synthesis of the work and findings of its various nodes (WAMSI 2019). The primary document from that study used to provide guidance in deriving effect thresholds of water quality for benthos was Jones et al. (2019), which operationalised the results of a large data review and a suite of experimental studies into thresholds. Of relevance to the current project, those findings were based predominantly on benthic communities of the Pilbara coastal environment. Recommendations on water quality thresholds within the Western Australian Environmental Protection Authority's guidance on the assessment of marine dredging projects (WAEPA 2021) adopt the WAMSI findings directly.

Both the WAMSI recommendations and the WAEPA guidance specify that thresholds should be adapted to reflect the background water quality environment in which the communities under assessment have developed and to which they are adapted. Data used to derive the default thresholds in the WAMSI work were drawn predominantly from the extensive monitoring study conducted for the Gorgon dredging program around Barrow Island in an offshore region of the Pilbara coast, supplemented with experimental work. While the water quality environment in that program outside of dredging periods would have been similar to that for the more offshore areas of the trunkline dredging, it would have been less turbid than that of the inshore areas of Mermaid Sound.

Three data sources from previous studies have been used to adapt those recommendations to areas relevant to the trunkline dredging. Those studies were:

- Various reports and data from water quality monitoring during Woodside's Pluto LNG Foundation Project dredging program, which provided data on turbidity from twenty locations throughout Mermaid Sound and adjacent sites every thirty minutes for almost three years;
- A baseline study of water quality from Chevron's Wheatstone Project draft environmental impact assessment (Appendix Q7 MScience 2009 Report MSA134R03 Baseline Water Quality: https://australia.chevron.com/-/media/australia/our-businesses/documents/wheatstone-draft-eis-ermp-technical-appendices-q6-q7-r1-s-web.pdf)
- Assessment of water quality including light and turbidity from offshore of James Price Point in Western Australian Kimberly for Woodside's Browse LNG Project.

The Pluto LNG Foundation data provides a comprehensive treatment of turbidity variation seasonally, inside and outside of dredging periods, and near and far from dredging, but does not contain complementary light data. The Wheatstone study does contain light data as well as turbidity and contains a series of investigations to relate those two aspects of water quality. The Browse data is comprehensive and provides an indication of light-turbidity relationships in a more offshore environment.

6 THRESHOLDS

Appendix A of this document provides the details of data, assumptions and calculations used to derive the set of water quality thresholds used to interrogate the plume dispersion modelling outputs. The threshold for each zone is expressed as the transition from one zone to another. Notes on how the model interrogation should use these thresholds are included for each section.

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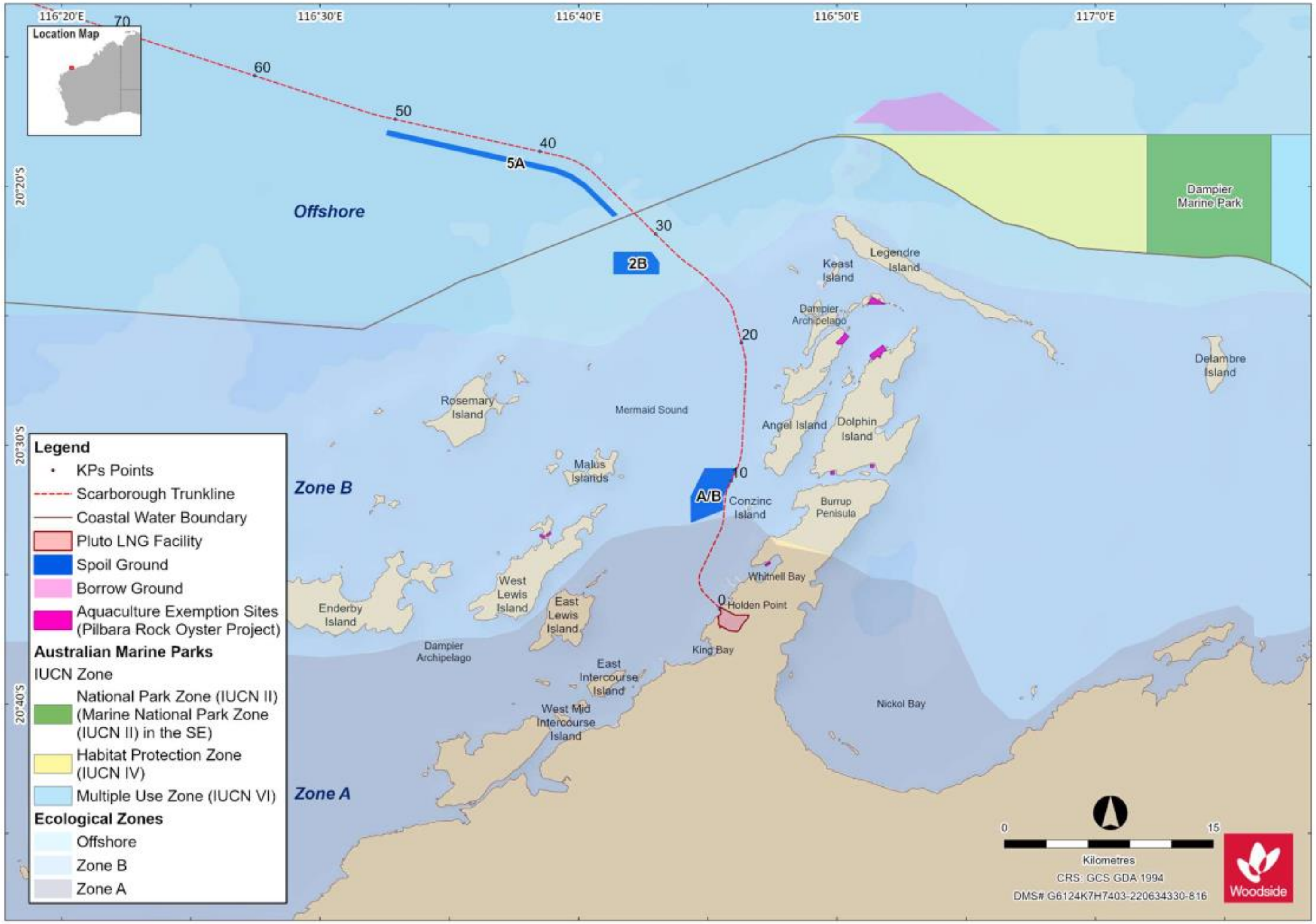

Figure 1. Ecological zones established for impact prediction (From DSDMP)

APPENDIX A

i) NTU<->SSC CONVERSION (for model outputs)

Monitoring of turbidity during the Pluto LNG Foundation Project (Pluto) was undertaken by nephelometers recording nephelometric turbidity units (NTU), while modelling deals with particles expressed as suspended sediment concentration (SSC) in mg.l^{-1}. Thus, a conversion factor is necessary to link the previous data with model outputs.

Experimental works during Pluto suggested relationships of NTU~SSC varying from SSC=>3*NTU to SSC=1.9*NTU. With the higher multipliers being more typical of offshore sediments. More recent work within Mermaid Sound using in situ measurements showed a relationship of SSC=1.3*NTU for waters within Ecological Zones A and B.

Based on a review of methods, some Pluto estimates may have been too high as energy imparted by stirring in laboratory-based estimation of this relationship was beyond natural phenomena. In situ, the multiplier between NTU and SSC would be greater offshore than inshore under most conditions as offshore sediments tend to be coarser, implying a greater mass per unit of light attenuation.

Boat-based studies undertaken for the Wheatstone Project baseline (MScience 2009) showed SSC to be highly correlated with NTU. In a set of over 110 samples with turbidity and SSC averaged across the water column from surface, midwater and bottom samples an overall relationship of SSC = 2 + 1.1*NTU with r^2 = 0.85. If that line is forced through a 0:0 intercept (i.e. no turbidity = 0 mg/l) then it becomes SSC=1.4*NTU.

For the Scarborough Project, the following relationships were used in converting SSC to NTU.

Zone A and Zone B	SSC = 1.4*NTU
Offshore	SSC = 2.0*NTU

As monitoring of water quality for operational purposes normally uses turbidity rather than SSC, this conversion will not be needed for operational triggers.

ii) BACKGROUND WATER QUALITY

Turbidity characteristics in Pilbara waters routinely differ between summer and winter, especially in the nearshore areas where wave and tide activity are the primary drivers of sediment resuspension (Dufois et al. 2017).

All following tables assume that Summer months are Nov, Dec, Jan, Feb, Mar, while the remainder are Winter. Values were calculated as the means for sites in the relevant zone which were recorded for the 3 years of Pluto monitoring (MScience 2010). Outer sites were not measured during that time, but the instrument at Legendre Island on a seaward reef was considered to be representative of the Offshore zone and Table 1 uses data from that site.

The summary report of water quality data for the Pluto LNG Foundation Project (MScience 2010) demonstrated that, over the life of the monitoring program, dredging was likely to have elevated turbidity at Zone A sites by 0.7 NTU and Zone B by 0.3 NTU. Therefore, when using the 2007-2010 data set, summary statistics have been reduced by that amount. It might be expected that statistics like the 80th%ile would have been more affected by dredging than means. However, many anthropogenic sources elevate turbidity in this area as part of normal operations and going beyond a simple reduction of means and 80th%iles by 0.7 NTU or 0.3 NTU to indicate non-dredging conditions is not warranted.

Table 1 presents the means of the site means and 80th%iles corrected by these dredging factors and converted to SSC by the factors above. As the model only accounts for sediment from dredging, <u>mean values of Table 1 should be added to model estimates to provide a total suspended sediment concentration</u> experienced by benthos.

Table 1: Mean and 80th%ile of SSC (mg.l^{-1}) over the 3 years of Pluto monitoring categorised into summer and winter for each of the three ecological zones and corrected to remove dredging effects.

Zone A	*Season*	*Mean SSC*	*80%ile*
	Summer	4.1	5.0
	Winter	1.8	2.3

Zone B	*Season*	*Mean SSC*	*80%ile*
	Summer	2.5	2.7
	Winter	1.2	1.6

Offshore	*Season*	*Mean SSC*	*80%ile*
	Summer	1.8	1.8
	Winter	0.6	0.9

The above data were measured from instruments placed approximately 1 m above seabed level and have been corrected to remove the dredging-derived contribution. The model will use predictions in a number of depth intervals in the water profile.

<u>Where NTU/SSC values are quoted in the following sections, these will refer to depth-averaged values</u>.

iii) NTU to Light CONVERSION

Many of the WAMSI thresholds are stated in DLI – Daily Light Integral (the sum of moles of photons from within the PAR spectrum per square metre per day). All DLI measurements in this report are stated as mol photons.$m^{-2}.d^{-1}$.

The Pluto water quality monitoring program did not monitor light and thus there is limited data relating turbidity to light attenuation. Woodside own some data on NTU~PAR relationships collected during a recent monitoring program conducted for a maintenance dredging program adjacent to the Karratha Gas Plant (MScience 2016). That project collected 30-minute PAR and NTU recordings at depths of approximately 4-5m (mean water depth above instrument) from 3 sites within Zone B-Inner – with usable data from 2 sites for the period 21-Oct-2016 to 31-Oct-2016 (Winter).

Table 2: Depth light and turbidity at two sites monitored in late October 2016.

Site	***Mean depth (m)***	***Mean DLI* (mol.$m^{-2.}d^{-1}$*)***	***Mean NTU***
Angel Island	5.1	15.8	1.3
Conzinc Island	4.1	17.3	1.6

Regressing DLI against depth (actual measured depth which included tidal variation) and turbidity produces the equation:

$$DLI\ (mol.m^{-2.}d^{-1}) = 35.5 – 2.95\ Depth(m) – 3.58\ NTU$$

$(R^2 = 0.58$, p for both coefficients $<0.01)$

Or when the equation is converted into SSC

$DLI\ (mol.m^{-2.}d^{-1}) = 35.5 – 2.95\ Depth(m) – 2.56\ SSC\ (mg.l^{-1})$ (**Eq.1**) – Zones A & B

$DLI\ (mol.m^{-2.}d^{-1}) = 35.5 – 2.95\ Depth(m) – 1.79\ SSC\ (mg.l^{-1})$ (**Eq.2**) - Offshore

Note 1: The paucity of variation in NTU (1-3 NTU) and depth (3.9 – 5.5 m) and the relatively short period of measurement mean that extending this relationship to all seasons and all sites may not be valid.

Note 2: The above study found there was no evidence that maintenance dredging occurring at the time these measurements were recorded had an influence on water quality at the instruments. Thus the above relationship is not based on sediment uplifted by dredging.

Those equations can be used to convert turbidity into light for October. Solar radiation is close to its annual maximum daily level in October, rising only 4-5% in November-December, and falling to 50-60% in June-July (BOM data from Legendre Weather Station: http://www.bom.gov.au/climate/data/). Given that the above relationship is drawn from a very small data set (with a very small depth range) and that the actual DLI just below the surface is likely to vary between 55 $mol.m^{-2}.d^{-1}$ in summer down to 30 $mol.m^{-2}.d^{-1}$ at the June-July low point and that the intercept of the relation is already at only 35.5, this relationship should probably not be seasonally adjusted downwards.

The equations above are quite specific to the sites and conditions under which the data used to derive these equations was collected and limited in their generality. Relationships between suspended sediments and light attenuation will be sediment specific, depending on the particle size distribution, the colour of sediment particles and the depth at which attenuation is occurring. In addition, the spectrum of light within the photosynthetically active radiation bands will alter the amount of energy available (Jones et al. 2019).

Using depth and turbidity as independent factors is a consequence of the limited depth and turbidity ranges available in the empirical data used here. For generalised equations, depth and turbidity should be multiplicative and used as an exponential, expressed as the light attenuation coefficient K_d (Kirk 1994). Comparative studies used here from the Wheatstone (MScience 2009) (MScience 2009) and Browse (MScience 2013) data sources show that the nearshore locations (Wheatstone and Pluto) produce similar relationships:

This study: $K_d = 0.17 + 0.055*NTU$

Wheatstone: $K_d = 0.18 + 0.07*NTU$

However, the more offshore environment of Browse (with larger, whiter sediments) produced a much lesser effect of NTU on light attenuation:

Browse: $K_d = 0.19 + 0.015*NTU$

Clearly all these equations predict that PAR runs out of light (i.e. DLI -> 0) at around 10-12 m depth for typical NTU values in all the zones (as shown above). Habitat mapping for Mermaid Sound shows that coral communities below 10-12 m are extremely rare and that most of the corals fringing the Burrup Peninsula and Angel and Gidley Islands are above that depth limit.

In summary, while the equations chosen here may be subject to argument, they are representative of the target area and if anything, overpredict the level of light attenuation from dredging.

Using SSC to calculate DLI: Data used to calculate equations 1 and 2 used daily average NTU from 08:00 to 18:00 hrs, when PAR was non-zero. In that data set, there was little variation in NTU throughout the day. Turbidity from dredging impacts will show very short-term peaks (Jones et al. 2015b). A daily average NTU (or SSC) which was influenced by high values at periods of low light (such as may occur at night or in crepuscular periods) would underestimate the actual DLI. The majority of light as PAR contributing to DLI enters the water between 10:00 and 14:00 hrs (Kirk 1994). Therefore, the use of SSC estimates for model timesteps should be restricted to those occurring 10 – 14 hrs in deriving SSC units to predict DLI from those equations.

iv) Thresholds

Thresholds chosen to indicate a transition between ZOI and ZOMI use the Possible Mortality thresholds of (Jones et al. 2019) as a basis while ZOMI to ZOHI thresholds use the Probable values. These thresholds are provided only for corals.

At present, management zone predictions are not based directly on the presence of receptor species. For instance, a ZOMI based on coral may occur where there is no coral. However, thresholds will be taxon-specific and some distinctions can be made as follows:

1) Seagrass thresholds should only be used at depths of less than 6 m – to reflect the distribution of seagrass noted previously within Mermaid Sound;

2) Within the Offshore zone, only thresholds of relevance to sponges and filter feeders will be used as corals, seagrasses and macroalgae are not known to form significant communities there;

3) The Jones et al (2019) thresholds were developed predominantly on data from coral communities in the waters around the Gorgon Project at Barrow Island. The coral communities there are described in Jones et al. as being part of a "clear water, high diversity shallow water coral reef ecosystem". Such coral species are usually more susceptible to elevated turbidity than those experiencing turbidity levels typical of inshore Pilbara waters (Gilmour et al. 2006). Monitoring of baseline (pre-dredging) water quality around the coral communities of Barrow Island demonstrates these corals routinely experience turbidity levels considerably lower than those of ecological Zone A, somewhat lower than those of Zone B, but higher than those of the Offshore zone. The WAMSI thresholds have been adopted for Scarborough Zone B, as the water quality (turbidity and light) environment of Zone B will be closest to the Barrow Island water quality conditions;

4) Having developed in routinely higher levels of turbidity, corals in Zone A will be more tolerant to elevated suspended sediments and low light levels than those of Zone B. This is due to these communities being comprised of a greater proportion of more turbidity-tolerant species and the adaptation of corals to higher turbidity conditions (Blakeway and Radford 2005; Gilmour et al. 2006).

   Assessments of coral health for both the Pluto baseline (MScience 2007) and the post dredging assessment (MScience 2010) showed that coral communities in Zones A and B , with the exception of periods of coral bleaching induced by high water temperatures, coral communities in Zones A and B were not suffering significant mortality as a result of the levels of suspended sediment prevalent in the water column. To account for the resilience of the inshore corals of Zone A to suspended sediment levels consistently greater than those experienced in Zone B, the Barrow Island thresholds used for Zone B have been adjusted upwards. Table 1 shows that summer means and 80th percentiles in Zone A are higher than those of Zone B: on an annual basis, the mean suspended sediment concentration in Zone B is 1.6 times that of Zone A while the 80th percentile is 1.7 times greater. To account for that higher background and greater resilience, the Zone B thresholds have been adjusted by a factor of 1.5 to be relevant to Zone A coral communities.

5) Sponges and filter feeders in Zones A and B occur amongst corals and this mixed community is best evaluated using coral thresholds.

The thresholds proposed within the Jones et al. (2019) report list values for NTU, SSC and DLI. For non-acute impacts, DLI is noted as potentially the most important factor (Bessell-Browne et al. 2017).

In the model, NTU will be predicted from SSC in a linear model, while DLI will be a function of SSC (NTU) and depth (Eq1). Thus thresholds here use the SSC and DLI from that report.

Seagrass thresholds are drawn from Table ES1 of the Abstract in Statton et al. (2017). For *Halophila* spp. which are the most abundant seagrass species found in the area, that paper was unable to develop a satisfactory threshold. As all seagrasses found in the area which may be impacted by trunkline dredging are ephemeral and impacts will be of a short duration, recovery within 5 years (other things being equal) is highly likely. Thus, only a ZoMI threshold is proposed. That threshold is drawn from recommendations in the paper for *Halodule uninervis*.

A sedimentation threshold is not proposed here, as studies on sedimentation effects of corals and sponges continue to be equivocal on the effects of sedimentation alone (Duckworth et al. 2017; Pineda et al. 2017a). In practice, sedimentation impacts will be driven by high SSC levels (which will also drive low light). Where thresholds have been evaluated for multiple stressors, SSC and DLI levels have been an order of magnitude below the SSC levels required to sustain a sedimentation rate close to that reported as having effects on benthos (Duckworth et al. 2017; Pineda et al. 2017a). Thus, SSC and DLI thresholds proposed here would be breached well before SSC reached levels capable of sustaining required sedimentation rates. Other considerations mitigating against a sedimentation threshold are listed below.

Note 1: As pointed out by several papers from the WAMSI Dredging Node studies (see for example Duckworth et al. 2017; Jones et al. 2015a), historical data from studies of sedimentation effects on corals are based on methodologies that are unable to provide parameters of direct relevance to coral stress. While the WAMSI publications suggest their proposed sensor is relevant to measuring sediment stress, publications do not yet suggest any quantitative links.

Note 2: As Zone A experiences generally higher levels of suspended sediment, it follows that sedimentation rates will be higher in those areas. However, the susceptibility of corals to sedimentation effects is heavily dependent on coral morphology (Duckworth et al. 2017). Zone A coral communities have a higher proportion of foliose and massive/submassive species than Zone B communities (Blakeway and Radford 2005), which are more susceptible to sedimentation impacts than the branching species common in the Zone B communities.

Note 3: Impacts of sediment settling on corals is highly dependent on the organic content of the sediment. Sediments with high organic content are rapidly detrimental to coral health, while sediments with low organic content can be tolerated for long periods (Duckworth et al. 2017; Weber et al. 2006). Sediments within Mermaid Sound and offshore are very low in organics: usually <0.2% (DEC 2006).

v) ZONE OF INFLUENCE

A zone where impacts to water quality will be detectable but below a level causing detectable impacts to biota.

WAEPA guidance (WAEPA 2021) generally equates this to the total area around dredging covered by a plume visible to an observer with the naked eye.

THRESHOLD

Definition: Where dredging is predicted to raise the concentration of suspended sediment by an amount greater than the seasonal $80^{th}\%^{ile}$ of SSC for a one-day average.

The 80th%iles in Table 3 represent the seasonal 80th%iles measured for relevant sites during the Pluto LNG Foundation Project and converted to SSC, and then corrected to remove any elevation of suspended sediments caused by dredging.

Table 3: Threshold criteria for outer boundary of the Zone of Influence.

Area	***Threshold (mean daily SSC (mg.l^{-1})***	
	Summer	*Winter*
Zone A	5.0	2.3
Zone B	2.7	1.6
Offshore	1.8	0.9

Calculation Notes 1:

1- Develop a depth-averaged SSC estimate for cell(x).
2- Calculate the daily (24 hr) mean SSC from model results and add background.
3- If Daily Average SSC ≥ threshold of Table 3, that cell is in the ZoI

vi) ZONE OF MODERATE IMPACT

A zone where impacts are sub-lethal or lethal but recoverable (in terms of the community) within a 5-year period.

Definition: Where dredging elevates suspended sediment sufficiently to trigger impacts to EC_{10} or one shown to cause bleaching through loss of light or sedimentation.

THRESHOLDS

Offshore

Filter feeder-sponge thresholds adapted from Pineda et al. (2017a): (based on papers Pineda et al. 2016a; Pineda et al. 2016b; Pineda et al. 2017b; Pineda et al. 2017c). The threshold chosen in Table 4 is that quoted in Pineda et al. (2017a) as relating to an LC_{10} effect in a 28 day exposure (the only timeframe quoted).

Table 4: Thresholds for the boundary from ZoI to ZoMI in the Offshore zone. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoMI.

Averaging period (d)	SSC ($mg.L^{-1}$)	DLI ($mol.d^{-1}$)
28	22.5	0.9

<u>Calculation Notes 2</u>:

1- SSC: average all SSC estimates for cell(x) in a rolling 28d period. Add relevant background. Any cell where a single rolling mean is greater than the SSC trigger is in the ZoMI.

2- DLI: average all SSC estimates for cell(x) between 10:00 and 14:00 hrs in a rolling 28d period, add the relevant background and apply to Eq. 2 to predict DLI. Any cell where a single rolling mean is greater than the DLI trigger is in the ZoMI

Zone B

Values for the coral/mixed benthos communities are drawn from (Jones et al. 2019) as Table 5 to indicate thresholds of cells in the Moderate Impact category.

Table 5: Thresholds for the boundary from ZoI to ZoMI in Zone B for coral/mixed community. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoMI.

Averaging period (d)	SSC ($mg.L^{-1}$)	DLI ($mol.d^{-1}$)
3	19.4	1.1
7	14.7	1.8
10	13.1	2.2
14	11.7	2.5

Seagrass threshold: 14d DLI average not to be below 2.3 mol m-2.d-1

<u>See Calibration Notes 2: using Eq 1.</u>

Zone A

Table 6 shows the Coral/mixed community thresholds for Moderate Impact as those listed for Zone B adjusted by 1.5 as explained in point #4 at the start of this ZOMI section. SSC has been multiplied by that factor while DLI has been divided by it.

Table 6: Thresholds for the boundary from ZoI to ZoMI in Zone A for the coral/mixed community. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoMI.

Averaging period (d)	SSC ($mg.L^{-1}$)	DLI ($mol.d^{-1}$)
3	29.1	0.7
7	22.5	1.2
10	19.6	1.5
14	17.6	1.7

See Calibration Notes 2: using Eq 1.

vii) ZONE OF HIGH IMPACT

A zone where impacts are lethal and not recoverable (in terms of the community) within a 5-year period.

Definition: Where dredging elevates suspended sediment sufficiently to trigger impacts to EC_{50} or greater.

Offshore

Filter feeder-sponge thresholds adapted from Pineda et al. (2017a): (based on papers Pineda et al. 2016a; Pineda et al. 2016b; Pineda et al. 2017b; Pineda et al. 2017c). The threshold chosen in Table 7 is that quoted in Pineda et al. (2017a) as relating to an LC_{50} effect in a 28 day exposure (the only timeframe quoted).

Table 7: Thresholds for the boundary from ZoMI to ZoHI in the Offshore zone. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoHI.

Averaging period (d)	**SSC ($mg.L^{-1}$)**	**DLI ($mol.d^{-1}$)**
28	47	0.3

<u>See Calibration Notes 2: using Eq 2.</u>

Zone B

Table 8 contains thresholds that, if any one is exceeded, identify a cell as being in the Zone of High Impact.

Table 8: Thresholds for the boundary from ZoMI to ZoHI in Zone B. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoHI.

Averaging period (d)	**SSC ($mg.L^{-1}$)**	**DLI ($mol.d^{-1}$)**
3	35.7	0.3
7	24.5	0.6
10	20.9	0.9
14	18.0	1.1

<u>See Calibration Notes 2: using Eq 1.</u>

Zone A

Thresholds of Table 9 are for High Impact as for Zone B above – adjusted by 1.5 (see previous note).

Table 9: Thresholds for the boundary from ZoMI to ZoHI in Zone A. Any area which has a running mean for the averaging period above the listed SSC or below the listed DLI value is in the ZoHI.

Averaging period (d)	SSC ($mg.L^{-1}$)	DLI ($mol.d^{-1}$)
3	53.6	0.2
7	36.8	0.4
10	31.4	0.6
14	27.0	0.7

See Calibration Notes 2: using Eq 1.

Appendix H

Supplementary risk assessment and conceptual model

Table H-0-1: Further work proposed in the Scarborough nearshore component – referral supplementary report, for the key environmental factor – benthic communities and habitat

Receptor (value)	Aspect/impact	Likelihood (unplanned impacts only)	Magnitude	Impact significance level/environment risk consequence	Further work proposed in the project referral	Studies completed and summary of results/ management actions included in the DSDMP	Has the impact significance level/ environment risk consequence changed?
Benthic Communities – Corals (High) Benthic Communities – Seagrass (High) Benthic Communities – Mangroves (High) Benthic Communities – Macroalgae (Medium) Benthic Communities – Marine invertebrate fauna (Medium)	Planned – physical removal of benthic communities and habitat	N/A	Slight	Minor	The spatial distribution of existing BCH will be confirmed through additional survey work to provide additional confidence in the distribution of BCH that may be impacted by the project. Local assessment units will be established and direct habitat loss will be determined quantitatively.	Spatial distribution confirmed through a towed video survey. LAUs are defined in **Section 5.7** and percentage loss calculations are presented in **Section 5.7.1**.	No change.
	Planned – indirect impacts from dredging and spoil disposal activities	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling).	Dredge modelling results presented in **Section 5** and full modelling report included as Appendix E	No change to the magnitude or impact significance level predicted from the modelling. All risks will be managed to maintain water quality levels below intensity and duration definitions for the ZoMI at BCH. Modelling results are shown to be conservative when used to calculate percentage loss when compared with empirical evidence (**Section 5.8**). Trigger values are set based on the latest WAMSI research where relevant to prevent loss of BCH.
	Planned – project vessel discharges	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP).	Addressed in **Section 7.3**.	No change – impacts managed to an acceptable level in accordance with relevant marine orders.
	Unplanned – introduction of IMS impacting benthic communities	Highly unlikely	Major	Moderate	Impact addressed within management plans (DSDMP).	Addressed in **Section 8.2**	No change – impacts managed in accordance with legislative requirements and best practice guidance to an acceptable level.

Table H-0-2: Further work proposed in the Scarborough nearshore component – referral supplementary report, for the key environmental factor – marine environmental quality

Receptor (value)	Aspect/impact	Likelihood (unplanned impacts only)	Magnitude	Impact significance level/environment risk consequence	Further work proposed in the project referral	Studies completed and summary of results/ management actions included in the DSDMP	Has the impact significance level/ environment risk consequence changed?
Water quality (High)	Planned – indirect impacts from dredging and spoil disposal activities	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling).	Dredge modelling results presented in **Section 5** and full modelling report included as Appendix E.	The ZoI defines where suspended sediment concentrations may be detectable but at which no impacts to BCH are predicted. Any change in water quality is expected to be spatially confined and temporary in duration with no lasting effect.
	Planned – project vessel discharges	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP).	Addressed in **Section 7.3**.	No change – impacts managed to an acceptable level in accordance with international best practice and relevant Marine Orders.
Sediment quality (High)	Planned – indirect impacts from dredging and spoil disposal activities	N/A	Slight	Minor	Impact addressed within relevant management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling; SAP).	SAP completed and no contaminants were present above the NAGD screening levels.	Magnitude reduced to 'No lasting effect' and impact significance levels reduced to 'slight' as no contaminants are expected to be dredged.
	Unplanned – resuspension of contaminated sediments	Highly unlikely	Minor	Low			No change to risk ranking. No contaminants are expected to be dredged.

Table H-0-3: Further work proposed in the Scarborough nearshore component – referral supplementary report, for the key environmental factor – marine fauna

Receptor (value)	Aspect/impact	Likelihood (unplanned impacts only)	Magnitude	Impact significance level/environment risk consequence	Further work proposed in the project referral	Studies completed and summary of results/ management actions included in the DSDMP	Has the impact significance level/ environment risk consequence changed?
Marine mammals (High) Fish (High) Marine reptiles (High) Planktonic communities (Medium)	Planned – noise and light emissions	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (noise modelling).	Management measures provided in Section 9.1.	No change
	Planned – reduced water quality from dredging activities (e.g. increased turbidity)	N/A	Slight	Minor	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling).	Dredge modelling results presented in Section 5 and report included as Appendix E.	Impacts observed from dredging projects in Western Australia have been attributed to a loss of BCH within the ZoHI (Harvey et al., 2016). The management framework (Section 7.4) is designed to prevent impacts to BCH that provide support to early life stages of fishes and foraging habitat for turtles. Modelling used to confirm assumptions in the referral document on Section 5 .
	Planned – sedimentation of important/critical habitats	N/A	No lasting effect	Slight	Impact addressed within management plans (DSDMP) and supported by additional studies to be undertaken (dredge plume modelling).	Dredge modelling results presented in Section 5 and report included as Appendix E.	
	Unplanned – vessel strikes	Highly unlikely	Slight	Low	Impact addressed within management plans (DSDMP).	Management actions included in Section 9.	No change.
	Unplanned – introduction of IMS	Highly unlikely	Moderate	Moderate	Impact addressed within management plans (DSDMP).	Management actions included in Section 8.	No change.
Marine Reptiles (High)	Unplanned – entrainment during dredging	Highly likely	Slight	High	Impact addressed within management plans (DSDMP).	Management actions included in Section 9.1.	Likelihood reduced to ‘possible’ following implementation of management actions. Impact significance level reduced to ‘moderate’.

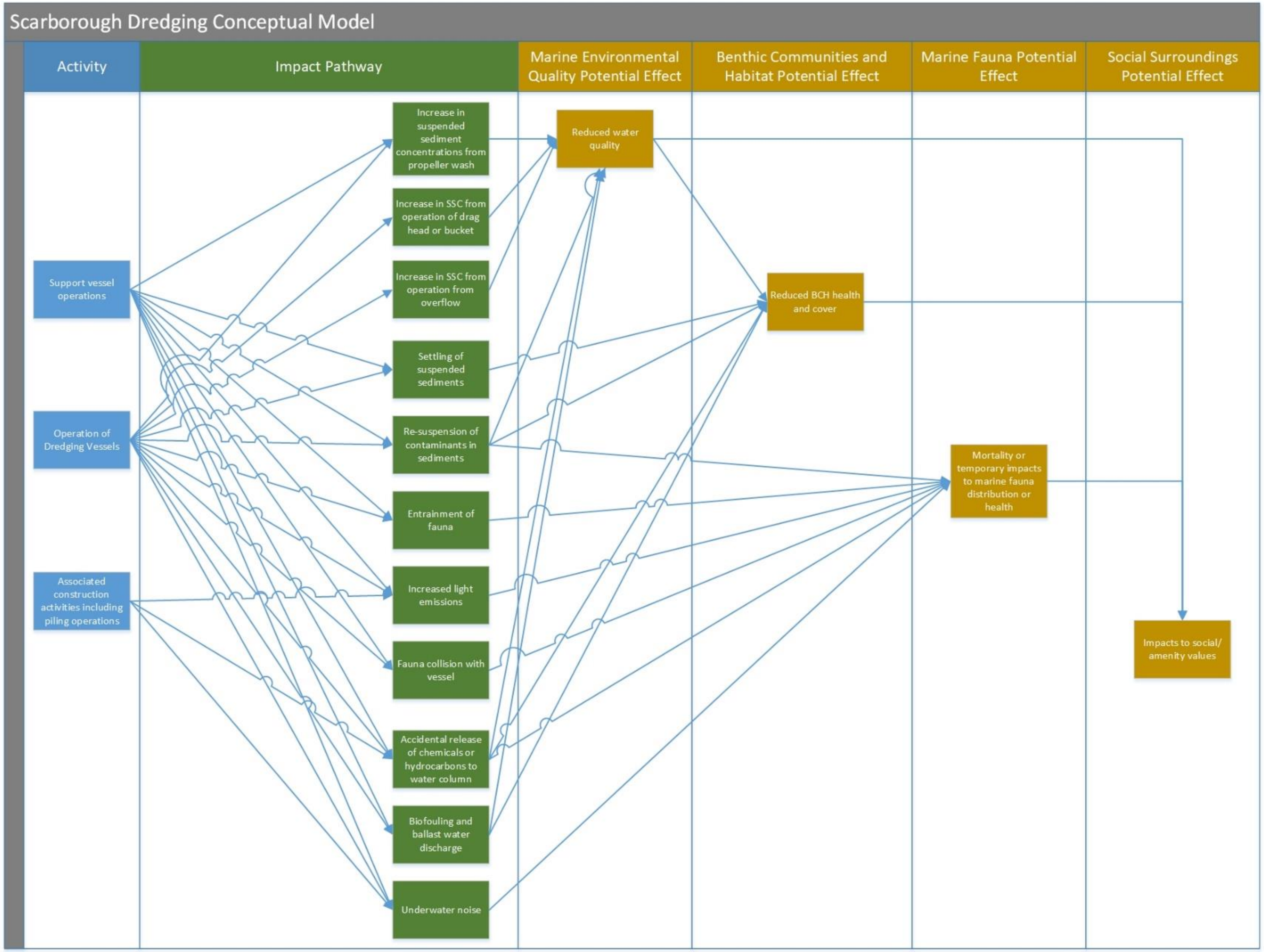

Figure H-0-1: Scarborough Project conceptual model