AQUIS RESORT AT THE GREAT BARRIER REEF PTY LTD

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 7

APPENDIX H

OFF SHORE LAKE INLET ASSESSMENT

Aquis Resort
Proposed Offshore Intake

Aquatic Ecology Assessment

Prepared for:

Flanagan Consulting Group

frc environmental

PO Box 2363, Wellington Point QLD 4160
Telephone: + 61 3286 3850
Facsimile: + 61 3821 7936

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freshwater estuarine marine

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Summary

Aquis Resort at the Great Barrier Reef (the Resort) will be designed to attract international tourists as well as international meetings and conferences. The Resort has been declared a coordinated project under the Queensland *State Development and Public Works Organisation Act 1971* (SDPWO Act). The proposed development includes a large man-made lake.

frc environmental were contracted to assess the likely impacts of Option 2 for the intake of seawater for the lake (i.e. the impacts associated with construction and operation of an offshore water intake pipeline for the Resort). The study area for this assessment included the proposed pipeline alignment and immediate surrounds. Benthic habitat types, water quality, sediment quality and benthic macroinvertebrate communities were assessed at seven sites during a brief field survey in March 2014.

The dominant ecosystem-type in and around the proposed pipeline alignment was un-vegetated soft sediment. Silt and clay dominated the sediment at most sites, with some sand. Sites close to the mouth of Richters Creek were sandy; whereas sites further offshore were predominantly silt and clay. No seagrass or reef habitat was found in the vicinity of the proposed pipeline alignment.

During the survey, the water was turbid particularly toward the mouth of Richters Creek, and water clarity was low at all sites. The pH was lower than expected for open coastal waters. This was likely to be a result of high freshwater inputs at the time of survey, which also led to differences in surface salinity between sites. The percent saturation of dissolved oxygen was within the range anticipated in estuarine surface waters.

The surface sediment at the mouth of Richters Creek was loosely consolidated and there was little evidence of epi-benthic faunal activity (e.g. crab burrows), which was likely due to the rapidly shifting nature of the sediment in this zone. Further offshore, where sediments were finer and more consolidated, the low to moderate density of burrows on the ocean floor indicated there was relatively low activity of benthic fauna.

Sediment quality varied between sites, but concentrations of nutrients were typically highest at site 5. At site 7, closest to the mouth of Richters Creek, concentrations of all nutrients were below laboratory limits of reporting, except total phosphorous. The concentration of metals and metalloids were below ISQG-low trigger values, where applicable, at each site. Concentrations of metals and metalloids increased with distance offshore, but were below trigger levels at all sites.

The community composition of benthic invertebrates along the pipeline route comprised polychaetes, crustaceans and molluscs. The benthic communities were dominated by

polychaetes at each site. The taxonomic richness and abundance of benthic invertebrates was highest at site 6 (approximately 0.86 km offshore of the mouth), and lowest at sites 7 (approximately 0.57 km offshore of the mouth) and site W2 (Richters Creek mouth). Changes in benthic communities between sites 6 and 7 were likely to be due to changes in water and sediment quality between these two sites (e.g. difference in turbidity).

The construction, operation and maintenance of the proposed pipeline has the potential to impact aquatic communities near the pipeline. However, provided that appropriate mitigation measures are implemented and adhered to, impacts will be highly localised and the long-term impacts associated with the construction and operation of the proposed pipeline are likely to be minimal.

1 Introduction

1.1 The Proposed Development

Aquis Resort at the Great Barrier Reef (the Resort) will be designed to attract international tourists as well as international meetings and conferences. It is expected the Resort will assist in the economic growth of North Queensland through government taxes (e.g. gaming taxes once operational) and by increasing job opportunities (approximately 26 700 jobs when fully operational). If approved, the Resort will begin significant works in mid 2014, and completion is set for late 2018.

The proposed development includes a large man-made lake. There are two options for the intake of seawater for the lake: Option 1 is an intake near the mouth of Richters Creek, with a standby inlet near the mouth of Half Moon Bay; Option 2 is an intake in the Coral Sea approximately 2.2 km north-east of the Resort site where the water is some 6.5 m deep at low water. Option 2 is currently favoured, as it can be relied upon to deliver good quality saltwater free from local fresh conditions and any effects of a partial closure of Richters Creek. Water (essentially seawater) from the lake will be discharged via a diffuser near the mouth of Richters Creek (Environment North 2014).

It is the proponent's intention for the Resort to be constructed in two stages; Stage 1 will be completed from 2014 to 2018, and Stage 2 will be completed from 2020 to 2024. The intake pipeline will be constructed early in Stage 1. For a complete description of the proposed development, refer to the draft report *Aquis Resort at the Great Barrier Reef: EPBC Act Issues, March 2014 Version 1* (Environment North 2014).

The Resort has been declared a coordinated project under the Queensland *State Development and Public Works Organisation Act 1971* (SDPWO Act).

1.2 Scope of This Report

This report assesses the likely impacts of Option 2 for the intake of seawater for the lake, (i.e. the impacts associated with construction and operation of the proposed offshore water intake pipeline for the Resort).

The study area for this assessment includes the proposed pipeline alignment and immediate surrounds. The following were assessed during a brief field survey in March 2014:

- types of habitat present (including un-vegetated soft sediment, seagrass and macroalgae, epi-benthic fauna and coral or rocky reef habitat)
- water quality (in situ measurements only)
- sediment quality, and
- benthic invertebrate communities.

Potential impacts to matters of national environmental significance (MNES) relating to aquatic ecology as a result of construction and operation of the pipeline, including impacts to listed threatened and migratory aquatic species, are considered in the separate report *Aquis Resort EPBC Act Issues: Aquatic Ecology* (frc environmental 2014a).

1.3 Constraints and Limitations

The field survey was completed at the end of the wet season in March 2014. The distribution and abundance of seagrass varies seasonally, with maximum distribution and abundance in late spring / early summer, when water clarity is generally good (Rasheed et al. 2013). High rainfall and associated runoff during the wet season reduces water clarity, resulting in suboptimal growth conditions for seagrass. Consequently, the survey was not at an optimal time to determine the maximum distribution of seagrass in the area.

While construction of the pipeline will involve excavation of the seabed to a depth of 1.5 m, only surface sediment quality samples (to approximately 0.3 m) were collected. Further sampling of sediment may therefore be required to fully characterise the sediment to be disturbed.

Prevailing weather conditions during the survey were moderate to poor, with high rainfall and wave action. This resulted in poor water clarity throughout the survey area, and meant that obtaining video footage of benthic habitats was difficult. A combination of techniques (including video footage, visual observation of exposed sediment, sediment grabs and grappling) were used to survey benthic habitats along the proposed pipeline alignment.

The poor weather conditions and wave action also meant that sampling close to shore, where the water was shallow, could not be carried out safely by boat.

2 Relevant Legislation and Guidelines

2.1 Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*

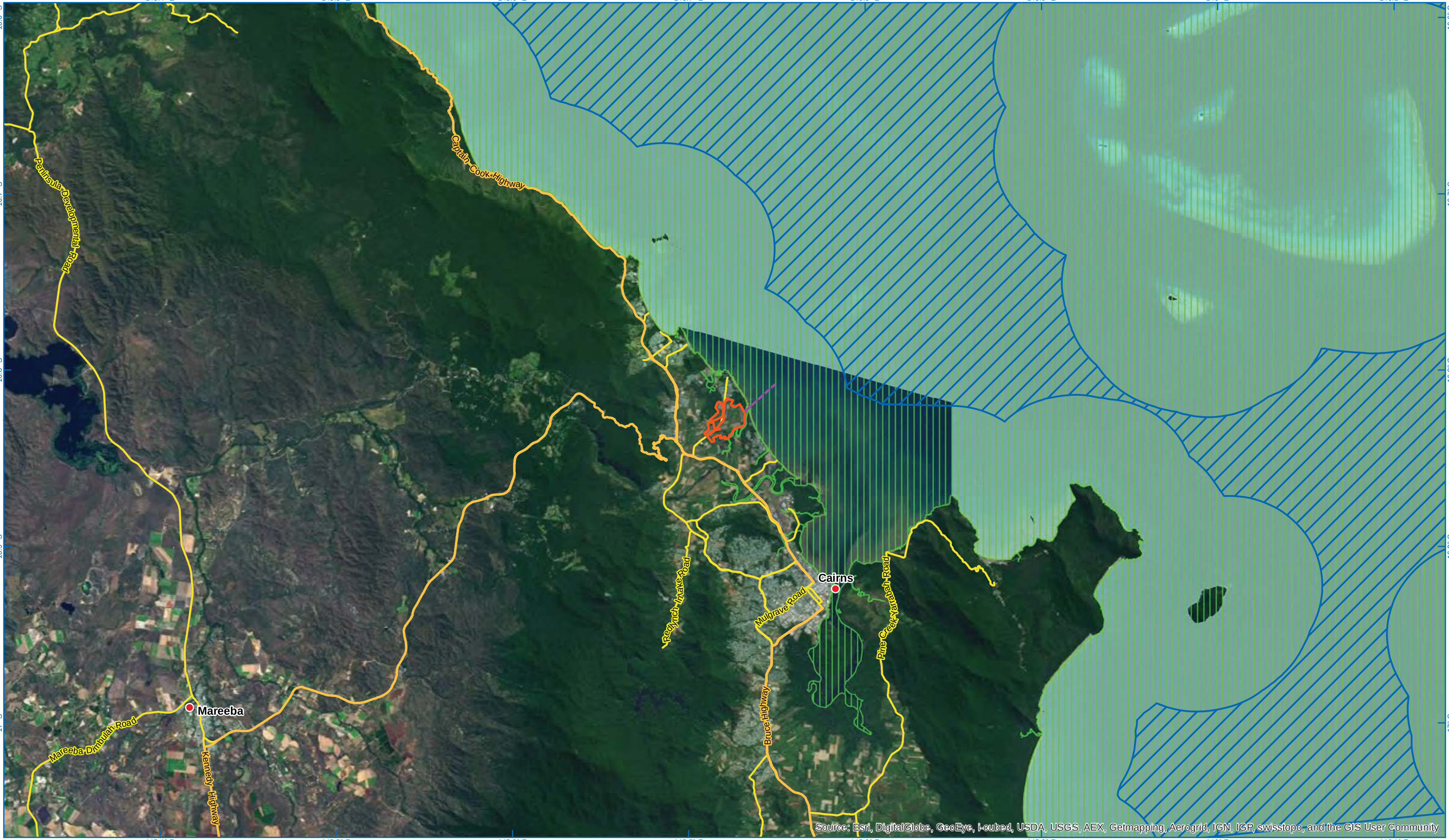
Any actions that are likely to have a significant impact on a matter of national environmental significance (MNES) are subject to assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* [1] (EPBC Act) approval process. The MNES potentially relevant to the pipeline are:

- world heritage properties (the proposed pipeline is within the Great Barrier Reef World Heritage Area)
- national heritage places (the Great Barrier Reef World Heritage Area is also considered a natural heritage place)
- threatened species and ecological communities, and
- migratory species protected under international agreements.

The pipeline is not located within Commonwealth Marine Waters or the Commonwealth Great Barrier Reef Marine Park (Map 1).

A comprehensive discussion of the relevant MNES, and the potential impacts of constructing and operating the pipeline on MNES, is provided in the separate report *Aquis Resort EPBC Act Issues: Aquatic Ecology* (frc environmental 2014a). This includes a detailed description of listed threatened and migratory aquatic species relevant to the pipeline.

[1] Act no. 91 of 1999 as amended, prepared on 27 March 2014 taking into account amendments up to Act No. 93, 2013. Prepared by the Office of the Parliamentary Counsel, Canberra.



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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
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Aquis Resort Proposed Offshore Intake: Aquatic Ecology Assessment

Map 1: Boundary of the Great Barrier Reef Marine Park and World Heritage Area, and Commonwealth Marine Areas in relation to the proposed Aquis Resort

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LEGEND

- Project Site
- Inlet Pipe
- Outlet Pipe
- Great Barrier Reef World Heritage Area
- Great Barrier Reef Marine Park
- Commonwealth Marine Area

Road Network

- Highway
- Main Road

N

SCALE

0 2.5 5 10
Kilometres

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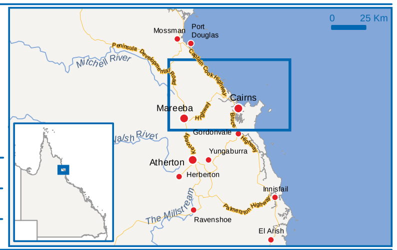

2.2 *State Development and Public Works Act 1971*

The Resort has been declared a coordinated project under the Queensland *State Development and Public Works Organisation Act 1971* (SDPWO Act), which will require an environmental impact statement (EIS). A coordinated project declaration means the project requires a rigorous and comprehensive impact assessment, involving whole of government coordination.

The declaration does not exempt the proponent from the need to:

- obtain necessary development approvals, or
- comply with relevant planning and environment laws and planning instruments.

2.3 Queensland's *Sustainable Planning Act 2009*

Development within the coastal zone is regulated under the *Sustainable Planning Act 2009* [2] (SP Act). Coastal development is assessed by the Department of State Development, Infrastructure and Planning (DSDIP) against the *State Planning Policy* (2013) and the State Development Assessment Provisions (SDAP) – Module 10: Coastal Protection.

Development undertaken in, on or over tidal land, such as construction of the pipeline (which will require dredging), will require a development permit for tidal works. Tidal works are considered to be operational work under the SP Act. In addition to a development permit for tidal works, the State of Queensland must give permission for the development to proceed.

State Planning Policy

The Queensland State Planning Policy came into effect on 2 December 2013. The State Planning Policy defines the Queensland Government's policies about matters of State interest in land use planning and development. Matters of state interest relevant to aquatic ecology include:

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[2] Current as at 20 February 2014. Reprint prepared by the Office of the Queensland Parliamentary Counsel.

- biodiversity
- coastal environment, and
- water quality.

Items relevant to the proposed pipeline with respect to aquatic ecology include:

- considering matters of national, state and local environmental significance
- facilitating the protection of coastal processes and coastal resources
- protecting identified environmental values and the achievement of relevant water quality objectives, and
- protecting the natural environment from the potential impacts of acid sulfate soils.

State Development Assessment Provisions – Module 10: Coastal Protection

Under the SDAP Module 10, the following performance outcomes apply to tidal works and may be relevant to the construction of the proposed pipeline:

- PO1 Tidal work that is private marine development does not result in adverse impacts to tidal land, and
- PO3 Development includes and complies with a dredge management plan that demonstrates how environmental impacts will be managed and mitigated, and how the requirements of the National Assessment Guidelines for Dredging (DEWHA 2009) will be met.

2.4 Queensland's *Coastal Protection and Management Act 1995*

The coastal zone is defined in the *Coastal Protection and Management Act 1995* (Coastal Act)[3] as 'coastal waters and all areas to the landward side of coastal waters in which there are physical features, ecological or natural processes or human activities that affect, or potentially affect the coast or coastal resources.' State coastal waters are defined as waters within three nautical miles from low water or as otherwise stated. The proposed pipeline is within the coastal zone and a coastal management district (Map 2).

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[3] Current as at 31 March 2013. Reprint issued by the Office of the Queensland Counsel.

Draft Coastal Management Plan

A draft Coastal Management Plan is currently being finalised, and will apply to management planning, activities, decisions and works that are not assessable development under the *Sustainable Planning Act 2009* and therefore not subject to the State Planning Policy. It is a draft statutory amendment to the existing Queensland Coastal Plan under the Coastal Act, and includes policies for Nature Conservation.

The State Policy for Coastal Management, part of the existing Coastal Plan, will remain in effect until the Coastal Management Plan is finalised. The State Policy for Coastal Management provides policy direction for natural resource management decision makers about land on the coast.

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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
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Aquis Resort Proposed Offshore Intake: Aquatic Ecology Assessment

Map 2: Boundary of the Coastal Zone and Coastal Management Districts in relation to the proposed Aquis Resort

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LEGEND

- Project Site
- Inlet Pipe
- Outlet Pipe
- Coastal Management District
- Coastal Zone

Road Network

- Highway
- Main Road

N

SCALE

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Kilometres

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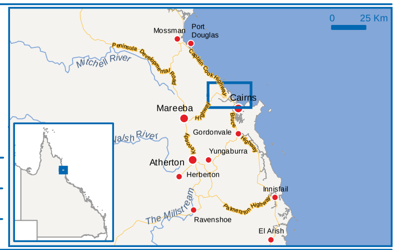

2.5 Queensland's *Environmental Protection Act 1994*

The *Environmental Protection Act 1994* (EP Act) [4] is the key legislation for environmental management and protection in Queensland. The EP Act establishes a general environmental duty, and a duty to notify environmental harm that applies to all persons and corporations. The EP Act provides for environmental protection policies that establish the environmental values to be preserved, and that may set quality standards for segments of the environment (e.g. water, air, waste and noise). The environmental values of waterways in Queensland are protected under the EP Act and the subordinate Environmental Protection (Water) Policy 2009 (EPP Water) [5].

Environmental Protection (Water) Policy 2009

The EPP Water was established to protect Queensland waters while allowing for ecologically sustainable development. The purpose of the policy is to identify environmental values for aquatic ecosystems and for human uses; and determine water quality guidelines and water quality objectives (WQOs) to protect environmental values (EVs).

EVs and WQOs have been established for many waterways in Queensland under Schedule 1 of the EPP Water. The EPP Water defines an indicator for an environmental value as a property that can be measured or decided in a quantitative way. WQOs are numerical concentrations or statements for indicators that protect a stated environmental value and are generally developed based on the review of the available site-specific information relevant to each environmental value.

The environmental values of waters to be enhanced or protected under the EPP Water are:

- biological integrity of a modified aquatic ecosystem
- suitability for recreational use
- suitability for minimal treatment before supply as drinking water
- suitability for agricultural use, and

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4 Current as at 20 February 2014. Reprint prepared by the Office of the Queensland Parliamentary Counsel.

5 Current as at 6 December 2013. Reprint prepared by the Office of the Queensland Parliamentary Counsel.

- suitability for industrial use.

Specific environmental values and WQOs have not been prescribed for the coastal waters where the proposed pipeline will be constructed. Therefore, the environmental values and WQOs should currently be considered by addressing water quality guidelines. For the purposes of this report the following documents were referred to for the appropriate WQOs and guidelines for the coastal waters where the proposed pipeline will be constructed:

- Draft Surface Water Quality Guidelines for the Wet Tropics Region (DEHP 2013)
- the Water Quality Guidelines for the Great Barrier Reef Marine Park (the GBRMP guidelines) (GBRMPA 2010)
- the Queensland Water Quality Guidelines (QWQG) (DERM 2009)
- the Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters (ANZECC & ARMCANZ guidelines) (ANZECC & ARMCANZ 2000a), and
- the National Assessment Guidelines for Dredging (NAGD) (DEWHA 2009).

Summary of Aquatic Ecological Values

The following EVs were identified for the pipeline study area:

- aquatic ecosystem (slightly to moderately disturbed)
- primary recreation
- secondary recreation, and
- visual recreation.

2.6 Queensland's *Fisheries Act 1994*

All waters of the state are protected against degradation by direct or indirect impact under section 125 of the *Fisheries Act 1994* (Fisheries Act) [6]. If litter, soil, a noxious substance, refuse or other polluting matter is on land (including the foreshore and non-tidal land), in

[6] Current as at 1 November 2013. Reprint prepared by the Office of the Queensland Parliamentary Counsel.

waters, or in a fish habitat, and it appears to the Chief Executive that the polluting matter is likely to adversely affect fisheries resources or a fish habitat, the Chief Executive of the Department of Agriculture, Fisheries and Forestry (DAFF) may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation.

Fish Habitat Areas

Fish Habitat Areas (FHA) are declared under the Fisheries Act to enhance existing and future fishing activities and to protect the habitat for fish and other fauna. They mainly cover inshore and estuarine habitats, as these are recognised as being highly valuable habitats for commercially and recreationally important fish and crustaceans. While normal community use and activities (including legal fishing activities) are not restricted in fish habitat areas, any works or activities that may disturb habitats within a fish habitat area, require a specific permit under the provisions of the Fisheries Act.

The inshore portion of the proposed intake pipeline, as well as the outlet pipeline, is within the Yorkeys Creek FHA (FHA-034), which is a Management Level 'B' FHA (Map 3). Management level B is designed to protect important fish habitat for the purpose of productive and sustainable fishing (short and long term), minimise the impacts of non-fisheries related disturbance to important fisheries habitat, maintain biodiversity of fisheries resources, and provide a management buffer the level A Fish Habitat Areas. Permanent public and private structures that are assessed as having an overriding requirement to be on tidal land or within the FHA may be authorised subject to assessment. A resource allocation authority (RAA) issued under the Fisheries Act will be required for any structures or disturbance in these areas, as well as development approval with referral to Queensland Fisheries.

Marine Plants

Marine plants are protected under the Fisheries Act. Under this Act marine plants include:

- a plant that usually grows on or adjacent to tidal land, whether living, dead, standing or fallen
- material of tidal plant, or other plant material on tidal land, and
- a plant, or material of a plant, prescribed under a regulation or management plan to be a marine plant (Couchman & Beumer 2002).

Tidal land is defined under the Act as any land that is at or below the highest astronomical tide (HAT) level (Couchman & Beumer 2002).

Marine plants include macro- and microscopic plants such as mangroves, seagrass, samphires, saltcouch and saltmarsh plants, algae and other tidal plants growing next to the tidal zone, landward and seaward (Couchman & Beumer 2002). The primary values of marine plants to estuarine ecology and fisheries are their contribution, through the process of photosynthesis, to a detritus-based food web; and the provision of a range of habitats (i.e. shelter, foraging and nurseries) for fish and invertebrates (Connolly 1999). Plants of highest significance to fisheries include all mangroves, seagrasses, marine algae, marine couch and samphires (Couchman & Beumer 2002).

Disturbance of marine plants to construct the pipeline will require a development approval, and if the disturbance will occur off-site on unallocated state land, a RAA will also be required.

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Wellington Point
Q 4160 Australia

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Aquis Resort Proposed Offshore Intake: Aquatic Ecology Assessment

Map 3: Boundary of Fish Habitat Areas in relation to the proposed Aquis Resort

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LEGEND
- Project Site
- Inlet Pipe
- Outlet Pipe

Declared Fish Habitat Area Management Type
- Management A
- Management B

Road Network
- Highway
- Main Road

N

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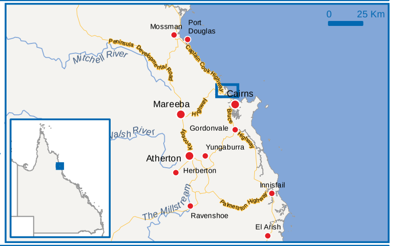
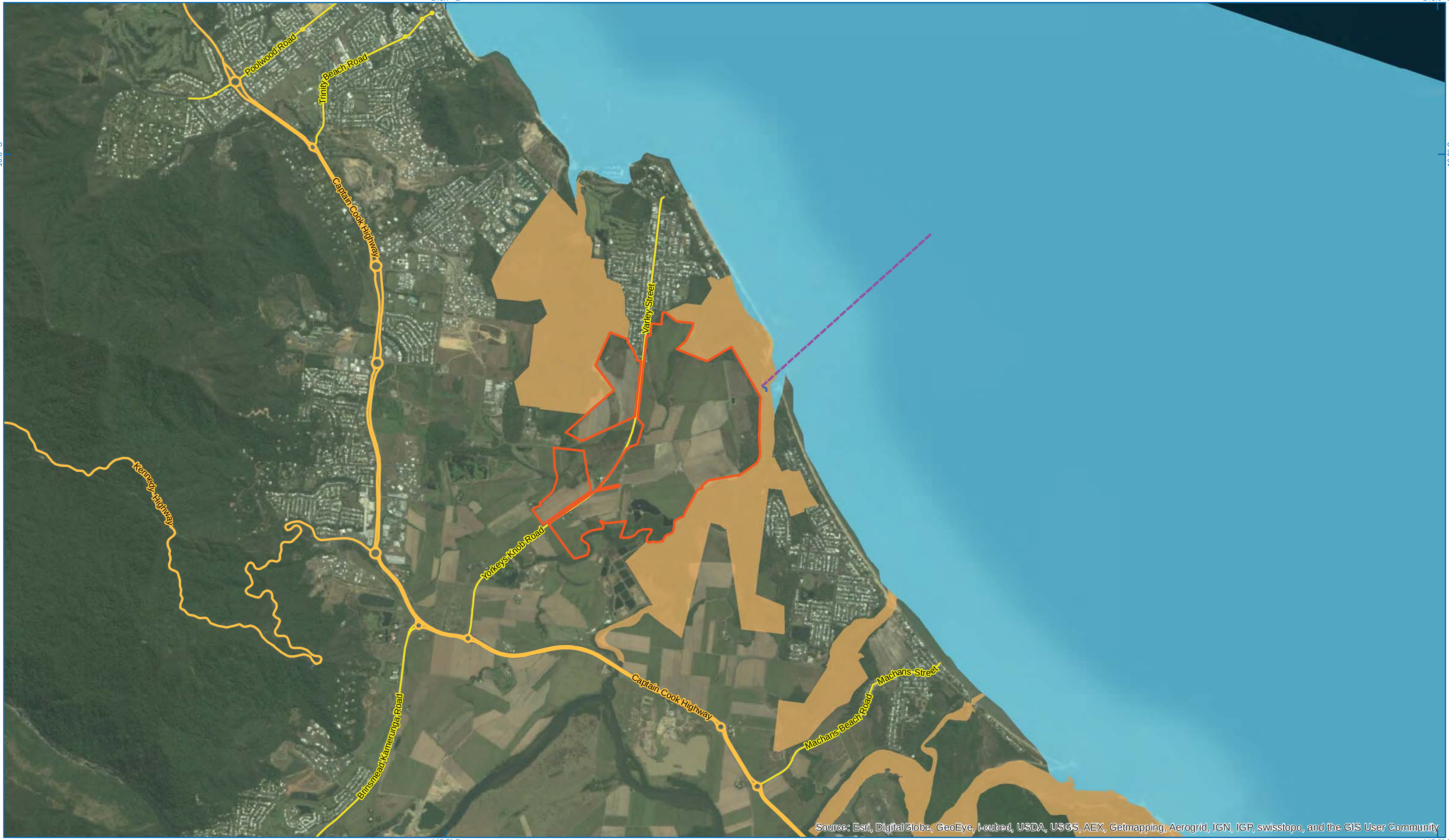


2.7 Queensland's *Marine Parks Act 2004*

The Great Barrier Reef Coast Marine Park is a state marine park declared under the *Marine Parks Act 2004* [7] and protected under the Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004. In general, it provides protection of areas of the Great Barrier Reef Marine Park from the edge of state coastal waters up to the highest astronomical tide (HAT), therefore protecting tidal lands and waters. The Great Barrier Reef Coast Marine Park Zoning Plan ensures the protection of habitat types by defining activities that can occur at each location (DNPRSR 2013).

The inshore portion of the intake pipeline, and the outlet pipeline, is in an estuarine conservation zone (brown) (Map 4). This zone provides for the protection of areas in a natural state while allowing the public to appreciate and enjoy relatively undisturbed nature, maintaining fisheries production and use and providing for traditional hunting and gathering. The offshore portion of the intake pipeline is in the general use zone (light blue) (Map 4). A permit from the Department of National Parks, Recreation, Sport and Racing will be required to construct the pipeline.

[7] Current As at 7 November 2013. Reprint prepared by the Office of the Queensland Parliamentary Counsel.



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Wellington Point
Q 4160 Australia

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Aquis Resort Proposed Offshore Intake: Aquatic Ecology Assessment

Map 4: Boundary of the Great Barrier Reef Coast Marine Park Zones in relation to the proposed Aquis Resort

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LEGEND
- Project Site
- Inlet Pipe
- Outlet Pipe

Great Barrier Reef Coast Marine Park Zoning Plan
- General Use
- Estuarine Conservation

Road Network
- Highway
- Main Road

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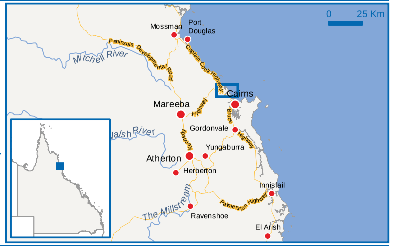


2.8 Queensland's *Nature Conservation Act 1992*

Native flora and fauna species are protected in Queensland under the *Nature Conservation Act 1992* [8]; extinct in the wild, endangered, vulnerable, near threatened and least concern species are listed in the Queensland's Nature Conservation (Wildlife) Regulation 2006 [9] (NCWR). A number of the species protected under the Commonwealth's EPBC Act are also listed as threatened under the NCWR, including:

- the following vulnerable species:
  - humpback whale
  - green turtle
  - hawksbill turtle
  - flatback turtle
  - salt water crocodile
- the following endangered species:
  - loggerhead turtle
  - leatherback turtle, and
  - olive ridley turtle.

These species are discussed in detail in the separate report *Aquis Resort EPBC Act Issues: Aquatic Ecology* (frc environmental 2014a).

[8] Current as at 24 November 2013. Reprint prepared by the Office of the Queensland Parliamentary Counsel.

[9] Current as at 27 September 2013. Reprint prepared by the Office of the Queensland Parliamentary Counsel.

3 Methods

3.1 Study Approach

Well recognised indicators of aquatic ecological health that are known to respond to changes in aquatic ecosystems and impacts, such as those that may occur directly or indirectly due to the construction and operation of the pipeline were used in the design of the survey.

The survey design, aquatic ecological indicators and methods used in this study are based on accepted ecological impact monitoring methods, such as those described in the *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC & ARMCANZ 2000b) and the Queensland *Monitoring and Sampling Manual 2009* (DERM 2010). The specific methods used for each indicator are described in Section 3.3 below.

3.2 Desktop Assessment

The aquatic habitats and communities previously described in the study area and wider Cairns region were described through a desktop study. Information sources included:

- a review of the relevant legislation and guidelines applicable to the pipeline (with respect to aquatic ecology), including a review of the State Planning Policy Interactive Mapping System (DSDIP 2014)
- bathymetric charts and Great Barrier Reef Marine Park zoning maps, showing the locations of reefs or other notable features
- seagrass surveys completed in the region (Coles et al. 1993; Campbell et al. 2002; Reason et al. 2012; Rasheed et al. 2013)
- the aquatic ecology section of the Aquis Resort technical study, including sites previously surveyed for sediment quality and benthic macroinvertebrates (frc environmental 2014b)
- sediment surveys undertaken for the Cairns Port Long-term Management Plan (Worley Parsons 2010), and
- benthic macroinvertebrate communities surveyed in the region (e.g. Neil et al. 2003).

3.3 Field Survey

Survey Design

The field survey was completed from 21 to 23 March 2014. The weather during this period was moderate to poor; and was characterised by overcast conditions with frequent showers. Throughout the survey there were light to moderate (~10 knots) southerly winds and a 0.75-1.5 m south-easterly swell. There were neap tides during the survey and the tidal varied from 1.19 m to 2.29 m (Table 3.1).

Table 3.1 Tide heights and times at Cairns each day during the survey.

Tide	21 March 2014		22 March 2014		23 March 2014	
	Height (m)	Time	Height (m)	Time	Height (m)	Time
high	2.17	1115	2.29	0036	2.32	0321
low	1.19	1748	1.74	0646	1.64	1013
high	–	–	1.96	1211	1.88	1512
low	–	–	1.32	1848	1.32	2114

Rainfall recorded at the Bureau of Meteorology station number 31011 (Cairns Aero) in the three months prior to the survey was below the long-term median (BOM 2014). However, there was high rainfall in March prior to the field survey, with the total rainfall in March 2014 29 mm above the long term median (Figure 3.1).

In this survey, seven sites were sampled for water quality, sediment quality and benthic macroinvertebrates (Table 3.2). Sites were positioned at 250 m intervals along the proposed alignment (Map 5).

One site in Richters Creek mouth, site W2, was surveyed during the wet season survey on 27 February 2014 and results were incorporated in this report (Map 5). This site was surveyed for water quality, sediment quality and benthic macroinvertebrates. Sediment quality was only assessed for total nitrogen, total phosphorous and moisture content.

In addition to assessing these sites described, subtidal habitat was characterised visually along ten transects (Map 6).

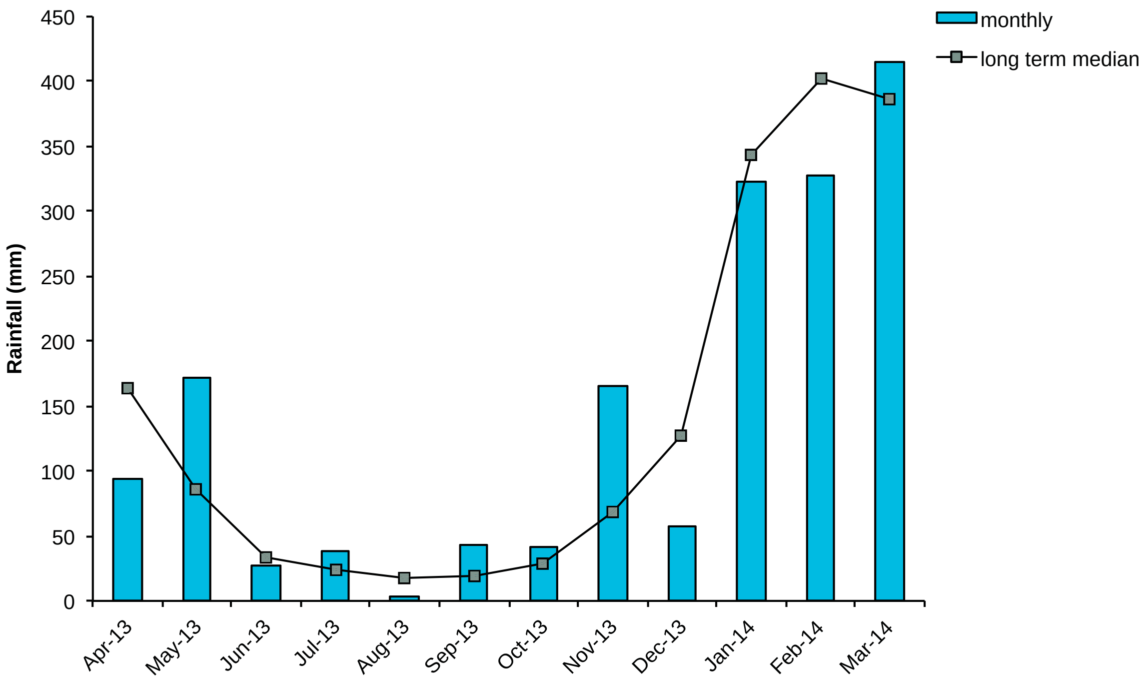
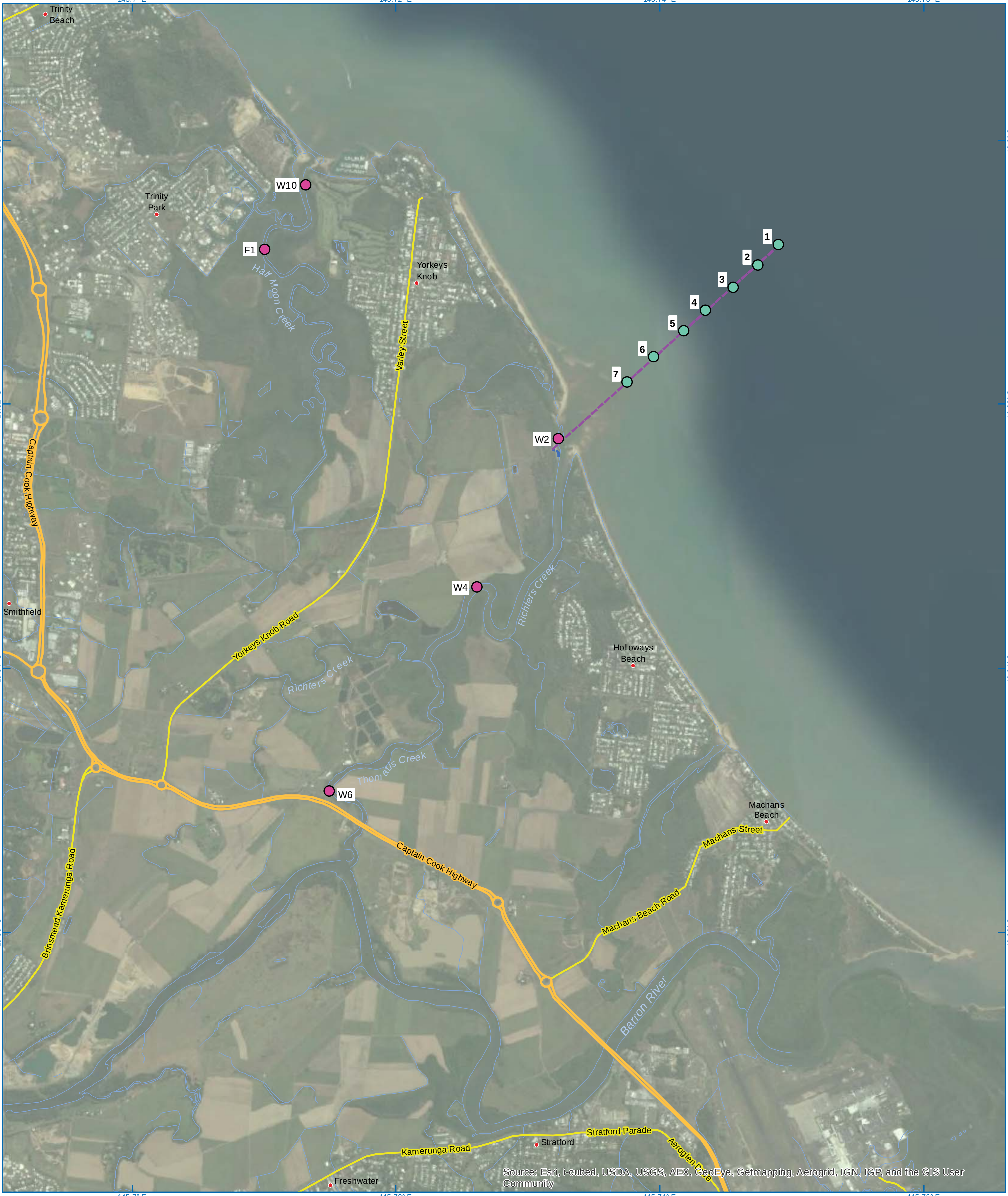


Figure 3.1 Monthly and long term median rainfall (1942 – 2014) at Cairns Aero between April 2013 and March 2014.

Table 3.2 Survey sites, locations and coordinates.

Site	Location	Easting [a]	Northing [a]
1	pipeline alignment, offshore of Richters Creek	366 695	8 141 272
2	pipeline alignment, offshore of Richters Creek	366 532	8 141 099
3	pipeline alignment, offshore of Richters Creek	366 332	8 140 912
4	pipeline alignment, offshore of Richters Creek	366 110	8 140 720
5	pipeline alignment, offshore of Richters Creek	365 936	8 140 543
6	pipeline alignment, offshore of Richters Creek	365 693	8 140 324
7	pipeline alignment, offshore of Richters Creek	365 481	8 140 112

[a] GPS (WGS84, zone 55K)



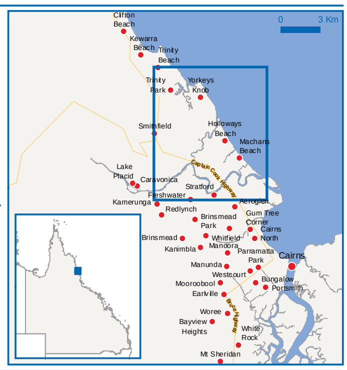
Aquis Resort Proposed Offshore Intake: Aquatic Ecology Assessment

Map 5:
Benthic macroinvertebrate survey sites

LEGEND

Benthic Macroinvertebrate Survey Site
- Current Survey
- February 2014 Wet Season Survey
- Watercourse
- Inlet Pipe
- Outlet Pipe

Road Network
- Highway
- Main Road



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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
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DATE	DRAWN BY	VERSION	PROJECTION
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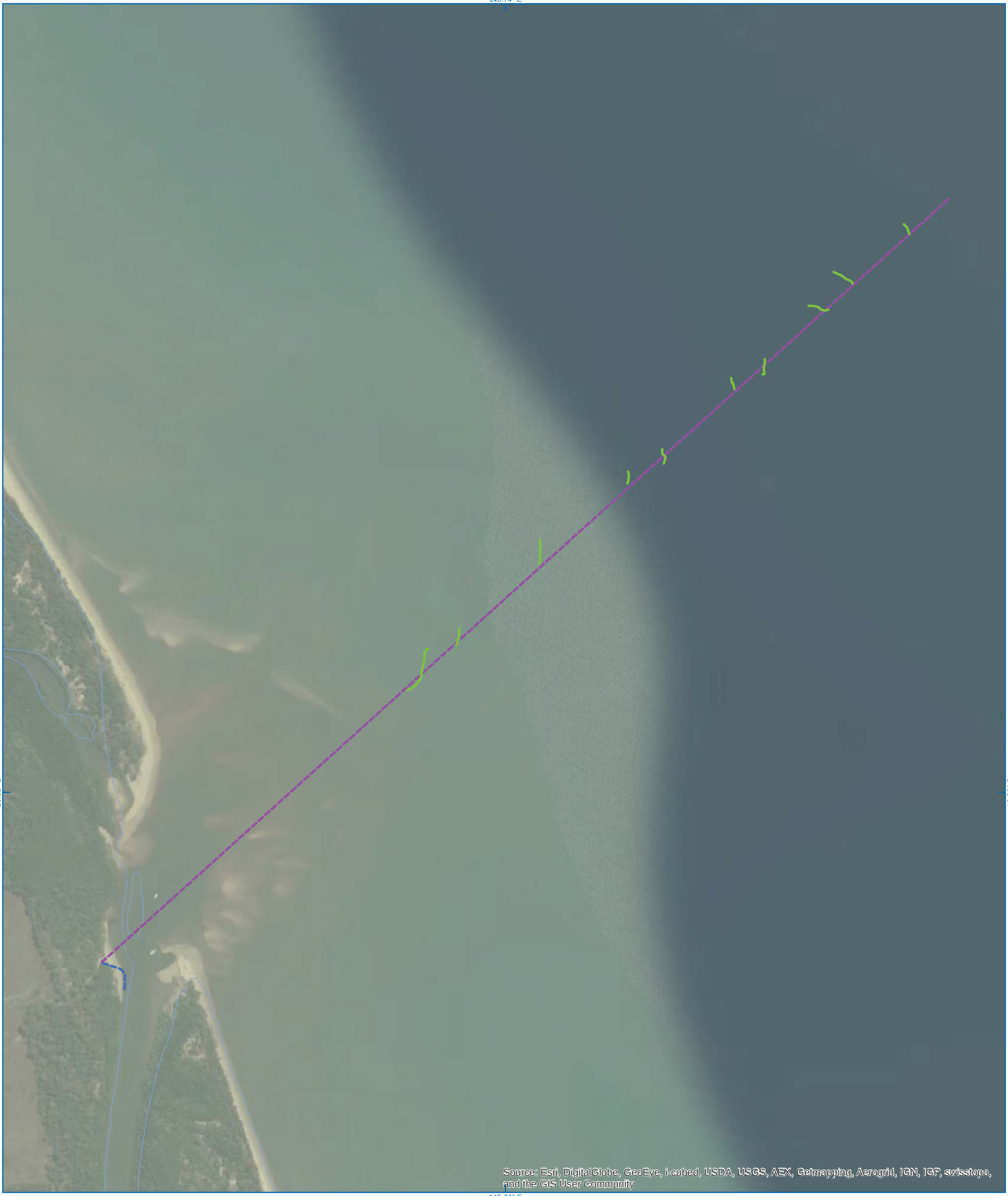
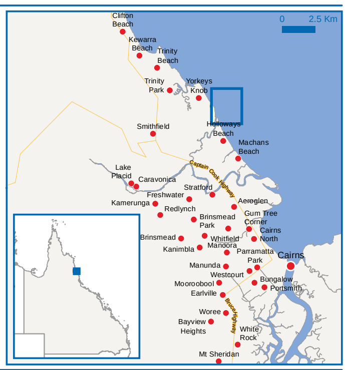


Aquis Resort Proposed Offshore Intake: Aquatic Ecology Assessment

Map 6:
Subtidal survey transects

LEGEND

- Transect
- Watercourse
- Inlet Pipe
- Outlet Pipe



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PO Box 2363
Wellington Point
Q 4160 Australia

P 07 3286 3850
E info@frcenv.com.au
www.frcenv.com.au

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DATE	DRAWN BY	VERSION	PROJECTION
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Habitat Survey

Based on the results of the desktop study, the habitat survey targeted searches for the presence of seagrass, and descriptions of epi-benthic communities. It also included in situ water quality monitoring and visual assessments of freshwater plumes discharged from Richters Creek and other waterways.

In Situ Water Quality

Water quality was profiled using a YSI 6600 V2 Sonde. The probe was lowered through the water column to the seafloor twice at each site, with the following parameters logged at five second intervals:

- depth (m)
- temperature (°C)
- turbidity (nephelometric turbidity units, NTU)
- pH
- conductivity (mS/cm)
- salinity (ppt)
- total dissolved salts (TDS) (ppt), and
- dissolved oxygen (percent saturation and mg/L).

Cross validation of turbidity was done in the field by collecting a surface water sample at each site, and measured using a HACH 2100Q. These meters are more accurate than the Sonde; however, they were not practical for the entire profile as they require manual sample collection for each data point. Secchi depth was also collected at each site.

Surface water quality data (<30 cm) from the profiles, as well as water quality from depth (approx. 7.5 m) at site 1 (i.e. the proposed entrance to the intake pipeline), was then averaged across the two profiles and compared to the *Wet Tropics Draft surface water quality guidelines for open coastal waters in the Barron Basin* (DEHP 2013), provided in Table 3.3.

Table 3.3 Water Quality Guidelines relevant to the study area.

Parameter	Units	Draft WQG [a]
pH		8.15 – 8.4
turbidity	NTU	1
dissolved oxygen	% sat	95 – 105
secchi	m	10

[a] Wet Tropics draft surface water quality guideline for open coastal waters in the Barron Basin (DEHP 2013)

Subtidal Benthic Habitat

Subtidal benthic habitat was surveyed in the vicinity of the proposed pipeline using a:

- remote underwater video camera
- seagrass grapple, and
- Van Veen grab.

The remote underwater video camera was secured below the boat, and was towed along to record the seafloor. Ten transects, approximately 0.25-1 km long, were surveyed. Each transect was perpendicular to the pipeline alignment (Map 6). The track of each transect was mapped using a GPS and linked to depth and other key characteristics of the habitat. High definition video footage of each transect was recorded, and video of benthic habitats was viewed ‘live’ on board the boat. If seagrass beds, macroalgae or other notable habitat features, such as rocky outcrops, were identified further details would have been recorded (however these were not identified during the surveys).

The remote underwater video camera was also deployed at each benthic macroinvertebrate sampling site and small transects were completed along the anchor line at each of these sites.

A Van Veen grab (0.026 m^2) was deployed a minimum of six times at each of the seven sediment and benthic macroinvertebrate survey sites (see below), and samples were checked for the presence of seagrass. In addition, a grapple was deployed four times at each of the seven sampling sites. Had seagrass or macroalgae been collected, the species of seagrass or macroalgae and site location would have been recorded.

Sediment Quality

Sediment samples were collected using a Van Veen grab (0.026 m^2) at each of the seven sites (Table 3.2 and Map 5). At one site, an additional sediment sample was collected to analyse variation within sites. Sediment was transferred directly into the sample containers provided by the analytical laboratory.

All sampling was in accordance with the Queensland *Monitoring and Sampling Manual 2009* (DERM 2010).

Sediment samples were analysed by Symbio Alliance (a NATA-accredited laboratory) for:

- moisture content
- particle size distribution
- total organic carbon
- nutrients (total nitrogen, total phosphorus, ammonia, nitrate, nitrite, soluble phosphate and total Kjeldahl nitrogen)
- total metals (aluminium [Al], tin [Sb], arsenic [As], cadmium [Cd], chromium [Cr], cobalt [Co], copper [Cu], iron [Fe], manganese [Mn], mercury [Hg], lead [Pb], nickel [Ni], selenium [Se], silver [Ag], vanadium [V] and zinc [Zn]), and
- tributyltin (TBT).

Results were compared with the results of sediment quality assessments undertaken in the Cairns region, including other surveys completed for the Resort (frc environmental 2014b). In addition, the concentrations of some metals and TBT was compared with the screening levels outlined in the *National Assessment Guidelines for Dredging* (NAGD) (DEWHA 2009; DoTE 2009), which are generally consistent with the interim sediment quality guideline (ISQG) 'low' trigger values presented in ANZECC & ARMCANZ (2000a) (Table 3.4). There are no screening levels for the other parameters analysed.

To assess within-site variation, the RPD between the two samples collected from one site was calculated. A RPD of 50% for field replicates is considered acceptable (DEWHA 2009; DoTE 2009).

Table 3.4 Sediment Quality Guidelines relevant to the study area.

Parameter	Units	Screening Level (ISQG Low Trigger Value)
Metals and Metalloids		
Arsenic [a]	mg/kg	20
Cadmium	mg/kg	1.5
Chromium	mg/kg	80
Copper	mg/kg	65
Lead	mg/kg	50
Mercury	mg/kg	0.15
Nickel [a]	mg/kg	21
Zinc	mg/kg	200
Tributyltin (as Sn) [b]	µg Sn/kg	9

[a] maximum (Bq/g is becquerels per gram)

[b] where a numerical maximum value (ISQG-High) for TBT is required, the USEPA's final chronic value of 80 µg/kg may be used.

Benthic Macroinvertebrates

Sample Collection and Processing

Benthic macroinvertebrates were sampled from each of the seven sites (Map 5, Table 3.2). At each site, five samples were collected using a Van Veen grab (0.026 m^2). Sediment composition was similar at sites one to five, comprising silt and / or clay. Sediment composition at sites six and seven was dominated by riverine sand with some silt. The grab samples were sieved in the field through a 1 mm sieve (Figure 3.2) and the benthic fauna, sediment and detritus retained on the sieve were preserved in methylated spirits, and sent to the frc environmental biological laboratory for identification.

Five samples from each site were stained with Rose Bengal and invertebrates were picked, counted and identified to the lowest taxonomic level possible (in most cases, family).

Figure 3.2

Field sieving benthic macroinvertebrate samples.

Data Analysis

Mean abundance (i.e. the average number of individuals in the samples from each site), mean taxonomic richness (i.e. the average number of taxa in the five samples from each site), and mean abundance of abundant taxa (i.e. the average number of individuals from each abundant taxa in the five samples from each site) was calculated. Mean abundances were converted to individuals per square metre prior to analysis.

Capitellid polychaetes are indicators of organic pollution (Beesley et al. 2000). The densities of capitellid polychaetes in environments with high nutrient and organic loads are typically above 1000 individuals per m^2 (Tsutsumi 1990; Hutchings et al. 1993). Such densities are generally indicative of organic enrichment and are used as a biological trigger value in the ANZECC & ARMCANZ (2000a) guidelines. The density of capitellid polychaetes was compared with this trigger value.

Differences in the composition of macroinvertebrate communities were visualised using non-metric multidimensional scaling (nMDS) plots in PRIMER. The nMDS attempts to place samples on a 'map', such that the rank order of the distances among samples matches the rank order of the matching similarities from the similarity matrix (Clarke & Warwick 2001). This provides a visual representation of the similarities among communities within each sample. Note that each of the axes is not related to any particular variable, and axes can be rotated to provide the best visual representation of the data.

Environmental parameters relating to habitat composition in aquatic ecosystems are known to influence the structure and composition of macroinvertebrate communities. The

BIOENV routine (Clarke & Warwick 2001) was used in PRIMER to test for correlations between the composition of macroinvertebrate communities and environmental parameters. BIOENV determines whether environmental parameters are correlated with patterns in the composition of macroinvertebrate communities using the Spearman's rank correlation coefficient (Clarke & Warwick 2001). Data was normalised prior to analysis, and Draftsman plots were used to determine if any of the environmental parameters were correlated prior to completing the BIOENV.

4 Aquatic Habitat

4.1 In Situ Water Quality

Of the Region

Trinity Inlet and Trinity Bay are highly turbid systems as a result of substrate composition, shallow water and prevailing winds (Carter et al. 2002; Worley Parsons 2010). Closer to the survey area at Richters Creek, water quality at the mouth of Richters Creek is characterised by elevated turbidity as a result of flow velocity and the presence of fine sediments (BMT WBM 2014). Salinity in Richters Creek is variable and largely influenced by rainfall; the creek is at times completely estuarine or completely freshwater.

Of the Study Area

The pH of surface waters was slightly below the draft WQG at all sites, except site 1 and site 3 (Table 4.1). Frequent rainfall throughout the survey and subsequent freshwater flows from Richters Creek and the Barron River are likely to have lowered the pH of surface water. The salinity of surface waters was lower than expected at all sites (salinity of seawater is approximately 35 ppt) (Table 4.1). Despite low salinity in surface waters, salinity was at normal levels in deeper water (for example, 34.4 ppt at ~2 m at site 1) (Figure 4.2). This is indicative of a freshwater plume in surface waters, likely due to rainfall and freshwater flows from Richters Creek and the Barron River.

Turbidity and secchi values of surface waters were well above the draft WQG at all sites. Turbidity was lowest at site 1, which was the greatest distance from the mouth of Richters Creek (Table 4.1 and Figure 4.2). Poor water clarity is likely to be associated with runoff from the local area (Figure 4.1). Dissolved oxygen was within the draft WQG for surface waters; however, dissolved oxygen was below the draft WQG in deeper waters both near the mouth of Richters Creek (e.g. site 7) below ~0.7 m depth, and in open water (e.g. site 1) below ~6.5 m depth (Figure 4.2). The depth of water where the concentration of dissolved oxygen was below the draft WQG increased with distance offshore.

Water quality at site 1 (i.e. the proposed entrance to the intake pipeline) at depth (approx. 7.5 m) was similar to that at the surface, except for salinity, which was close to the expected range of seawater (Table 4.2). Water quality parameters were within the WQG, where available.

Table 4.1 Surface water quality (< 30 cm depth) of the study area.

Parameter	Units	WQG	Site							
			W2	**1**	**2**	**3**	**4**	**5**	**6**	**7**
temperature	°C	–	27.6	27.9	27.1	27.8	27.9	28.1	27.9	26.2
pH	–	8.15 – 8.4	7.82	8.16	8.11	8.21	8.10	8.14	8.12	8.08
salinity	ppt	–	17.4	26.8	21.3	18.6	31.0	25.8	19.5	21.3
turbidity	NTU	1	40	8	16	16	3	17	22	30
dissolved oxygen	% sat.	95 – 105	90	97	97	96	98	98	98	95
secchi	m	10	–	1.5	0.7	0.5	1.1	0.5	0.6	0.4

Shaded cell indicates that the value was outside the draft WQG range

Table 4.2 Near bottom water quality (0.5 m from substrate) of the study area.

Parameter	Units	WQG	Site							
			W2	**1**	**2**	**3**	**4**	**5**	**6**	**7**
depth	m	–	2.5	7.5	7.5	7.4	6.6	5.8	4.3	2.3
temperature	°C	–	28.1	27.5	27.5	27.4	27.5	27.5	27.5	27.8
pH	–	8.15 – 8.4	8.06	8.16	8.15	8.14	8.09	8.12	8.09	8.09
salinity	ppt	–	33.03	34.4	34.3	34.3	34.2	34.2	34.15	33.11
turbidity	NTU	1	92	1	3.3	3.7	8.2	7.5	21.3	45.8
dissolved oxygen	% sat.	95 – 105	90.6	95	92	91	90.7	89	88	92

Shaded cell indicates that the value was outside the draft WQG range

Figure 4.1

Turbid freshwater plume (foreground) adjacent to Richters Creek.

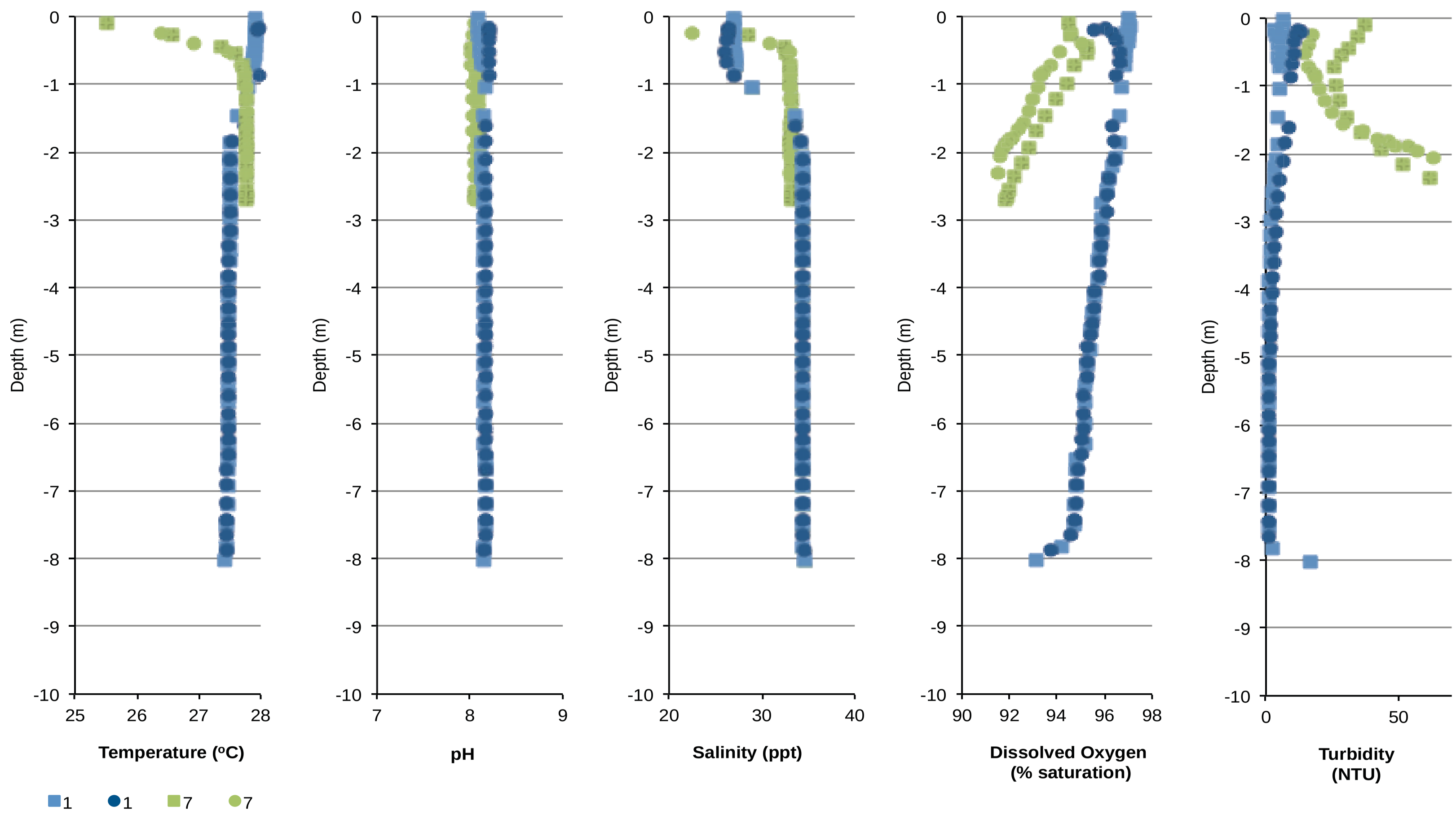


Figure 4.2 Example water quality profiles for temperature, pH, salinity, dissolved oxygen and turbidity at site 1 (furthest site offshore) and site 7 (furthest site inshore). Squares represent profile replicate number one; circles represent profile replicate number 2.

4.2 Un-vegetated Soft Sediment

Of the Region

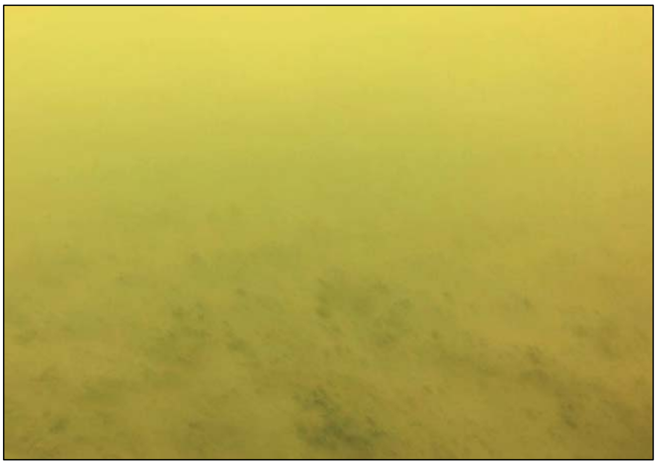
Un-vegetated soft sediment habitat comprises the majority of benthic habitats within the Cairns Ports Limited and wider Trinity inlet area (Worley Parsons 2010). The un-vegetated soft sediment marine habitats in this region consist primarily of silt and clay (Neil et al. 2003; Worley Parsons 2010). However, there is often a large amount of variation in sediment grain size between inshore areas and those further offshore. For example, there is generally a higher proportion of sand and gravels at the mouth of the Trinity Inlet than in areas further offshore. Burrows are common along the ocean floor, indicating a low to moderate level of epi-benthic faunal activity.

Of the Study Area

Un-vegetated soft sediment habitats in the current survey were generally similar to those recorded in previous regional surveys. Silt and clay dominated the sediment composition at most sites, with some sand (Figure 4.3). Sediment near the mouth of Richters Creek was sandy; whereas sediment at sites further offshore was predominantly silt and clay.

Figure 4.3

Un-vegetated benthic soft sediment at site 3.



The surface sediment at the mouth of Richters Creek was loosely consolidated and there was little evidence of epi-benthic faunal activity (e.g. crab burrows). This was likely due to the rapidly shifting nature of the sediment in this zone. Further offshore, where sediments were finer and more consolidated, there were more burrows on the ocean floor than in inshore areas; however, the density of burrows was still relatively low, indicating relatively low activity of benthic fauna.

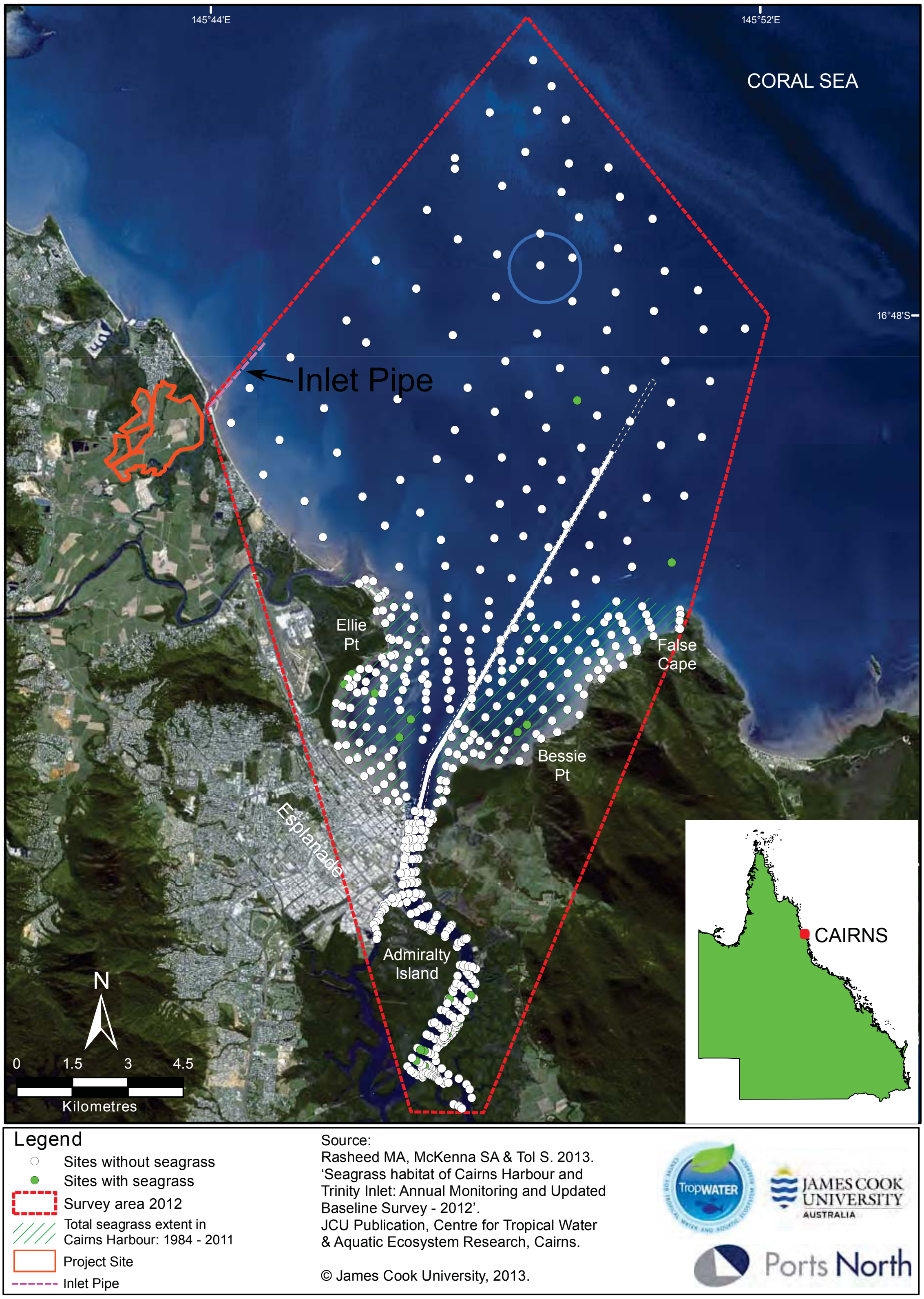
4.3 Seagrass

Of the Region

The seagrass meadows in the broader Cairns region are considered to be regionally important both economically and ecologically (Campbell et al. 2002); however, there has been a substantial reduction in the distribution and abundance of seagrass throughout the region in recent years (Rasheed et al. 2013). Given the sensitivity of seagrass meadows to environmental conditions, these declines are likely to have been associated with the cumulative impacts of several years of above average rainfall, severe storm and cyclone activity, and increased urbanisation throughout the catchment (Reason et al. 2012; Rasheed et al. 2013). Seagrass meadows throughout the region are generally restricted to isolated, remnant patches of low to moderate density seagrass; *Halophila* spp.*, Zostera* spp. and *Halodule* spp. are the dominant species (Coles et al. 1993; Rasheed et al. 2013).

The majority of the seagrass meadows in the region are in Cairns Harbour, adjacent to the Esplanade, and in the estuarine reaches of Trinity Inlet (Map 6) (Rasheed et al. 2013); some isolated patches of seagrass have been recorded further offshore. However, no seagrass was recorded by Rasheed et al. Rasheed et al. (2013) during a late dry season / early wet season survey (October 2012 to January 2013) in the vicinity of the pipeline alignment (Map 7).

Queensland seagrass communities are seasonal (Reason et al. 2012; Rasheed et al. 2013). Maximum abundance and distribution of seagrass generally occurs in late spring and early summer, when rainfall and terrestrial runoff are low and water clarity is high (allowing for high light penetration in the water column, and therefore increased rates of photosynthesis for seagrass). During the wet season in summer, when rainfall and terrestrial runoff are high, water clarity is reduced; this restricts the ability of seagrass to photosynthesize and grow.



Map 7 Distribution of seagrass within the Cairns region (adapted from Rasheed et al. 2013).

Of the Study Area

No seagrass was found in the vicinity of the proposed pipeline alignment in the current survey. Benthic habitats consisted primarily of un-vegetated soft sediment. These findings are consistent with previous regional surveys in the area.

4.4 Rocky and Coral Reefs

Of the Region

There are no rocky or coral reefs in the vicinity of the proposed pipeline alignment. The closest known reef is approximately 7 km to the north-west, at Taylor Point. This reef covers a small area (approx. 0.0075 km^2) on the western side of the headland, and is likely to provide habitat for a variety of flora and fauna that are usually found on inshore reefs.

Of the Study Area

The field survey confirmed that no rocky or coral reefs were present in the survey area. As such, reef habitat will not be directly impacted by construction of the pipeline.

5 Sediment Quality

5.1 Of the Region

Detailed sediment quality studies have been carried out in Cairns Harbour with Cairns Port since 1995, approximately 12 km south-east of the proposed pipeline alignment (Worley Parsons 2010). Silt and clay dominated the sediment throughout the harbour; sands and gravels were more prevalent at inshore sites near the mouth of Trinity Inlet.

The concentration of various nutrients (e.g. total nitrogen, total phosphorus and ammonia) did not vary substantially between inshore and offshore areas.

The concentration of metals and metalloids were generally within acceptable limits, with the exception of arsenic, cadmium, copper and zinc, which were often high. However, the concentration of these metals was generally highest in the inner port area, which may not be representative of the concentration of these metals in sediments further offshore (such as those in the vicinity of the proposed pipeline alignment). The concentration of arsenic is also known to be high in sediments in the Cairns region, due to natural geological processes operating in the catchment (Worley Parsons 2010).

The concentration of tributyltin was generally high within the Cairns Port area, but did not exceed the recommended guideline in areas further offshore. Although concentrations were often high, they did not pose a significant risk to water quality of benthic communities in the area (Worley Parsons 2010).

5.2 Of the Study Area

Sediment Composition

Physical characteristics of the sediment in the current survey were generally consistent with those recorded in the Cairns Harbour. Silt and clay dominated the sediment composition at most sites, with some sand (Figure 5.1). Sites close to the mouth of Richters Creek were sandy (e.g. sites 7 and W2); whereas sediment at sites further offshore was predominantly silt and clay (e.g. sites 1 and 2). Disturbance of these finer sediments further offshore is likely to result in sediment plumes.

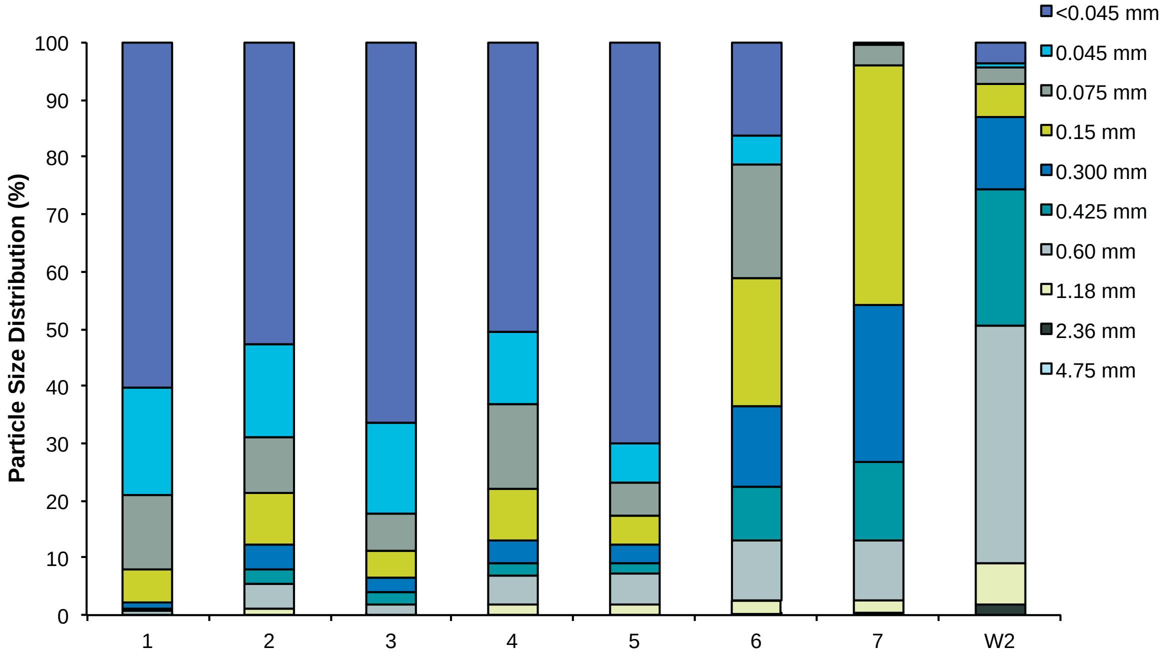


Figure 5.1 Particle size distribution of surface sediment at each site.

Nutrients

The concentrations of nitrogen and phosphorous were similar at sites 1 through 4, furthest offshore, and lowest at sites 6, 7 and W2 (Table 5.1). Site 5 had a higher concentration of total nitrogen than all other sites. The concentrations of nitrite, nitrate and ammonia were all below laboratory limits of reporting at all sites. Concentrations of nutrients are unlikely to be of concern to marine organisms during construction.

Table 5.1 Concentrations of nutrients in sediment of the study area.

Parameter	Units	ISQG	Site							
			1	2	3	4	5	6	7	W2
total carbon	%w/w	–	2.4	2.5	2.3	2.4	2.5	0.7	<0.1	–
total Kjeldahl nitrogen	mg/kg	–	760	810	940	960	1350	360	<20	–
nitrite	mg/kg	–	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	–
nitrate	mg/kg	–	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	–
ammonia	mg/kg	–	<10	<10	<10	<10	<10	<10	<10	–
total nitrogen	mg/kg	–	760	810	940	960	1350	360	<20	380
total phosphorous	mg/kg	–	170	170	170	170	150	96	29	22
ortho-phosphorous	mg/kg	–	0.15	0.13	0.12	<0.1	<0.1	0.12	<0.1	–
moisture content	%w/w	–	44	49	49	54	55	32	18	28.6

Metals and Metalloids

The concentration of metals and metalloids were below ISQG-low trigger values, where applicable, at each site (Table 5.2). Concentrations of all metals and metalloids typically increased with distance offshore from Richters Creek mouth with highest concentrations at site 1. Higher concentrations of metals and metalloids are common in finer sediments, particularly sediments associated with terrestrial runoff that settle offshore (Johns et al. 1994). Overall, concentrations of metals and metalloids in the sediment are low, and do not present a risk to marine organisms.

Table 5.2 Concentrations of metals and metalloids in sediment of the study area.

Parameter	Units	ISQG-low Trigger Value	Site							
			1	2	3	4	5	6	7	W2
aluminium	mg/kg	–	9270	9380	8930	9050	8650	4810	678	–
antimony	mg/kg	–	0.1	0.1	0.1	0.1	0.2	<0.1	<0.1	–
arsenic	mg/kg	20	5.8	5.8	5.4	5.4	6.2	3.8	1.4	–
cadmium	mg/kg	1.5	0.3	0.3	0.3	0.3	0.4	0.2	<0.1	–
chromium	mg/kg	80	16	13.9	13.2	12.9	11.4	6.7	1.7	–
cobalt	mg/kg	–	4.7	4.5	4.4	4.7	4.8	3.0	0.9	–
copper	mg/kg	65	4.7	4.2	4.1	4.9	5.4	2.3	<1	–
iron	mg/kg	–	11300	9850	8980	8800	8340	4790	1050	–
lead	mg/kg	50	6.0	5.9	5.8	6.3	6.4	4.1	1.1	–
manganese	mg/kg	–	178	184	168	156	139	118	46.2	–
mercury	mg/kg	0.15	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	–
nickel	mg/kg	21	9.2	8.3	7.9	8.3	7.8	4.7	1.0	–
selenium	mg/kg	–	1.4	1.3	1.2	1.2	1.2	0.78	<0.5	–
silver	mg/kg	–	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	–
vanadium	mg/kg	–	16.4	16	15.4	15.5	14.4	9.4	2.2	–
zinc	mg/kg	200	19	18.6	18.2	19.4	19.2	11.8	<5	–

Tributyltin

The concentration of tributyltin was below laboratory limits of reporting at each site. In 2008, tributyltin was detected in sediment from the Cairns harbour with concentrations above trigger levels; however, further analysis showed that concentrations were not bioavailable to marine organisms (Worley Parsons 2010). As the offshore region of Richters Creek is not used as a port, it is highly unlikely that tributyltin would be present.

6 Benthic Macroinvertebrates

Of the Region

A study by Neil et al. in 2003 examining the composition of benthic macroinvertebrate communities at several sites outside of the Cairns Harbour found that the majority of taxa recorded were not abundant, with few dominant taxa occurring in high numbers. The distribution of macroinvertebrate taxa throughout the region was relatively patchy; however, dominant taxa were recorded at most sites. There were no significant onshore-offshore gradients in the diversity of benthic macroinvertebrate communities in the area.

The benthic macroinvertebrate communities inhabiting un-vegetated soft sediment in the region were relatively diverse, and consisted of a range of taxa, primarily molluscs, polychaetes and crustaceans (Neil et al. 2003). Gastropods were the most abundant taxa recorded at most sites. A similar study in 2009 had similar findings; although deposit feeding crustaceans (primarily tanaid and amphipod crustaceans) were the most abundant taxa (WorleyParsons 2009); these taxa are common in silty environments (Long & Poiner 1994).

Of the Study Area

Community Composition

The community composition of benthic macroinvertebrates was dominated by polychaetes and crustaceans at each site, with low abundances of molluscs. The community composition of benthic macroinvertebrates comprised sediment deposit feeding organisms and detritivores that forage on particulate matter in and on the sediment. Dominant taxa were:

- capitellid polychaetes
- cirratulid polychaetes
- spionid polychaetes
- gammarid amphipods, and
- palaemonid shrimps.

Other common taxa included brittle stars, juvenile ascidians and bivalves (family Veneridae).

The community composition of benthic macroinvertebrates was significantly different between sites (ANOSIM, Global R = 0.328, p = 0.0001), which was due to the low abundance and diversity at the two sites closest to the mouth of Richters Creek (site 7, approximately 0.57 km offshore of the mouth and site W2, in the mouth) (Figure 6.1 and Figure 6.2).

There was no correlation between benthic macroinvertebrate communities, and water and sediment quality parameters (BIOENV, p = 0.062).

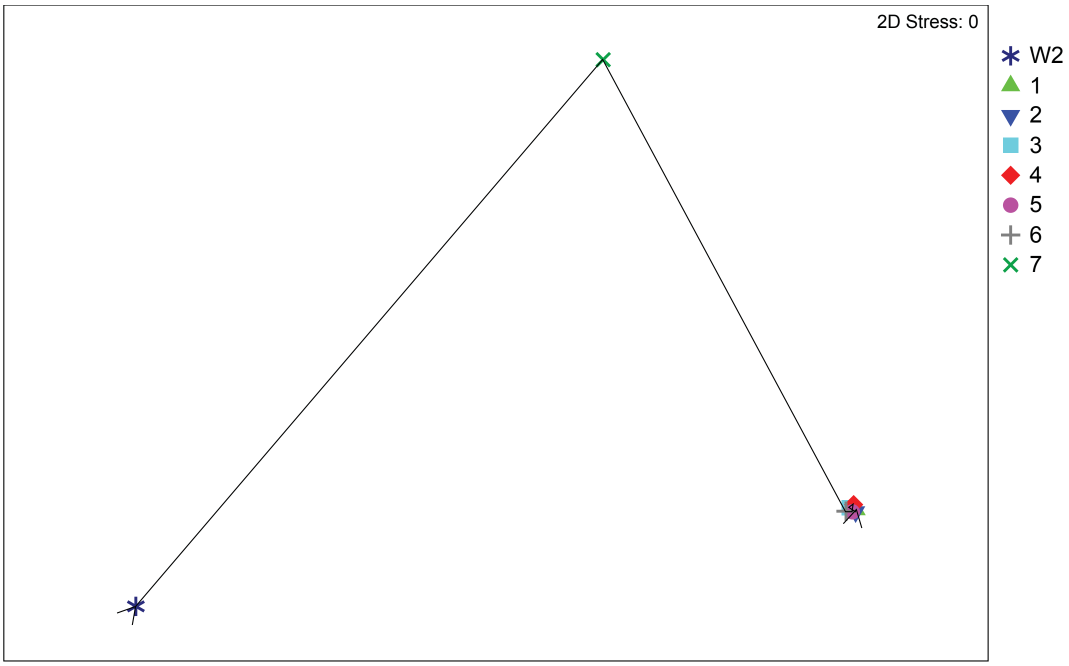


Figure 6.1 Non-metric multidimensional scaling plot of benthic macroinvertebrate communities at each site and vector line showing site distance from Richters Creek mouth.

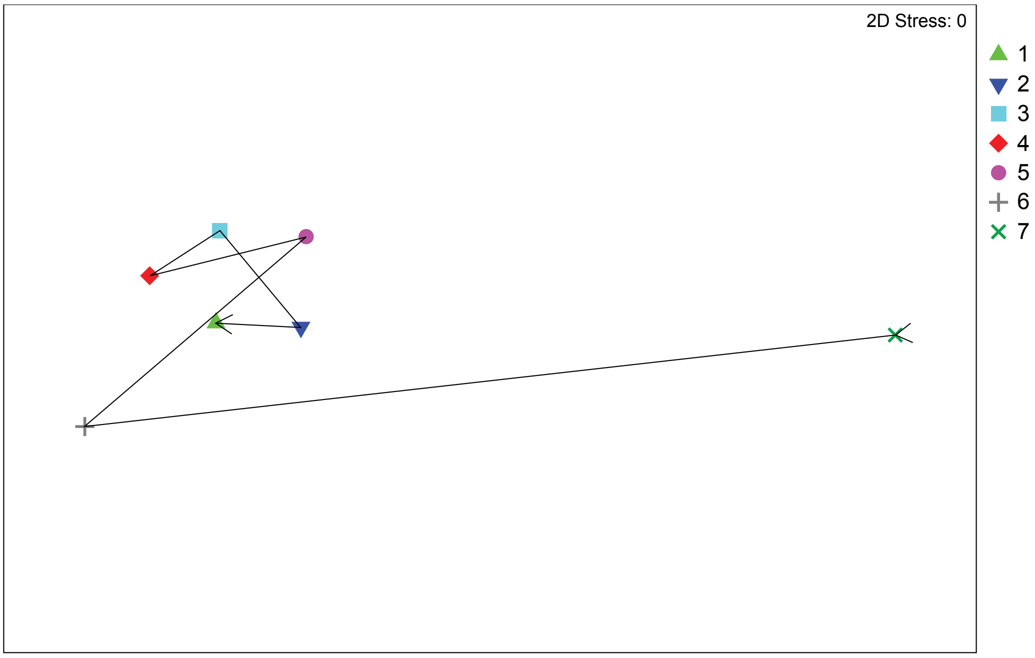


Figure 6.2 Non-metric multidimensional scaling plot of benthic macroinvertebrate communities at each site, except site W2, and vector line showing site distance from Richters Creek mouth.

Taxonomic Richness

The mean taxonomic richness of benthic invertebrates was lowest at sites 7 and W2, (Figure 6.3). The mean taxonomic richness was highest at site 6 (approximately 0.86 km offshore from Richters Creek mouth) comprising a variety of polychaetes, crustaceans and molluscs. The increase in taxonomic richness between sites 6 and 7 is likely to be related to the decrease in turbidity (Section 4.1) and a shift in sediment composition (Section 5.2).

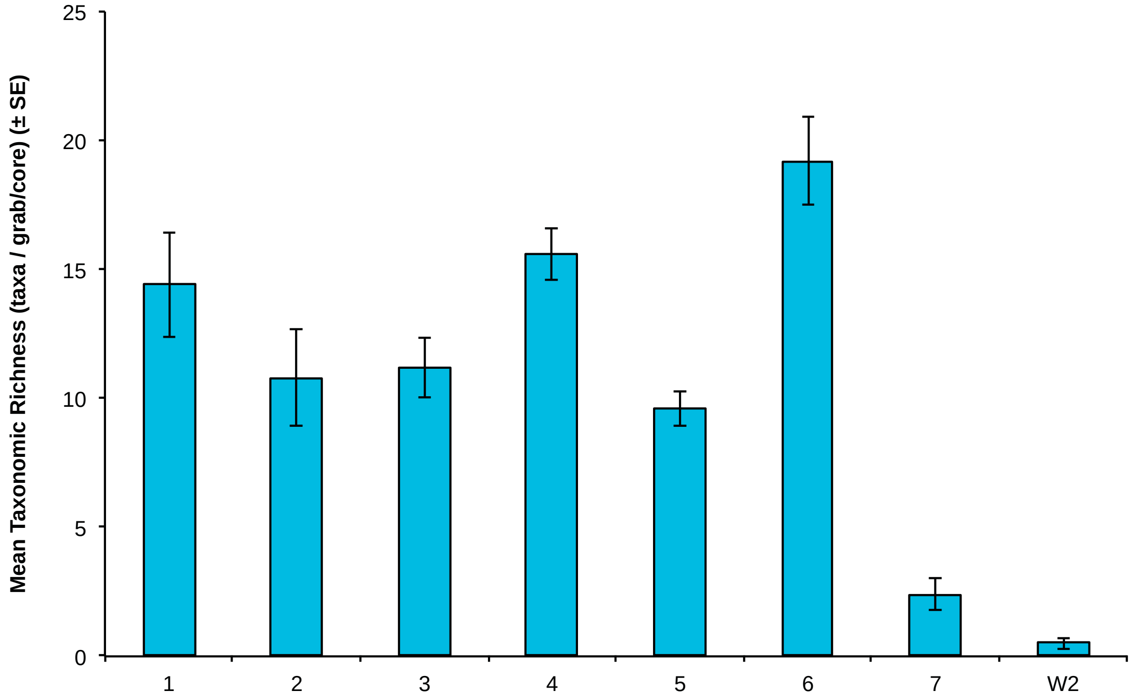


Figure 6.3 Mean taxonomic richness of benthic macroinvertebrates (± SE) at each site.

Abundance

The mean abundance of benthic macroinvertebrates was highest at site 6 and lowest at site W2 (Figure 6.4). Benthic macroinvertebrates at site 6 were dominated by cirratulid and spionid polychaetes. Spionids are one of the most commonly found polychaetes, often in large numbers, in all marine habitats, while cirratulid polychaete species can be tolerant of hypoxic conditions in sediment (Beesley et al. 2000). The difference in abundance between sites 6 and 7 are also likely to be due to differences in water (Section 4) and sediment quality (Section 5) as well as the shifting environment of the mouth (i.e. mobile sand bars).

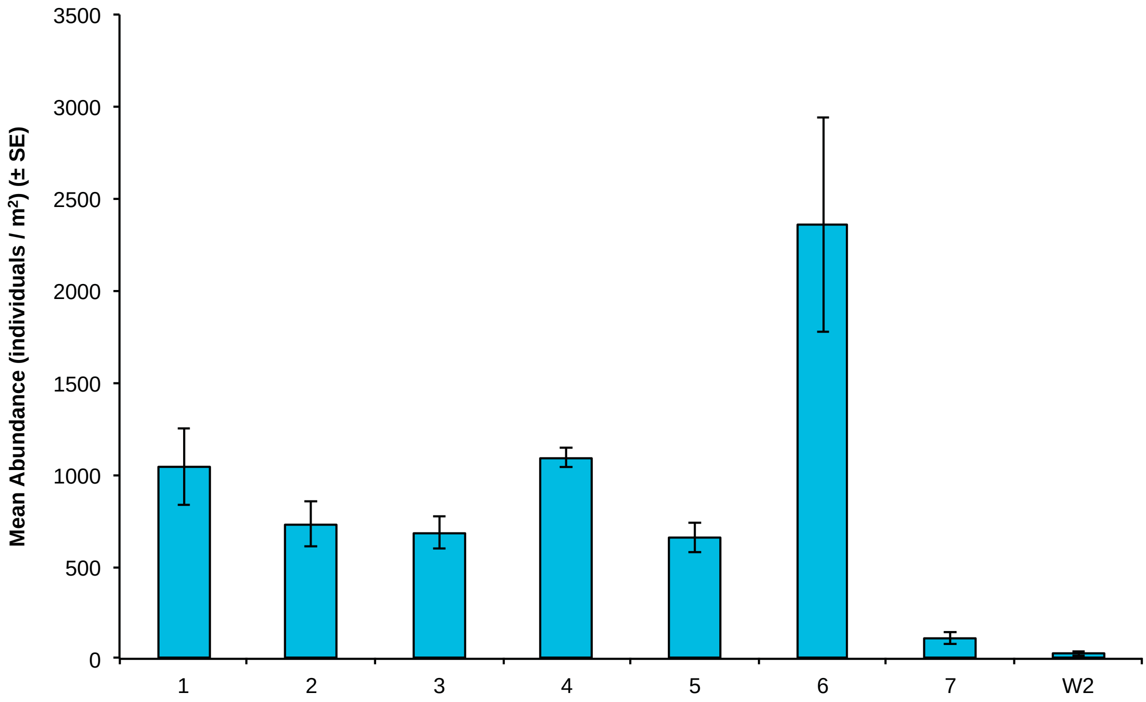


Figure 6.4 Mean abundance (± SE) of benthic macroinvertebrates at each site.

Abundance of Key Taxa

Capitellidae

The mean abundance of capitellid polychaetes was highest at sites 4 and 6 (Figure 6.5). Capitellid polychaete abundances are typically highest in areas that are defaunated by natural or anthropogenic causes and in polluted areas (Beesley et al. 2000). High abundances of capitellid polychaetes at site 6 are likely to reflect the inability of other species to survive in the harsh conditions created by the discharge from Richters Creek. While abundances were higher at these sites than elsewhere, they were still well below abundances indicative of organic enrichment (1000 individuals per $m^{2;}$ ANZECC & ARMCANZ 2000b).

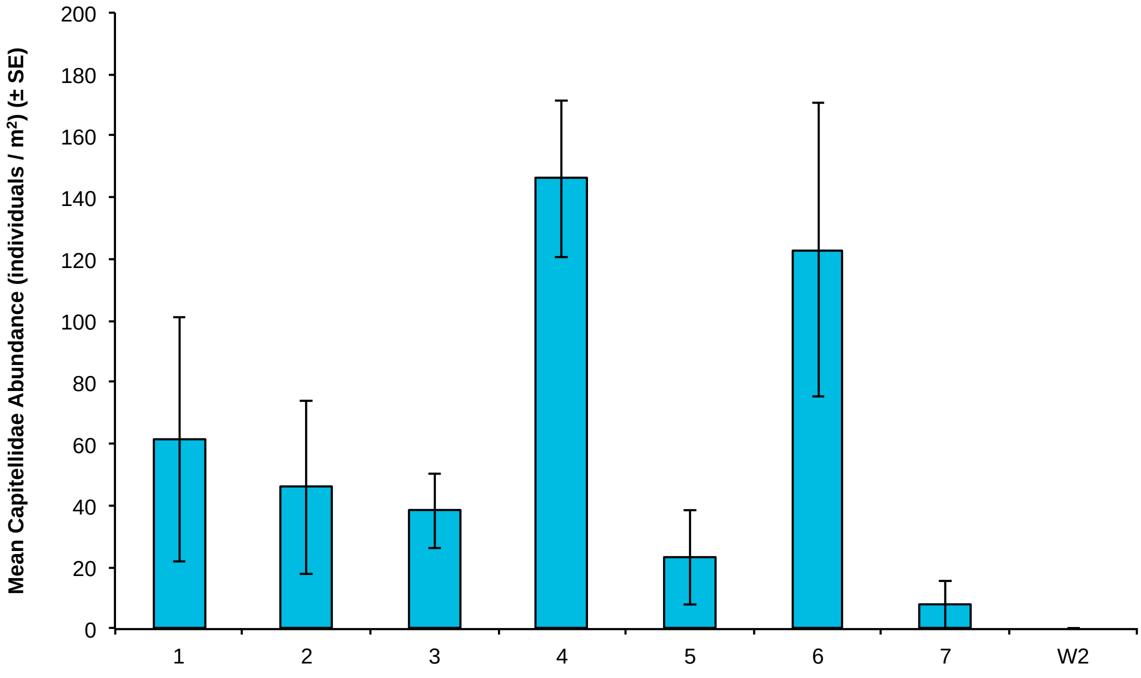


Figure 6.5 Mean Capitellidae abundance (± SE) at each site.

Cirratulidae

The mean abundance of cirratulid polychaetes was highest at site 6 (Figure 6.6). Cirratulid polychaetes are generally free living, surface deposit feeders and can tolerate a wide range of environmental conditions (Beesley et al. 2000). Cirratulids are a stress-tolerant family known to be abundant in areas of low dissolved oxygen (Joydas & Damodaran 2014) and high in organic matter (Huang et al. 2012). High abundances of cirratulid polychaetes at site 6, were likely to be due to the low percent saturation of dissolved oxygen (Section 4) and the lack of many other species that can tolerate the conditions at this site.

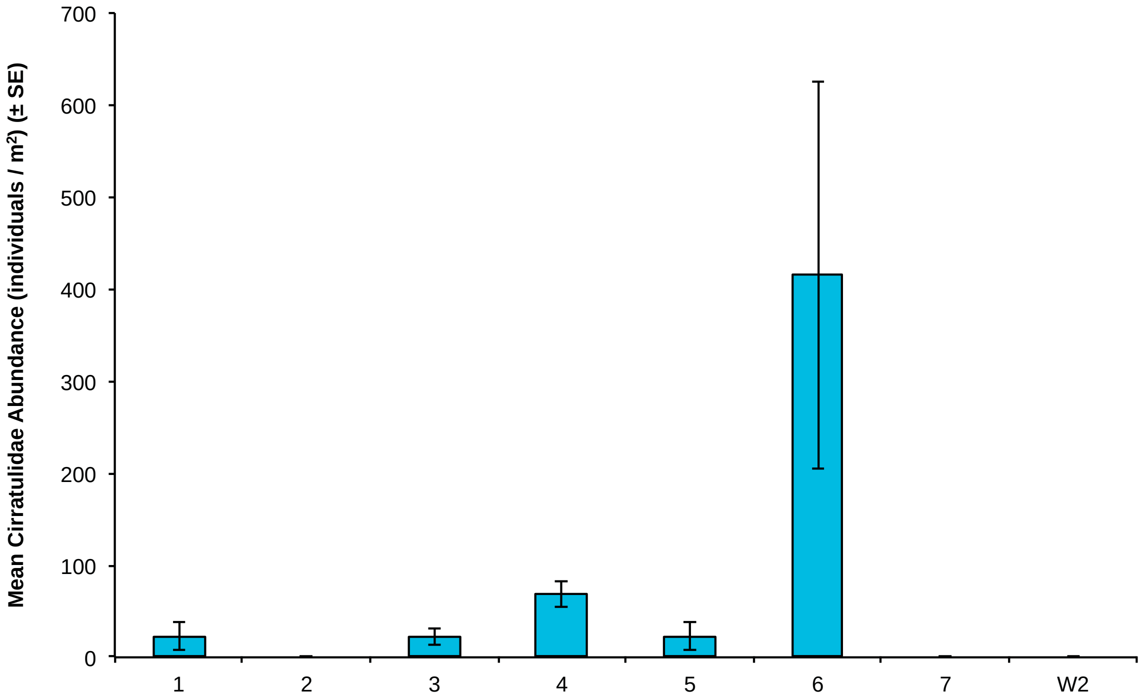


Figure 6.6 Mean Cirratulidae abundance (± SE) at each site.

Spionidae

Similar to capitellid and cirratulid polychaetes, the abundance of spionid polychaetes was highest at site 6 (Figure 6.7). Some spionid species are highly adapted to high-energy environments (including high turbidity) and can tolerate oligotrophic conditions (Frouin et al. 1998), both of which are characteristic of site 6.

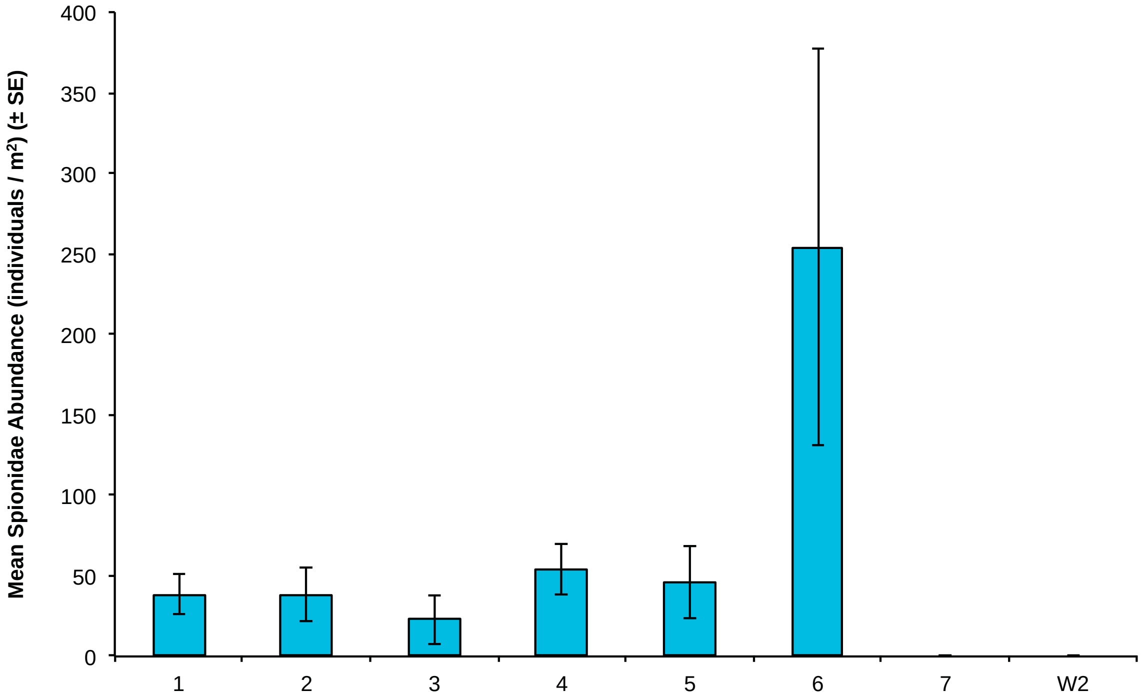


Figure 6.7 Mean Spionidae abundance (± SE) at each site.

Gammarid Amphipods

The abundance of gammarid amphipods was highest at sites further offshore from Richters Creek mouth (Figure 6.8). Gammarid amphipods typically feed on detritus or scavenge on dead material, and are found in fresh and marine waters (Jones & Morgan 1994). Gammarid amphipods are often the most abundant crustacean in benthic samples. The higher abundance of gammarid amphipods offshore of the mouth is likely to be related to the finer sediments and lower turbidity at sites 1 through 5 (sections 4 and 5).

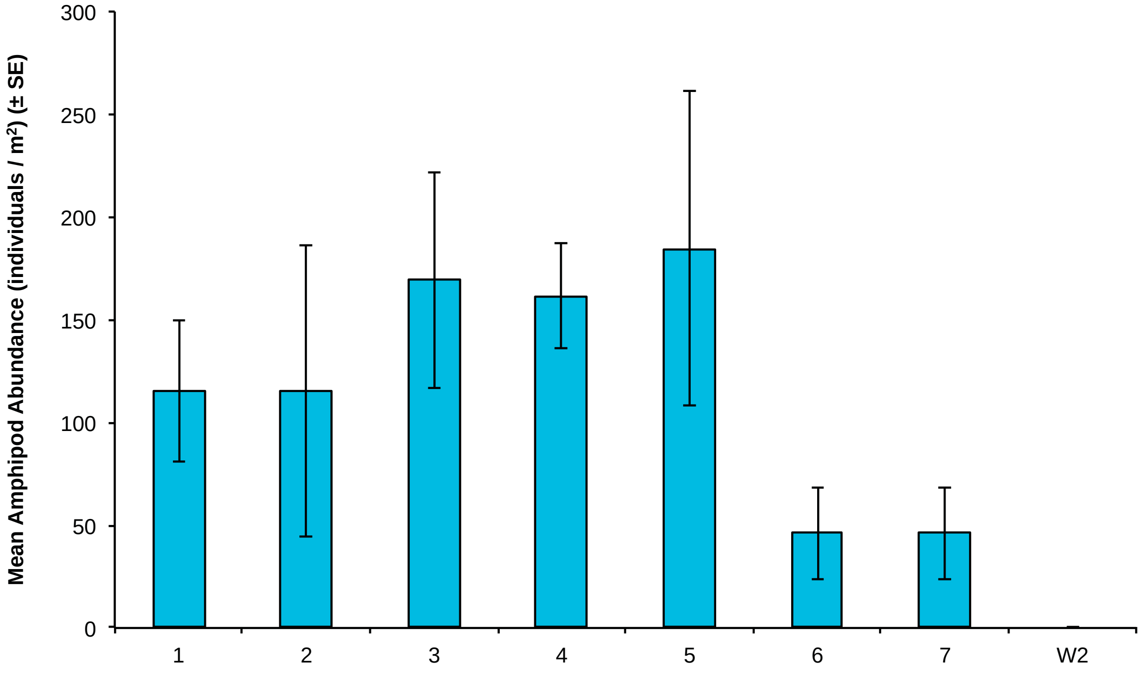


Figure 6.8 Mean amphipod abundance (± SE) at each site.

7 Potential Impacts and Mitigation Measures

7.1 Potential Impacts During Construction

Direct Disturbance to Aquatic Habitats

Impacts to Un-vegetated Soft Substrate

Aquatic habitats along and in the vicinity of the proposed pipeline are dominated by un-vegetated soft sediment. Soft sediment provides habitat for benthic marine invertebrates such as polychaetes and crustaceans, which are an important part of aquatic ecosystems and a key component of many aquatic food webs. They also directly influence many aquatic ecological processes such as primary production, sedimentation and the processing of organic matters (e.g. shrimps and crabs).

Construction of the proposed pipeline will result in the direct loss of un-vegetated soft sediments, and the associated benthic macroinvertebrate communities. Soft sediment infauna may also be indirectly lost due to changes in water quality. Given that the estuarine and marine areas adjacent to the areas of disturbance are typical of the region, the loss of these macroinvertebrate communities is not likely to have a measurable ecological impact beyond the disturbance footprint of the proposed pipeline alignment.

Impacts to Marine Plants

Intertidal pipeline infrastructure (e.g. the pipeline and pump station) will be in existing clearings so that any disturbance to intertidal marine plants is minimised. The exact location will be detailed by a targeted survey in the design phase.

No seagrass was recorded along or immediately adjacent to the pipeline alignment, or was detected in a previous survey undertaken in the late dry season / early wet season by Rasheed et al. (2013).

Proposed Mitigation and Effectiveness

The loss of relatively small areas of soft sediment infauna is unavoidable during construction of the proposed pipeline.

Direct impacts to mangroves will be minimised by putting intertidal infrastructure in existing clearings. Mangrove communities in the vicinity of the proposed pipelines appear to provide relatively poor habitat for fauna compared with other mangrove forests that fringe the Project Site, based on surveys of macroinvertebrate communities within the mangrove forests (frc environmental 2014b). That is, the value of Richters Creek mouth to aquatic ecology is unlikely to be significantly affected by the loss of any mangroves.

Impacts to aquatic habitats and biota will be reduced where areas of direct disturbance are rehabilitated immediately following construction, including restoration of the subtidal seabed to its original bathymetry.

Impacts to Water Quality

Potential impacts to water quality, and the resulting impacts to aquatic biota, as a result of the construction of the inflow and outflow pipelines are detailed in the report *Aquis Resort EPBC Act Issues: Aquatic Ecology* (frc environmental 2014b). Potential impacts include sediment disturbance during excavation and dredging which may result in the following impacts to water quality:

- increased turbidity and sediment suspension
- nutrient enrichment, and / or
- release of contaminants.

In addition, water quality may be impacted by spills of hydrocarbons or other contaminants. It is not expected that potential acid sulfate soils (PASS), if present in the sediment to be disturbed, will be exposed to air during construction, and consequently will not oxidise and produce acid).

Proposed Mitigation and Effectiveness

Potential mitigation measures to avoid or reduce impacts associated with poor water quality are detailed in the report *Aquis Resort EPBC Act Issues: Aquatic Ecology* (frc environmental 2014a). Potential mitigation measures include:

- perimeter silt curtains, bunds or similar technologies around the site to contain sediments / materials that become suspended during construction

- testing of the sediments that may be disturbed during construction for contaminants prior to disturbance, and implementation of appropriate management measures according to the results
- implementation of an Acid Sulfate Soils Management Plan (ASSMP) is i during excavation and backfilling of the site
- use of coarse-grained sediments during backfilling to prevent siltation (where sediment testing indicates a high proportion of fines are present in the sediments to be dredged)
- water quality monitoring during the construction period, including the use of ‘trigger levels’ to effectively control suspended solids concentrations in adjoining waters.

Where these measures are implemented, the risk of impacts to aquatic biota during construction due to changes to water quality is low. During construction, select parameters, such as turbidity, should be monitored to ensure that water quality is not being impacted. Specific trigger values should be established prior to construction, with management actions if the trigger values are exceeded.

Increased Noise

Dredging works have the potential to increase noise underwater, which may impact marine fauna. This noise is likely to disturb marine mammals and reptiles (e.g. dolphins, dugongs and turtles), which may initially move away from the area. However, this is likely to be a short-term response, and they are likely to return once the activity-intensive construction period has ceased.

Proposed Mitigation and Effectiveness

Impacts to marine fauna as a result of noise can be reduced where a marine fauna exclusion zone (nominally 500 m from the noise source) is established prior to the commencement of a noise-intensive activity (e.g. dredging). Impacts to marine fauna can be reduced if noise intensive activities are suspended when marine megafauna are sighted within the exclusion zone (until 30 minutes of observations have passed until the last sighting).

Where these measures are implemented, the risk of impact to marine fauna due to increased noise is low.

Impacts to marine fauna can be further reduced by using marina fauna spotters during dredging operations, with management implications where marine fauna are sighted in the vicinity of the works, and where turtle exclusion / disturbance devices (e.g. ticker chains) are used on the dredging equipment.

7.2 Potential Impacts During Operation

Entrainment and Impingement of Marine Fauna

During operation, exchange water will be delivered to the lake through a screened inlet pipe (1.2–1.8 m in diameter) and discharged from the lake through a screened outlet pipe (1.2 m in diameter). These pipes will operate under a combined gravity / pumping system. The lake inlet and outlet have the potential to entrain and impinge fish by capturing them in the flow of the incoming and outgoing water. Entrainment occurs when pipes take in aquatic organisms (including small items such as plankton, fish eggs and larvae) with the intake of water. Impingement is the pinning and trapping of fish or other larger organisms against the pipeline screens. There is also the risk of stress and injury to fish should fish impact the screen or be subjected to changes in water speed and direction caused by the inflow and outflow currents.

Proposed Mitigation and Effectiveness

The entrance to the inflow pipe will be screened to minimise entrainment of aquatic fauna in the pipework, to reduce the number of pest fish entering the lake and to prevent potentially dangerous species (e.g. sharks) from entering the lake via these pathways. Design and management of the lake, including pest and dangerous species, will be addressed in future reports.

Screens will also be provided on the entrance to the outlet pipe to avoid the risk of objects fouling the diffuser system and the export of aquatic organisms (Environment North 2014). The inlet screen will be designed to physically prevent fauna impingement and entrainment, and keep them at a distance where velocities are such that they can avoid entrainment.

Sharks will be excluded from entering the lake by using a vertical bar screen with a spacing of not more than 60–65 mm. Vertical bars will also exclude most adult fishes of commercial and recreational significance (e.g. barramundi, mangrove jack, threadfin), but will permit entry of a range of other fishes.

The pump system will be adequate to enable a 14-day lake turn-over, which requires an inlet and outlet flow. It is expected that the intake will be at a constant rate of 1.09 m^3/s (varying ±50% as required to control lake levels from rainfall and evaporation). Discharge will occur on the ebb tide at or near a rate of 2.15 m^3/s (±50% as required to control lake levels from neap tides and rainfall). The flow velocity from the inlet is expected to be between 0.4 m/s and 0.6 m/s immediately adjacent to the inlet. Further, it is proposed that pipes and pumps will be constructed to include an inlet grate area of at least 6 m^2 so that velocities can be reduced to below 0.4 m per second. While there are several variables that need to be considered to determine exact acceptable intake velocities (distant and near-field approach velocities, through-screen and sweeping velocities, swimming performance of specific species, etc.) an approach velocity at the screen of < 0.1 m per second is likely to avoid entrainment of all healthy adult fish.

The incorporation of specifically designed fish diversion screening will further reduce the likelihood of entrainment.

The risk to aquatic ecology of marine fauna becoming entrained or impinged is considered low.

Impacts to Water Quality

Potential impacts to water quality as result of the intake and discharge of lake water to Richters Creek include:

- increased suspended sediments, which can smother aquatic habitat affecting aquatic plant growth
- increased nutrients, which can upset the natural balance of the waterway ecosystem e.g. causing eutrophication
- reduced dissolved oxygen, which can kill aquatic life and encourage anaerobic micro-organism growth
- increased algae growth, which can cause fish kills and is unsightly, and
- increased gross pollutants, including rubbish discarded by people that can be aesthetically displeasing, environmentally damaging, and cause death to aquatic life.

Of these, the discharge of nutrient rich waters has the greatest potential to impact on all aspects of aquatic ecosystem health.

Proposed Mitigation and Effectiveness

Risks to the receiving environment through the release of nutrient-rich water via the outflow pipe will be minimised through design of the water exchange system and outflow pipe (e.g. outfall diffuser designed to enhance initial dilution of lake water) and through ongoing and comprehensive water quality management of the lake. The design of the system and proposed management of the lake water are summarised in the draft report *Aquis Resort at the Great Barrier Reef: EPBC Act Issues, March 2014 Version 1* (Environment North 2014).

With these mitigation measures in place, modelling indicates that typical dilutions of the lake discharge are high, with:

- Negligible change in water quality concentration off-shore, with 90th percentile changes indicating over 99% dilution.
- Median dilution rates at the mouth of Richters Creek and near-shore is in the order of 4% to 5%, indicating high dilution rates from the discharge. It is also noted that the 90th percentile dilution is the order of 9% to 14%, indicating that 90% of the data results in dilutions greater than this.
- Dilution rates upstream of the lake inlet / outlet are also high, with median changes in concentration in the order of 2% to 5%. Furthermore, the 90th percentile data indicates dilution rates in the order of 5% to 8% (i.e. 400 m upstream of the discharge point) indicating that the discharge from the proposed lake is largely advected out into Trinity Bay.

Dilution is lowest during dry periods, but only increase by 0.5% at the discharge point (Environment North 2014).

Modelling of stormwater indicates that compared to current conditions (an undeveloped cane farm), the development will:

- reduce export of TSS by 132.1 t/a (46%)
- reduce export of TP by 0.24 t/a (28%)
- reduce export of TN by 0.7 t/a (12%), and
- reduce export of the modelled pollutants by 133 t/a (45%) (Environment North 2014).

Effluent re-use (including net import of class 'A' treated effluent from nearby WWTP) will further reduce discharges to the estuaries and ultimately the Coral Sea.

Where these results are accurate, the risk of impact due to nutrient enrichment to aquatic flora and fauna is likely to be low.

Potential Impacts Associated with Maintenance of the Pipeline

The inflow and outflow pipelines are likely to become fouled internally with marine growth such as barnacles, mussels, shellfish and marine worms. This build-up will have an adverse effect on the performance of the pipeline, requiring maintenance to remove the marine growth. Removal of biofouling may result in a decline in water quality, as nutrients and particulate matter are released from the pipework.

Proposed Mitigation and Effectiveness

Impacts associated with maintenance of the pipework can be reduced where:

- chemical free UV disinfection is used to minimise biological growth in the pipes, thus reducing frequency of maintenance requirements
- a self-cleaning travelling screen is used for debris collection, and
- the collected debris is disposed in authorised waste disposal sites.

8 Conclusions

Un-vegetated soft substrate was the dominant ecosystem type found in and around the proposed pipeline alignment. Silt and clay dominated the sediment composition at most sites, with some sand. There was a high proportion of sand at sites close to the mouth of Richters Creek; whereas sites further offshore consisted predominantly of silt and clay. No seagrass or reef habitat was found in the vicinity of the proposed pipeline alignment.

Water quality along the proposed pipeline was very turbid during the survey, particularly toward the mouth of Richters Creek. This was likely to be a result of recent rainfall and runoff from Richters Creek and the Barron River. Similarly, salinity and pH were likely to have been affected by recent rainfall. The percent saturation of dissolved oxygen in surface waters met the draft water quality guideline at all sites.

The surface sediment at the mouth of Richters Creek was loosely consolidated and there was minimal evidence of epi-benthic faunal activity (e.g. crab burrows), which was likely due to the rapidly shifting nature of the sediment in this zone. Further offshore, where sediments were finer and more consolidated, the low to moderate density of burrows on the ocean floor indicated relatively low faunal activity.

The concentration of nutrients along the proposed pipeline was highest at site 5. The concentrations of metals and metalloids were below trigger values, where applicable. The concentration of tributyltin was below laboratory limits of reporting at all sites. Overall, the concentrations of potential contaminants in the sediment are unlikely to cause harm to marine organisms, if the sediments are disturbed during construction.

The benthic macroinvertebrate communities were dominated by polychaetes and crustaceans, with some molluscs. Abundances and taxonomic richness were highest at site 6, which was likely to be due to the changes in water (e.g. turbidity) and sediment (e.g. substrate composition) quality between sites 6 and 7. Dominant taxa included capitellid, cirratulid and spionid polychaetes, and gammarid amphipods.

The results of the current survey were generally consistent with results from previous surveys of the region.

The construction of the proposed pipeline has the potential to impact aquatic communities in the vicinity, primarily due to:

- direct disturbance of non-vegetated soft sediment habitat
- impacts to water quality, and
- increased noise.

Once it is constructed, the operation and maintenance of the pipeline also has the potential to influence aquatic communities, due to:

- entrainment and impingement of marine fauna, and
- impacts to water quality.

However, provided that appropriate mitigation measures are implemented and adhered to, the long-term impacts associated with the construction and operation of the proposed pipeline are likely to be minimal.

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