Northbank Enterprise Hub Pty Ltd

Lot 1001 DP 1127780 Tomago Rd, Tomago

Aquatic Impact Assessment

Job No: 100513

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COAST ECOLOGY

Environmental Assessment

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Aquatic Impact Assessment

Northbank Enterprise Hub, Lot 1001 DP 1127780, Tomago Road, Tomago NSW

Report prepared for Northbank Enterprise Hub Pty Ltd with instruction from ADW Johnson Pty Ltd.

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Executive Summary

Coast Ecology was commissioned by Northbank Enterprise Hub Pty Ltd with instruction from ADW Johnson to undertake an Impact Assessment in relation to the aquatic environment for the proposed development of Lot 1001 DP 1127780, Tomago Road, Tomago (Study Site). The Study Site covers an area of 239.7 hectares (ha) of which 154 ha is proposed for development (hereafter referred to as the Proposed Development Area (PDA)). The PDA is zoned IN1 General Industrial.

The land is low lying pasture / wetlands dominated by exotic grasses, freshwater wetlands and constructed drainage lines. The Study Site has approximately 800 meters of river frontage to the Hunter River, which is defined by a constructed revetment wall consisting of various sized rubble. Mangroves occur sporadically amongst the rubble, with higher densities at the confluence of the drainage lines and the Hunter River.

Northbank Enterprise Hub propose to subdivide the Study Site (with associated land filling, roads and services), forming a consolidated industrial and business park with the adjoining industrial and business park (MP07_0086) containing the recently completed WesTrac Facility.

The existing drainage lines within the Study Site drain the site through flapped outfalls (floodgates) into the North Arm of the Hunter River. The drainage lines are highly congested with instream vegetation and water quality within the drainage lines was below ANZECC standards for South-east Australia - estuarine systems, for dissolved oxygen and pH. In general, the drainage lines represented those subjected to a modified environment and fish habitat was considered to be of low- moderate quality, with surveys recording the exotic Eastern Gambusia and some hardy native species. As part of the proposal, some of the existing drainage lines would be filled however proposed vegetated channels would result in an increase in the combined length of drainage lines post development. The proposed re-instatement of vegetated drainage channels would result in improved fish habitat to what currently exists, constituting a 'no net loss' of aquatic habitat.

No threatened aquatic species (pursuant to the Fisheries Management Act) would be impacted by the proposal and no mangroves or saltmarsh species would be removed as a result of the proposal as mangroves occur outside of the PDA and no saltmarsh communities were mapped within the Study Site. The relative contribution of the PDA to food availability (i.e. particulate organic carbon) to aquatic detritus/filter feeders in the local aquatic area is considered minimal due to the large catchment area of the Hunter River and the many sources of organic carbon available (both autochthonous and allochthonous).

All stormwater will be treated on site prior to discharge into the Hunter River (BMT WBM 2012c). The nearest oyster leases are approximately 7.5 km downstream of the Study Site and while currently not operational, the proposal is unlikely to have an adverse impact on water quality in the Hunter River (including the oyster lease areas). An area of freshwater wetland EEC in the north east of the Study Site is proposed for retention and provides a 380 m buffer to the Ramsar Wetlands. There is the potential for this area to be included in the saltmarsh rehabilitation area on the adjoining Lot 1002 at a later date. Monitoring advice is provided for the reinstated drainage lines and overflow wetland area.

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1.0 Introduction

Coast Ecology was commissioned by Northbank Enterprise Hub Pty Ltd, with instruction from ADW Johnson to undertake an Impact Assessment in relation to the aquatic environment for the proposed development of Lot 1001 DP 1127780, Tomago Road, Tomago (Study Site; Figure 1). The Study Site covers an area of 239.7 hectares (ha) of which 154 ha is proposed for development, which is hereafter referred to as the Proposed Development Area (PDA). The broader Study Area is defined here as an area approximately 10 km radius of the PDA.

Coast Ecology (2010) prepared a preliminary assessment of the area for submission with the Part 3A project application. The preliminary assessment did not include an impact assessment of the proposed development. This assessment describes the proposal and considers the impacts of the proposal on the aquatic environment within the PDA and on the broader area.

2.0 Proposal

Northbank Enterprise Hub propose to subdivide the PDA (with associated land filling, roads and services), forming a consolidated industrial and business park with the adjoining WesTrac Facility (Figure 2). Use of the site will be restricted to light industrial warehouses and business facilities. A number of strategies have been incorporated into the design of the proposal to mitigate against potential impacts associated with an increase in impervious surfaces associated with the development. These are discussed in detail BMT WBM, (2012c).

Approximately 12.5 ha of freshwater wetland Endangered Ecological Community (EEC) located in the north east of the Study Site will be retained as part of the proposal and will provide a 380 m buffer to the Ramsar wetland located to the east of the Study site (Appendix 2). This area will be actively monitored as detailed in the Wetland Management Plan. Stormwater will be treated on site and directed via vegetated channels to the Hunter River. A perimeter berm will prevent any excess freshwater run-off from the Study Site entering the adjoining Lot 1002, however pit control discharge points will be installed to maintain hydrologic flow regimes and pathways, mimicking existing condtions. The berm would be constructed as part of the Stage 1 development and is described in BMT WBM (2012a).

For the proposed water management system on the Study Site to function with the existing floodgates, an overflow constructed wetland is proposed in the south-eastern corner of the site. The area will provide relief for ponding during times of high river/tide levels in the Hunter River. This area has been mapped as exotic grasses (by Ecobiological, 2011) and it adjoins a Swamp Oak Forest Endangered Ecological Community (EEC; Ecobiological, 2012).

The Study Site currently contains 7,345 meters (m) of existing drainage lines. The proposed development will retain 2,354 m of these existing drainage lines in addition to constructing 6,074 m of landscaped drainage lines. The base of the constructed drainage lines would be planted using local wetland species, while tree planting is proposed for the upper embankments (Terras Landscape Architects, 2010). The total length of drainage lines post development would be 8,428 m (Figure 2). This equates to an increase of 1,083 m of drainage lines from the existing combined length. The designs of the channels are detailed in BMT WBM (2012a). A batter slope of 1 in 4 has been assumed (BMT WBM, 2012a). This should allow sufficient slope for planting of macrophytes to assist in stabilizing the bank and aid in filtration of the stormwater. Bioretention systems are incorporated into the open drainage channels. The average depth of water in these channels will be similar to the current depths (approximately 1 m) of drainage lines on the Study Site. The existing floodgates will be retained. A large

ponded area connected to the drainage lines is also proposed in the southern section of the Study Site (outside and in addition to the proposed overflow wetland rehabilitation area). Additional mitigation advice and monitoring of the landscaping treatments proposed for the drainage channel is provided in Section 10 to ensure that aquatic habitat successfully establishes following works.

An acid sulphate soils (ASS) Plan has been prepared by Douglas Partners as part of the submission.

3.0 Background

In a letter to ADW Johnson dated 31/03/2011, The Department of Planning & Infrastructure (DoPI) requested the following be addressed in the aquatic impact assessment:

1. Impact Assessment of the proposal on nearby SEPP 14/Ramsar Wetlands;
2. Impact Assessment of the proposal on mangrove and/or saltmarsh within the PDA;
3. Collection of additional baseline information (as detailed in NOW's correspondence of 20/01/2011):
    a. Assessment of SEPP 14 wetlands
    b. Baseline water quality sampling for 2 years (including reactive phosphorus, dissolved iron and fluoride)
    c. Macroinvertebrate and macrophyte sampling for all sites including wetlands.
    d. Potential impacts, mitigation measures and impact threshold criteria to ecology and surface water sources.

In addition, the Department of Primary Industries (DPI), NSW Fisheries, requested the following:

4. Assessment of water quality issues in accordance with SEPP 62 – Sustainable Aquaculture
5. Assessment of the potential of the land as a future saltmarsh rehabilitation area and any potential proposal to offset this loss;
6. Assessment of the offsite impacts of removing the carbon food source currently supplied by the freshwater wetlands on Study Site;
7. Assessment of flooding impacts on the river caused by filling the site; and
8. Aquatic survey of the drainage system to determine their ecological importance;

Points 1, 3a, 3d are considered by Ecobiological (2012); Point 3b is discussed in the Environmental Assessment Report (ADW Johnson, 2012) and Point 7 is assessed by BMT WBM (2012b). The remaining concerns are addressed in this aquatic assessment:

- Point 2 Section 9.2 Aquatic Environment within the Study Site
- Point 3c Sections 8.2 Macrophytes and 8.3 Macroinvertebrates
- Point 4 Section 9.4 SEPP 62 Aquaculture
- Point 5 Section 9.3 Saltmarsh Restoration
- Point 6 Section 9.5 Organic Carbon Input
- Point 8 Section 9.2 Aquatic Environment within the Study Site

4.0 Site Description

The Study Site is comprised mostly of low lying pastures (145 ha) and freshwater wetlands (75 ha). The pasture is dominated by exotic grasses such as Kikuyu (*Pennisetum clandestinum*) and Paspalum (*Paspalum dilatatum*) and the low-lying wetlands are dominated by Broadleaf Cumbungi (*Typha orientalis*) and Common Reed (*Phragmitess australis*). In addition, there are some remnant patches of

Swamp Oak Forest on the site.

The Study Site has approximately 800 meters of river frontage to the Hunter River. The Hunter River is defined here as a Class 1 - Major Fish Habitat (Fairfull & Witheridge, 2003). Historically, the Study Site river frontage has been highly modified, with the deposition of large rocks as retaining and revetment and extensive clearing of mangroves. Some isolated mangroves remain among the rock wall retaining the foreshore of the Study Site (Plate 1) however the mangrove forests characteristic of the foreshores opposite and to the east and west of the Study Site are largely absent from the Study Site.

The Study Site is separated from Kooragang Island to the south by the North Arm of the Hunter River and lies to the west of Fullerton Cove. The wetlands to the east and south of the Study Site are protected under State Environmental Planning Policy (SEPP) 14 Coastal Wetlands. A Ramsar wetland of international importance (ID 24) which forms part of the Hunter Wetland National Park is located 380 metres from the eastern boundary of the Study Site.

The only oyster leases in the Hunter River are located near Fern Bay, approximately 7.5 km downstream of the Study Site (Figure 1). As there are less than five oyster farmers operating out of the Hunter River, oyster production figures are not available for privacy reasons (S. McOrrie pers. comm.).

A number of constructed drainage lines occur on the Study Site (Figure 3). They are steep sided drains with vertical banks and they are largely dominated by *T. orientalis* and *P. australis*. Under Strahler's (1952) system of stream classification, they would be defined as 1st and 2nd order. These drainage lines drain the site through flapped outfalls (floodgates) into the North Arm of the Hunter River. The majority of the Study Site catchment is contained from within its boundary, with the sources of both drainage lines within the Study Site.

The Study Site is surrounded by light and heavy industries such as Tomago Aluminium Smelter to the north-west.

5.0 Relevant Legislation

5.1 Fisheries Management Act 1994

5.1.1 Part 7 Protection of Aquatic Habitats

Division 3 Dredging and Reclamation

The objects of this Division are to conserve the biodiversity of fish and aquatic vegetation and to protect fish habitat by providing for the management of dredging and reclamation work, consistent with the objectives of ecologically sustainable development.

Circumstances in which a person may carry out dredging or reclamation work

A person must not carry out dredging or reclamation work except under the authority of a permit issued by the Minister.

Maximum penalty: In the case of a corporation, 2,000 penalty units or, in any other case, 1,000 penalty units.

This section does not apply to:

(a) work authorised under the *Crown Lands Act 1989*, or

(b) work carried out, or authorised, by a relevant public authority (other than a local government authority), or

(c) work excluded from the operation of this section by the regulations.

Division 4 Protection of Marine Vegetation

(1) This section applies to:

(a) mangroves, or

(b) seagrasses, or

(c) any other marine vegetation declared by the regulations to be marine vegetation to which this section applies,

but does not apply to protected marine vegetation under section 204A.

(2) A person must not harm any such marine vegetation in a protected area, except under the authority of a permit issued by the Minister under this Part.

The proposed development requires dredging/reclamation of the existing drainage lines however no marine vegetation would be damaged by the proposal. Assessment under Part 3A Major Projects of the EP&A Act would not require a permit issued under Part 7 of the FM Act, however assessment of the impacts of any proposed developments on aquatic habitat and / or marine vegetation (including mangroves) would be required. These are considered in Section 9.2 of this report).

5.1.2 Part 7A Threatened Species Conservation

The objects of this Part are as follows:

(a) to conserve biological diversity of fish and marine vegetation and promote ecologically sustainable development and activities,

(b) to prevent the extinction and promote the recovery of threatened species, populations and ecological communities of fish and marine vegetation,

(c) to protect the critical habitat of those threatened species, populations and ecological communities that are endangered,

(d) to eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities of fish and marine vegetation,

(e) to ensure that the impact of any action affecting threatened species, populations and ecological communities of fish and marine vegetation is properly assessed,

(f) to encourage the conservation of threatened species, populations and ecological communities of fish and marine vegetation by the adoption of measures involving co-operative management.

Potential impacts of the proposal on threatened species have been considered in Section 9 of this report.

5.1.3 Amendment Regulation 2010

The object of this Regulation is to amend the *Fisheries Management (General) Regulation 2002* as follows:

(c) to prescribe saltmarsh on public water lands as marine vegetation that is protected under the Act,

Saltmarsh is protected under the Fisheries Management Act however no saltmarsh communities have been mapped within the Study Site.

5.2 DPI: NSW Fisheries Policy and Guidelines (1999)

Section 6.4 Habitat Rehabilitation and Environmental Compensation

"NSW Fisheries will require habitat compensation as a condition of consent for many developments to maintain a 'no net loss' habitat policy. Habitat compensation will usually be calculated on a 2:1 basis for vulnerable habitats.

The aquatic habitat proposed for removal (i.e. constructed drainage lines) do not constitute "vulnerable habitat". The 'no net loss' of habitat is addressed in Section 9.2 of this report.

5.3 DPI: Fish Passage Requirements for Waterway Crossings

NSW DPI produced a document "why do fish need to cross the road? Fish Passage Requirements for Waterway Crossings, NSW Fisheries" (Fairfull and Witheridge, 2003).

The existing drainage lines within the Study Site are defined as Class 3 Minimal fish habitat using Fairfull & Witheridge's (2003) site assessment guide. In order to maintain a 'no net loss' in aquatic habitat on the Study Site, the minimum recommended road crossing type for the proposed drains is a low flow design culvert at locations where the proposed drainage line cuts are below existing surface level (Figure 5).

5.4 State Environmental Planning Policy (SEPP) 62 Sustainable Aquaculture

Part 3A of SEPP 62 provides for the consideration of the effects of a proposed development on oyster aquaculture. It applies to all development and all land.

(1) Before determining a development application for any development, a consent authority:

> (a) must consider whether, because of its nature and location, the development may have an adverse effect on oyster aquaculture development or a priority oyster aquaculture area, and
>
> (b) if it suspects that the development may have that effect, must give notice of the application to the Director-General of the Department of Primary Industries.

(2) In determining a development application for any development, a consent authority must consider any comments received from the Director-General of the Department of Primary Industries pursuant to subclause (1), including, in particular, such comments as identify:

> (a) any adverse effect that the development may have on, or ways in which the development may impede or be incompatible with, any oyster aquaculture development or priority oyster aquaculture area, and
>
> (b) any measures to avoid or minimise any such adverse effect, impediment or incompatibility.

The impact of the proposal on proximate oyster leases is considered in Section 9.4 of this report.

6.0 Aims

Based on outstanding concerns raised by DoP and DPI (Section 3.0), the aims of this impact assessment were to:

1. Assess the ecological importance of the aquatic habitat (within constructed drainage lines) on the Study Site and provide an impact assessment of the proposal on aquatic fauna habitat (including threatened species), saltmarsh and/or mangroves within the PDA.
2. Gain an understanding of the biota currently utilising the adjoining SEPP 14 wetlands.
3. Consider the impacts of the proposal on SEPP 62.
4. Consider the potential of the land as a future saltmarsh rehabilitation area, and
5. Consider the importance of the Study Site as a source of particulate organic carbon (POC) to the local aquatic environment.

7.0 Methods

7.1 Threatened Species

Threatened species impact assessment is an integral part of environmental impact assessment in NSW. The NSW DPI database for threatened species likely to occur within the Hunter/Central Rivers CMA was searched. A habitat assessment was also conducted on site to determine the presence/absence of suitable habitat for threatened species likely to occur in the area.

Fish surveys were conducted within the Study Site and adjoining SEPP 14 wetlands and water quality samples were collected from drainage and freshwater wetlands within the Study Site and from the Hunter River and North/South Drain to the east of the Study Site in July/August 2011. The weather and tidal information at the time of sampling/surveys is shown in Table 1

Table 1 Weather and tides during surveys/sampling (BOM, August, 2011)

Date	Temperature		Rainfall	Wind direction/speed		Tides
			Prev 48 hrs			
	Min	Max		am	pm	
18/07/11	7.1	19.7	5.1	NW 4km/hr	Calm	0519 0.36m
						1138 1.44m
						1700 0.52m
						11.32 1.68m
19/07/11	6.0	N/A	0.3	Calm	NW 4km/hr	0553 0.40m
						1206 1.44m
						1743 0.63m
						2357 1.61m
05/08/11	8.1	23.2	0.4	Calm	W/78km/hr	0707 0.34m
						1338 1.65m
						1952 0.52m
08/08/11	7.7	17.7	2.0	NW 2km'hr	N/A	0415 1.20m
						0957 0.58m
						1650 1.66m
						2345 0.52m

7.2 Macrophytes

Macrophyte surveys were conducted in the preliminary aquatic assessment (Coast Ecology, 2010) and instream vegetation was also recorded by EcoBiological (2011). Additional vegetation surveys were conducted in July/August 2011 using a random meander technique. The Study Site was traversed via 4WD and on foot, accessing as many of the drainage lines and wetlands within the Study Site as possible.

7.3 Macroinvertebrates

As part of the preliminary assessment (Coast Ecology, 2010), macroinvertebrate surveys were conducted within the drainage lines in the Study Site. Based on macroinvertebrate assemblages, the drainage lines within the Study Site were described in the preliminary assessment as being well below reference condition, indicating that the health of the drainage lines were relatively poor.

7.4 Fish Surveys

7.4.1 Bait Trap Surveys

Bait trapping was conducted in the Study Site in June 2010 as part of the preliminary aquatic assessment (Figure 3). As part of the impact assessment, additional fish surveys were conducted in August 2011 to provide temporal replication for fish data within the drainage lines and wetlands within the Study Site.

Bait traps (Plate 1) were used to sample fish within the drainage channels and freshwater wetlands that intersect the site on 5 August July 2011. The dimensions of the bait traps used were 22 x 22 x 42 cm and each trap had two openings with a diameter of 7 cm. Traps were baited with a mixture of crushed chicken pellets and sardines to aid in the capture of the fish. Traps were set within the drainage lines and wetlands around instream vegetation.

A total of 20 bait traps were set, four bait traps were set at each of the five sites within the Study Site (Plates 2-6; Figure 3). Sites were chosen based on having a suitable water depth and conditions for sampling.

Traps were left for approximately 2 hours at each site after which time, fish were removed from the traps, identified to species, counted and released.

Plate 1. Bait traps used to sample drainage lines and wetland areas within the Study Site.

Plate 2. Bait trap site 1 was located within a drainage line running northeast - southwest through the Study Site. This drainage line is approximately 1 metre wide and 1 metre deep and is heavily congested with *Typha* sp. This plate provides a typical view of the Study Area.

Plate 3. Bait trap site 2 was located within a drainage line within the Swamp Oak Forest EEC along the south-eastern perimeter of the Study Site. At this point, the drainage line is shallow (~0.4 m deep) and approximately 5 m wide and lined with *Casuarina glauca*, with some Water Ribbon *Triglochin procerum*.

Plate 4. Bait trap site 3 was located within the Swamp Oak Forest EEC along the south-eastern perimeter of the Study Site. The wetland is shallow (~0.4 m deep) and contains *Typha* sp and Water Ribbon *Triglochin procerum*.

Plate 5. Bait trap site 4 was located within North-South creek which is outside and to the east of the Study Site within the Hunter Wetlands National Park (RAMSAR Wetlands). This creek is ~ 4 m wide with a depth of ~1m. The creek is lined with exotic grasses, *C. glauca* and *Phragmites australis*.

Plate 6. Bait trap site 5 was located within North-South drain along the north-eastern boundary of the Study Site, upstream of floodgates. The creek is ~2.5 m wide with a depth of ~ 1m. *P. australis* occur within the channel.

7.4.2 Fyke Net Surveys

Fyke nets (Plate 7) were used to sample fish within the mangroves in the adjoining SEPP 14/Ramsar wetlands on 19 July 2011. Each fyke net consisted of a 4 m long funnel shaped net with a 400 mm diameter entrance and two lateral wings each 3 m in length. The mesh size of each entire net was 2 mm. Three nets were placed at each of the 4 sites selected within the wetlands on the seaward edge of the wetlands at low tide (Figure 3). Nets were orientated as to catch fish exiting the wetlands on the ebbing tide. Nets were collected on the next low tide, ~6 hrs after their deployment.

Plate 7. Fyke nets deployed in the adjoining SEPP 14 wetlands.

7.5 Organic Carbon Analysis

Seston is defined as the suspended particulate inorganic and organic matter (PIM and POM respectively) in the water column. The POM component of the seston is comprised of microalgae, detritus from terrestrial and/or estuarine sources and bacteria while the inorganic fraction is made up of terrestrially derived sediment or resuspended bottom sediments. Autochthonous sources of seston are produced in-situ rather than being transported to an area, whereas allochthonous contributions to the seston are derived from marine, freshwater or terrestrial sources. The quality and quantity of the seston determines the food available to bivalve filter-feeders, hence spatial and temporal changes in seston quality and quantity availability are known to affect their feeding behaviour. Particulate organic matter comprised mainly of detritus of terrestrial plants brought into estuaries by rainfall has a high particulate organic carbon content (or total organic carbon TOC), whereas POM comprised mainly of phytoplankton has a high Chlorophyll a content (refer Paterson et al, 2003 for further discussion).

Water samples (3 replicates) were collected from four locations: two at the mouth of each of the drainage lines within the Study Site; one within the Hunter River upstream of the Study Site; and one from the creek sourcing the wetlands

adjoining the Study Site to the east (Figure 3). Samples were collected on the outgoing tide on three occasions, 19 July, 2011, 5 August 2011 and 8 August 2011. Samples were tested for Total Organic Carbon (TOC) and Chlorophyll *a* (Chl *a*) by a NATA accredited laboratory.

8.0 Results/Discussion

8.1 Threatened Species

Threatened species that have been recorded within the Hunter / Central Rivers CMA are listed in Table A1, Appendix 1, along with their habitat requirements and their likelihood of occurrence. With the exception of Green sawfish *Pristis zijsron,* the Study site and broader Study Area does not provide optimal habitat for the proximate threatened species likely to occur in the area. An impact assessment for the Green Sawfish (Table A2 of Appendix 1) concludes that no threatened aquatic species listed under the FM Act are likely to be impacted by the proposal.

8.2 Macrophytes

The diversity of macrophytes within the Study Site drainage lines was low, however the density was very high, with instream vegetation accounting for 70% coverage on average. The drainage lines and wetlands were heavily congested with both *Typha orientalis* and *Phragmites australis*, which are native species but are known to be highly invasive in wetlands and creeks that have high nutrient levels. Other species observed within the Study Site but in less abundance include *Eleocharis acuta, Persicaria decipiens* and *Triglochin procera*.

Additional monitoring of macrophytes has been requested by Office of NOW however further monitoring of macrophytes within the drainage lines and wetlands within the PDA would not provide any additional data for later comparison as under the proposal, the majority of the existing drainage lines and freshwater wetlands within the PDA will be removed and replaced by vegetated drainage lines planted out with native macrophytes. The ongoing monitoring of the health and survival of macrophytes within the proposed drainage lines and within the retained freshwater wetland EEC in the north east of the Study Site would provide a better indication of the success of aquatic habitat rehabilitation following development. Recommendations for the proposed monitoring are provided in Section 10 of this report and will be detailed in the Wetland Management Plan (WMP) being prepared as part of this application.

8.3 Macroinvertebrates

No additional monitoring within the Study Site or adjoining SEPP 14 areas were conducted as part of the impact assessment as it was deemed inappropriate. The Ausrivas model provides a river health assessment based on predictive models of macroinvertebrate distribution and was developed from the sampling of reference sites across broad geographic regions and from all major river types (Davies, 1994). However, the Ausrivas model excludes systems that have a saltwater tidal influence and systems that are not primarily based on running water systems (Eren Turak, NSW EPA pers comm.). The two main drainage lines sampled within the Study Site were low flowing constructed drainage lines which typically do not contain sensitive macro-invertebrate families. While the existing floodgates exclude salt water, saline influence occurs, thereby influencing the macroinvertebrate assemblages present.

Not only is the aquatic environment of the study site not suited to an Ausrivas style assessment, the use of macroinvertebrates is also not recommended for similar reasons. As the Study Site contains limited sensitive taxa (Coast Ecology,

2010) as a result of past and present impacts (including impacts of saline intrusions), any changes resulting from the proposed development would be difficult to detect using macro-invertebrates as bio-monitors and the existing assemblages already reflect an impacted environment.

Thus, while macroinvertebrates were used in the preliminary assessment to gauge the appropriateness of further sampling and provide a basic understanding of macroinvertebrate assemblages in the drainage lines, the future use of macro-invertebrates to monitor the impacts of the proposal is inappropriate and is not recommended. Macro-invertebrates are not suitable for use as a bio monitors in saline environments such as the SEPP 14 and Ramsar areas, and the use of macroinvertebrates as bio monitors within the Study site would not provide any meaningful baseline data for later comparison. Conducting quadrat based monitoring of the health of the vegetation within the proposed drainage lines, retained freshwater EEC and wetland overflow areas within the PDA would provide more useful information regarding the success of re-instatement of aquatic habitat within the Study Site. Recommendations for the proposed monitoring are provided in Section 10 of this report and will be detailed in the Wetland Management Plan (WMP) being prepared as part of this application.

8.4 Water Quality

Water quality sample sites were collected at each of the bait trap sites and are presented in Table 2.

The conductivity at all sample sites was above the ANZECC range (200-300 µS/cm) for lowland rivers. As such, data was compared to ANZECC guidelines for South-east Australia - estuarine systems. The % DO at sample sites were all well below the ANZECC guidelines lower limit for % DO (80 %) indicating lower than expected dissolved oxygen levels.

The pH levels at sample sites were also well below the lower limit for pH (7.0) compared to the ANZECC guidelines, suggesting slightly acidic environments. There are a number of reasons why pH levels within the Study Site and surrounds are typically low. These are discussed in the wetland section of the Environmental Assessment Report (ADW Johnson, 2012).

Water quality results of groundwater and surface water testing conducted by Douglas Partners (2011) indicated water samples exceeded ANZECC trigger values for pH, total phosphorus, ammonia, total nitrogen, NOX, and metals. Elevated fluoride levels were also recorded but there are no ANZECC criteria for fluoride.

8.5 Fish Surveys

8.5.1 Bait Trap Surveys

Table 3 lists the catch per unit effort for the bait traps. The results of August 2011 bait trap surveys were similar to bait trap surveys conducted in June 2010 (Coast Ecology, 2010). The introduced Eastern Gambusia along with native Empire gudgeon and Common galaxias were recorded, while June 2010 surveys recorded Striped gudgeon and Flathead gudgeon. The fish assemblages sampled within the drainage lines that intersected the Study Site are fairly typical of those found elsewhere in NSW in similar habitats. Empire gudgeon are found in the lower reaches of rivers and juveniles occur in fast flowing water or estuaries. They can tolerate salinity levels equal to seawater. Striped gudgeon are usually found in muddy waterholes and slow-flowing creeks, but also occurs in clear, fast flowing streams. Juveniles are common in estuaries. Flathead gudgeon occur in lakes, reservoirs and brackish estuaries, over mud bottoms and often among aquatic vegetation (Allen et al., 2002).

The introduced Eastern Gambusia generally dominates the fish assemblages that are found within creeks and drainage channels that have been modified or disturbed, such as those situated within the Study Site. Therefore, it is not uncommon for these fishes to dominate fish abundance within a particular assemblage. The native fish species caught during the surveys are also quite hardy and are able to exist within disturbed habitats and estuarine (saline) environments.

8.5.2 Fyke Net Surveys

Estuarine wetlands support a highly productive food chain, the decay of vegetation and the deposition of river sediments providing the main sources of food. They provide essential nursery habitat for a wide variety of marine life. In NSW, some 60% of the commercially caught fish, molluscs and crustacean are dependent upon estuaries at some stage of their life cycle (NSW NPWS, 1998). In 2008_09, NSW Fisheries valued this industry in the Hunter Estuary at around $891,000 annually with the major components being (in order of landings): School Prawns, Sea Mullet, Sand Mullet, Black and Yellowfin Bream, Longfin River Eel, Sand Whiting, Luderick, Mulloway, Flathead, Blue Swimmer Crab, Silver Biddy and Mud Crab. Amateur fishing is also a popular activity in the estuary. The majority of aquatic species taken by fisherman are dependent on the estuary at some stage of their life cycle to provide food, protection from predators and nursery environments.

The results of fyke netting in August 2011 in the adjoining wetlands are provided in Table 4. Table 5 provides length data for commercial fish species caught. A total of 1,221 organisms were caught, consisting of 12 species of fish and 3 species of invertebrates. Commercial species caught during fyke net surveys include Flat-tail mullet, Sea mullet, Long-finned eel, Yellow-fin bream, Luderick and School Prawns. During seining in June 2010 within the Hunter River, 3,373 organisms were caught, consisting of 20 species of fish and 2 species on invertebrates. Commercial species caught during these surveys included Sea mullet, Flat-tail mullet, Silver biddy, Yellow-fin bream, Sand mullet, Southern herring, Sand whiting, Dusky flathead and River garfish. All species were released immediately following identification.

The variety and abundance of species recorded from the SEPP 14 wetlands and within the Hunter River in the vicinity of the Study Site reflects a typical healthy wetland environment.

Fish were caught in the Hunter River either side of the Study site as the artificial rock foreshore along the Study site does not provide good quality fish habitat. As the proposed development will not further alter the river frontage and usage will be restricted to light industrial and business, the proposal is considered unlikely to adversely impact the diversity of fish within the Hunter River.

Table 2. Water Quality results at bait trap sites (four sites within the Study Site and one creek site east of the Study Site leading into the SEPP 14 wetlands; n=3) collected in August 2011.

Site	Temp. °C	Cond. µS/cm^2	Salinity ppt	DO %	DO mg/l	pH	ORP
ANZECC Guidelines	**n/a**	**n/a**	**n/a**	**80-110**	**n/a**	**7.0-8.5**	
1	10.10±0.02	869±1.15	0.50±0.001	38±6.00	4.13±0.48	6.13±0.15	88.93±8.11
2	11.13±0.05	3,258±61.71	2.4±0.07	17±0.26	1.81±0.04	5.62±0.07	-84.83±3.00
3	10.73±0.03	1,061±9.50	0.6±0.01	35.27±2.68	3.91±0.29	5.82±0.01	-18.47±8.00
4	13.53±0.08	3,780±2.08	2.9±0.002	52.1±0.71	5.36±0.08	6.40±0.04	58.70±2.29
5	10.71±0.11	705±5.13	0.5±0.006	33.87±0.55	3.75±0.09	6.27±0.03	62.40±1.86

Data are Mean±se (Standard Error)
Cond. = Conductivity
Temp = Temperature
DO = Dissolved Oyygen
ORP= Oxidation Redox Potential

Table 3. Total abundance, percentage contributions and mean CPUE sampled from 5 sites using bait traps (four sites within the Study Site and one creek site east of the Study Site leading into the SEPP 14 wetlands; n=4) collected in August 2011.

				Site 1		Site 2		Site 3		Site 4		Site 5	
		Total	% Contribution	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Galaxias maculatus	Common galaxias	2	40%	0.23	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hypseleotris compressa	Empire gudgeon	2	40%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.18
Gambusia holbrooki	Eastern Gambusia	1	20%	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Number of fish	5	100%	0.75	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50
	Number of fish species	3	100%	0.50	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25

CPUE = catch per unit effort (number of fish per hour), SE = Standard Error

Table 4. Total abundance, percentage contributions and mean abundance of fish and nektonic invertebrates sampled with fyke nets from 4 mangrove sites within the Hunter River in July 2011 (n=3).

Scientific Name	Common Name	Total	% Contribution	Site 1		Site 2		Site 3		Site 4	
				Mean	SE	Mean	SE	Mean	SE	Mean	SE
Fish											
Gobiopterus semivestitus	Glass goby	326	26.70%	16.33	2.73	15.67	5.78	42.67	14.52	34.00	16.07
*Liza argentea**	Flat-tail mullet	67	5.49%	1.00	0.58	1.33	0.33	12.67	7.86	7.33	4.06
*Mugil cephalus**	Sea mullet	41	3.36%	0.33	0.33	1.33	0.67	7.00	3.46	5.00	0.58
Ambassis jacksoniensis	Port Jackson glassfish	40	3.28%	1.33	0.33	5.33	1.67	3.67	0.88	3.00	1.15
Mugilogobius platynotus	Flatback mangrove goby	17	1.39%	0.00	0.00	0.33	0.33	4.67	3.28	0.67	0.67
Psuedomugil signifer	Pacific blue-eye	12	0.98%	0.00	0.00	0.00	0.00	4.00	3.51	0.00	0.00
Ambassis marianus	Estuary glassfish	10	0.82%	1.00	1.00	0.67	0.67	1.00	0.58	0.67	0.33
*Anguilla reinhardtii**	Long-finned eel	5	0.41%	0.33	0.33	0.33	0.33	0.33	0.33	0.67	0.67
Afurcagobius tamarensis	Tamar river goby	3	0.25%	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.58
*Acanthopagrus australis**	Yellow-fin bream	1	0.08%	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00
Acanthogobius flavimanus	Yellowfin goby	2	0.16%	0.33	0.33	0.00	0.00	0.00	0.00	0.33	0.33
*Girella tricuspidata**	Luderick	1	0.08%	0.00	0.00	0.33	0.33	0.00	0.00	0.00	0.00
Nektonic Macroinvertebrates											
Acetes sibogae australis	Paste Shrimp	599	49.06%	35.00	18.93	32.67	9.13	61.67	6.01	70.33	34.93
Macrobrachium intermedium	Glass Shrimp	73	5.98%	1.33	0.67	2.33	0.33	17.67	13.72	3.00	1.00
*Metapenaeus macleayi**	School Prawn	24	1.97%	2.00	0.58	1.67	1.20	2.00	1.15	2.33	0.88
	Number of organisms	1221	100.00%	59.33	22.67	62.00	17.93	157.33	33.79	128.33	41.13
	Number of species	15	100.00%	7.00	0.58	7.67	0.88	9.00	0.58	9.00	1.15
	Number of fish	525	43.00%	21.00	4.04	25.33	8.57	76.00	28.73	52.67	19.68
	Number of fish species	12	80.00%	4.33	0.88	5.00	1.15	6.33	0.67	6.00	1.15
	Number of invertebrates	696	57.00%	38.33	18.67	36.67	9.94	81.33	6.89	75.67	35.37
	Number of invertebrate species	3	20.00%	2.67	0.33	2.67	0.33	2.67	0.33	3.00	0.00
	Number of commercial organisms	139	11.38%	4.00	1.00	5.00	1.53	22.00	9.85	15.33	4.18
	Number of commercial species	6	40.00%	2.67	0.33	3.00	0.58	3.00	0.58	3.00	0.58

* = commercial species

SE = Standard Error

Table 5. Length range (mm) of commercial fish species sampled with fyke nets from 4 sites in mangrove habitat within the Hunter River in July 2011. Where a single value has been provided, only 1 individual was captured.

Scientific Name	Common Name	Site 1	Site 2	Site 3	Site 4
Liza argentea	Flat-tail mullet	104-136	13-61	12-95	14-82
Mugil cephalus	Sea mullet	28	27-30	26-32	27-32
Acanthopagrus australis	Yellow-fin bream	88			
Girella tricuspidata	Luderick		300		
Anguilla reinhardtii	Long-finned eel	750	700	300	900

8.6 Organic Carbon Analysis

Water Quality samples and concentrations of total organic carbon (TOC) and Chlorphyll *a* (Chl *a*) were collected from the mouth of the two drainage lines within the Study Site, from within the Hunter River and from a reference creek to the east of the Study Site within the SEPP 14 wetlands (Figure 3) on an outgoing tide. The results are presented in Table 6.

There were no patterns in the concentrations of Chl *a* between sample sites. Over all sampling occasions, the highest concentration of Chl *a* was recorded from Drainage line 2 (on the 3rd sampling occasion), and the second highest Chl *a* concentration was recorded at Drainage line 1 (on the 1st sampling occasion). There was no correlation between Chl *a* concentrations and TOC concentrations at sites sampled.

Concentrations of TOC collected at the mouth of the drainage lines within the Study Site were higher on all three sampling occasions than concentrations collected in either the Hunter River or at the reference creek to the east of the Study Site. The higher concentrations of TOC within the drainage lines is a reflection of the high density of macrophytes within the drainage lines, and the high algal concentrations (Chl *a*) resulting from warm, nutrient rich, shallow waters of the drainage lines.

The Chl *a* and TOC entering the Hunter River from the Study Site drainage lines (through flapped gates) appears to be rapidly diluted once it reaches the large water body of the Hunter River.

Table 6 Water quality, Total Organic Carbon and Chlorophyll a concentrations sampled at two sites within the Study Site, one site within the Hunter River and one reference creek to the east of the Study Site in July/August, 2011 (n=3 for water quality, n=2 for TOC and Chl a)

Date	Site	Temp °C	Cond µS/cm^2	Salinity ppt	DO %	DO mg/l	pH	ORP	TOC mg/L	Chl *a* mg/m^3
18/07/11	Reference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5.5±0.35	<1±0.0
18/07/11	Drainage line 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	22.0±0.71	13.0±0.0
18/07/11	Drainage line 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	15.0±0.71	<1±0.0
18/07/11	Hunter River	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5.5±0.35	3.0±0.0
05/08/11	Reference	13.77±0.01	10939.33±12.44	7.0±0.01	81.93±0.86	8.15±0.09	7.16±0.01	81.10±1.65	7.5±0.35	2.5±0.35
05/08/11	Drainage line 1	12.48±0.01	1056.33±0.33	0.6±0.00	71.60±0.12	7.60±0.02	6.29±0.01	51.90±0.06	21.5±0.35	1±0.00
05/08/11	Drainage line 2	13.45±0.00	10157.33±1.67	6.5±0.00	77.63±0.09	7.79±0.00	6.72±0.00	76.83±0.15	15.5±0.35	3.0±0.71
05/08/11	Hunter River	14.81±0.01	9410.33±2.91	6.0±0.003	95.23±0.03	9.34±0.01	7.23±0.01	52.80±0.29	7.5±0.35	4.0±0.71
08/08/11	Reference	12.11±0.01	14229.67±2.03	9.1±0.04	60.37±0.09	6.16±0.01	7.17±0.00	65.00±0.23	8.5±0.35	6±2.83
08/08/11	Drainage line 1	10.90±0.00	1283.33±0.33	0.8±0.00	44.47±0.35	4.88±0.04	6.91±0.01	24.90±0.23	22.5±0.35	<1±0.0
08/08/11	Drainage line 2	11.10±0.00	1570.67±33.41	1.0±0.03	35.57±0.32	3.89±0.04	7.01±0.00	38.47±0.29	18.0±0.00	25±9.19
08/08/11	Hunter River	13.45±0.00	4932.00±1.53	3.2±0.00	83.33±0.34	8.55±0.02	7.70±0.01	33.57±0.24	6.0±0.00	2±0.71

Data are Mean±se (Standard Error)
NB: Due to technical difficulties, some water quality data from the 1st sampling occasion were not reported.

9.0 Impact Assessment

9.1 Threatened Species

Table A1 (Appendix 1) lists threatened species (FM Act) recorded within the Hunter/Central Rivers CMA and describes their habitat requirements. With the exception of Green sawfish *Pristis zijsron,* the Study Site and broader Study Area does not provide optimal habitat for the proximate threatened species likely to occur in the area as listed under the Fisheries database. An impact assessment for the Green Sawfish (Table A2 of Appendix 1) concludes that no threatened aquatic species listed under the FM Act are likely to be impacted by the proposal.

9.2 Aquatic Environment within the Study Site

The fish recorded in the drainage lines within the Study Site are typical of fish assemblages found within creeks and drainage channels that have been modified or disturbed. The exotic Eastern Gambusia dominated, along with some hardy native species (Section 8.4).

The abundance of macrophytes within the drainage lines was very high, however diversity of macrophytes was low. The drainage lines are dominated by macrophytes such as *Phragmites australis* and *Typha orientalis*. While both species are native, they are invasive species and are often associated with disturbed environments where elevated nutrient levels allow for their proliferation. Other instream vegetation recorded on site included *Eleocharis acuta, Persicaria decipiens* and *Triglochin procera*.

The aquatic habitat within the Study Site represents a highly disturbed, artificial environment. The existing drainage lines within the Study Site cover a length of 7,345 m with an average width of ~ 2 metres. The proposal would require the removal of 4,991 m of drainage lines and subsequent construction of 6,074 m of vegetated channels, equating to a net gain of 1,083 m of potential aquatic habitat. The proposed open drainage channels would be earth lined and vegetated with instream vegetation. The details of the proposed drainage channels are provided in the Local Drainage Assessment by BMT WBM (2012a). The depth of the proposed drainage channels would be at a similar level to existing levels, and there would be a higher volume of water in the proposed drainage channels than currently occurs in the existing channels. The existing floodgates at the mouth of the drainage lines entering the Hunter River will remain. Alterations to the existing drainage system within the Study Site will not result in a net loss of existing fish habitat following development. In addition, the overflow wetland rehabilitation area will provide some freshwater aquatic habitat. Details of the rehabilitation of this overflow area will be included in the Wetland Management Plan.

The freshwater wetlands on site were mapped by Ecobiological (2012) as covering an area of ~ 76 ha, 12.5 of which will be retained within the Study site following development. An assessment of significance of impact (pursuant to section 5A of the Environmental Planning & Assessment Act) on this community and offset requirements for this habitat have been addressed by Ecobiological (2012).

Mangroves mapped as occurring within the Study Site (Figure 4) are located on the river side of the existing foreshore retainment wall and as such, are outside of the PDA and there are no saltmarsh communities mapped within the Study Site. As such, no mangroves or saltmarsh will be removed as part of the proposal.

9.3 Saltmarsh Remediation

Between 1913 and 1928 a levee and internal drainage system was constructed

around Fullerton Cove including an internal ring drain following the levee bank. The levee bank, ring drain and other internal drains were enlarged by the NSW Public Works Department between 1968 and 1980. These engineering works, including the installation of floodgates at the tidal boundary, ensured that tidal waters were excluded from Tomago Wetland (Shortland Wetlands and the Kooragang Wetlands combined). The Kooragang Wetland Rehabilitation Project was formed in 1993 to rehabilitate the coastal wetlands of the Hunter estuary. As part of this project, tidal restoration works were proposed at Tomago Wetland. In August 2007, the main set of western floodgates was modified to permit tidal exchange via the installation of SmartGates. Other on-ground works to support this strategy included the construction of a levee, the installation of floodgate flaps and culverts to direct the tidal water, the clearing of exotic and undesired species, and the installation of floating booms to minimise mangrove colonisation of the restored floodplain. Approximately 248 hectares of the western section of Tomago Wetland was restored to saltmarsh habitat (cited from Rayner and Glamore, 2011). More recently, the rehabilitation of the eastern section of Tomago Wetland has commenced and aims on restoring tidal exchange at the eastern floodgates of Tomago Wetland. In addition, NSW Fisheries is in discussions with Port Waratah Coal Service (PWCS) with regards to Lot 1002 (immediately adjoining the Study Site) with the aim of achieving some saltmarsh rehabilitation on this site.

NSW DPI's requested an "assessment of the potential of the Study Site for saltmarsh rehabilitation".

Approximately 12.5 ha of freshwater wetland EEC in the north east of the Study Site will be retained under the proposed development. This area adjoins the current inundation saltmarsh area on Lot 1002. There is potential for this area to be included in the saltmarsh inundation area through the removal of the existing levee bank shown in green (Appendix 2). These works do not form part of the current proposal however can be discussed at a later date.

The remainder of the Study Site does not provide further opportunity for saltmarsh rehabilitation. The elevation and topography of the Study Site foreshore area have been modified substantially through the construction of a rock revetment wall (Plate 7), which does not allow a gradual slope on which tidal inundation could support a saltmarsh community. In addition, Mangroves would likely colonise this area as observed upstream and downstream of the Study Site. The proposal is designed to limit excess freshwater input from the Study Site into the saltmarsh rehabilitation area on Lot 1002. As such, the overflow wetland area and freshwater drainage lines that form part of the proposal (transporting stormwater run-off) assist the saltmarsh rehabilitation on the adjacent conservation lands.

Thus while there is potential for saltmarsh remediation in the north east of the Study site, it is not suitable elsewhere on the study site as it is inconsistent with mitigation measures proposed to protect the broader environment.

Plate 7. Rock revetment works along the Study Site foreshore on the Hunter River

9.4 SEPP 62 Sustainable Aquaculture

The New South Wales oyster aquaculture industry is the state's most valuable fishery (DPI, 2006). The principle aim of the NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS) is to establish the regulatory environment within which the industry can grow.

On average, a farmed Sydney rock oyster will filter an estimated 0.25 ML of estuarine river water in its lifetime removing large quantities of suspended material, chiefly nutrients bound in phytoplankton. This means that oysters are important in maintaining healthy estuaries, but in performing this role they are exceedingly vulnerable to poor estuarine water quality (DPI, 2006).

The Hunter River oyster leases are located near Fern Bay which is approximately 7.5 km downstream of the Study Site (Figure 1). The oyster industry in the Hunter River has suffered a number of setbacks in recent years. In August 2010, a coal ship spilled 12 tonnes of oil into Newcastle Harbour, with the worst affected areas in the north arm of the Hunter River, near the oyster leases. Oyster farmers reportedly lost millions of oysters as a result of the spill (Newcastle Herald, 29/09/10). One year later, in August 2011 Orica Chemicals reported the discharge of hexavalent chromium into the atmosphere and arsenic into the Hunter River. Based on discussions with NSW Fisheries staff (Dr W. O'Connor pers comm.), it is understood that oyster production in the Hunter River has currently ceased and at this stage, looks unlikely to resume in the near future. Water quality issues have a direct impact on oyster farming, and as such, the impacts of a development on oyster aquaculture development or a priority oyster aquaculture area must be considered under Part 3A of SEPP 62.

The proposed development of the site includes the filling of the land, the construction of internal roads and utilities and potential warehouse type

developments. The future usage of the site for light industry and business is unlikely to have an adverse impact on water quality in the Hunter River. BMT WBM (2012c) has proposed a number of mitigation measures to ensure that both the quantity and quality of stormwater are managed within the Study Site prior to discharge into the Hunter River.

Adult oysters grow best in salinities of 25-35 ppt (Nell & Holliday, 1988) but can tolerate salinities of 15-40 ppt (Nell and Dunkley, 1984). They can survive freshwater conditions by closing their valves for a couple of days, the exact time depending on other factors such as their size and the water temperature. The regional flooding assessment by BMT WBM (2012b) states that the impacts of the development, whilst covering a significant area, are relatively minor in absolute magnitude (i.e. peak flood level increases <0.05m). Based on modelling conducted by BMT WBM, there will be no changes to flooding in the area of the existing oyster leases.

Thus, it is considered that the proposed development would not adversely affect the water quality available to oysters cultured in the Hunter River nor would the changes in peak flood levels affect the survival of oysters cultured downstream of the Study Site.

9.5 Organic Carbon Input

Typically, phytoplankton (measured as Chlorophyll *a*) is the predominant food source for estuarine filter feeders, however in times of low phytoplankton abundance, some filter feeding organisms rely on detrital organic carbon sources for food (Paterson, 2003). Organic carbon is also an important substrate for microbial decomposition, and as such is an important component of the aquatic food chain.

The contribution of the Study Site to the organic carbon sources available to filter feeders downstream of the Study Site in the Hunter River cannot be quantified due to the size of the Hunter River catchment area (~22,000 km^2), the various catchment land uses and the many different allochthonous sources that organic carbon can originate from.

Based on samples collected on three occasions, total organic carbon (TOC) concentrations from the Study Site were higher than TOC concentrations recorded from samples taken in the Hunter River and samples collected in the SEPP 14 reference creek. The relatively higher concentrations of TOC from the Study Site sites are likely to be a reflection of the high density of macrophytes (in various stages of decomposition) that are in the drainage lines and freshwater wetlands within the Study Site and the higher concentrations of algal (Chl *a*) resulting from shallow, nutrient rich waters of the Study Site. The proposed filling of the PDA site will result in the removal of this source of carbon from the base of the aquatic food chain in the immediate vicinity.

However, House (2003) mapped ~2,300 ha of Freshwater Wetland Complex (MU 46) within the Study Area (i.e. 10 km radius of the Study Site and within the Hunter River catchment). The Study Site itself was not mapped as Freshwater Wetland Complex, but remained unmapped under the Lower Hunter Central Coast Regional Environmental Management Strategy (LHCCREMS) vegetation mapping, indicating that it was considered disturbed lands. Thus, assuming that the Study Site carbon contribution is equal to that of the areas defined as freshwater wetlands (by House, 2003), the Study Site would contribute to ~10% of the carbon input from freshwater wetlands in the local area. However, this estimate does not consider the broader catchment area of the Hunter River, and the contributions of organic carbon from other types of vegetation communities both terrestrial and aquatic based nor does it consider the contribution that developed catchments have to

detrital organic carbon input. While catchment development results in increased suspended inorganic matter in the water column, it also results in elevated levels of refractory detritus (including organic carbon), associated bacteria and an increase in phytoplankton production promoted by greater availability of nutrients, all of which are beneficial to bivalve growth (Paterson, 2003).

Thus, when all sources of organic carbon inputs entering the Hunter River are considered, the contribution of the freshwater wetlands and drainage lines within the PDA to the local aquatic food chain is considered minimal and removal of this source is unlikely to impact the food available to aquatic fauna.

10.0 Mitigation Measures

1. Mitigation measures addressing the impact of the proposal on water quality entering the Hunter River are addressed in BMT WBM (2011).
2. Mitigation measures addressing the impacts of the proposal on surface and groundwater entering the adjoining SEPP 14 wetland and Ramsar Wetlands are discussed in BMT WBM (2012a).
3. Mitigation measures addressing the impact of the proposal on the freshwater wetlands on coastal floodplains EEC located on the Study Site and potential offsets are discussed in Ecobiological (2012).
4. Mitigation measures addressing the impact of the proposal on SEPP 14 Wetlands and Ramsar Wetlands adjoining the Study Site are discussed in Ecobiological (2012).
5. An acid sulphate soil management plan has been prepared in accordance with mitigation procedures outlined in the Douglas Partners report.
6. Proposed road crossings within the subdivision layout are to be designed using culverts in accordance with NSW Fisheries guidelines for fish passage requirements for waterway crossings. The existing drainage lines are defined as Class 3 Minimal fish habitat (Fairfull & Witheridge, 2003). In order to maintain a 'no net loss' in aquatic habitat, the minimum recommended crossing type for the proposed drains is a low flow design culvert (refer Witheridge, 2002). Figure 5 shows locations requiring fish friendly culvert designs where the drainage line cuts are below the existing surface level.
7. Where possible, construction works on the existing drainage lines are to commence upstream and move downstream to allow fish an escape path downstream. Upstream sections of creek are not to be isolated from the drainage line along the southern border (that will be retained) during construction works.
8. Areas of mangroves are to be clearly marked on the ground and no unauthorised clearing or stockpiling of materials is to occur within the mangroves during works.
9. Appropriate sediment and erosion control methods are to be established prior to any clearing and/or construction in accordance with the Managing Urban Stormwater: Soils and Construction (commonly referred to as the Blue Book). Control methods are to take into consideration the existing aquatic habitat within the drainage lines to ensure turbidity is not excessive.
10. The Wetland Management Plan is to include a landscape plan in relation to the proposed vegetated channels and linked pond. Details are to be provided to ensure that the constructed drainage

channels/pond continue to provide fish refuge.

a. Proposed plant species, planting densities, planting specifications, planting techniques, establishment criteria, irrigation and weed removal are to be detailed.

b. If a planted species is performing poorly, it should be replaced with a suitable substitute species.

11. The Wetland Management Plan is to include monitoring of the overflow wetland rehabilitation area, the Environmental Zone containing the Freshwater Wetland EEC (in the north-east of Lot 1001) and success of plant establishment within the constructed channels and linked pond.

    a. Potential monitoring locations are to be identified in the Wetland Management Plan and should include a minimum of 3 quadrats with a minimum area of 20 x 20 m per quadrat within the overflow wetland rehabilitation area, three within the Environmental Zone and quadrats (40 x 10 m) along each of the two main proposed constructed channels.

    b. The % native cover, % exotic cover and % new growth of vegetation at each location are to be recorded. Any mortalities of planted species is to be noted and replaced.

    c. Set photo points are to be established to provide a visual assessment of the success of the planting and rehabilitation.

    d. Bush regeneration contractors are to be engaged for control of exotics within the rehabilitation area and within the constructed channels for a minimum of 2 years following the completion of the wetland rehabilitation.

12. Impact threshold criteria are to be detailed in the WMP and or the wetland section of the Environmental Assessment report (ADW Johnson, 2012).

13. Future development of the PDA and of individual lots should be subject to separate environmental impact assessments. Assessment of future development should determine appropriate land uses to ensure water quality in the Hunter River is not adversely impacted.

11.0 Conclusions

The water quality recorded from the drainage lines within the Study Site was below ANZECC guidelines for dissolved oxygen and pH and nutrient concentrations (total nitrogen and total phosphorus) exceeded ANZECC guidelines (Coast Ecology 2010) for estuarine systems. The drainage lines within the Study Site were congested with macrophytes, with up to 70% instream vegetation coverage, the dominant species being *Typha orientalis* and *Phragmites australis*. While these are native species, they are highly invasive in wetlands and creeks with high nutrient levels.

Fish species within the Study Site drainage lines were dominated by the exotic Eastern Gambusia, along with some hardy native species. Initial macro-invertebrate surveys (Coast Ecology, 2010) indicated that the majority of taxa present at sample sites were pollution tolerant species however further use of macro-invertebrates as bio monitors in this type of environment is not recommended.

The Study Site contains 7,345 m of highly modified, artificial drainage lines. A portion of these will be removed by the proposal, however following the construction of 6,074 vegetated channels, there will be a net increase of 1,083 m of potential aquatic habitat. Vegetated channels will be monitored to ensure they continue to develop into a healthy aquatic habitat system, thereby providing a no net loss of aquatic habitat.

The proposed development of the Study Site is unlikely to have an impact on any threatened aquatic species nor is it likely to have a significant impact on the mangrove environment within the Study Site as the extent of works does not include the Hunter River foreshore zone where mangroves occur. No saltmarsh communities have been mapped within the Study Site and as such, the proposal is will not impact on any saltmarsh. The impact of the proposal on the freshwater wetlands EEC within the PDA is considered by Ecobiological (2011).

Mitigation measures have been proposed to minimise potential impacts of the proposal on the adjoining SEPP 14 and Ramsar wetlands (BMT WBM, 2012a,b &c), by maintaining the same hydrologic flow regime to the wetlands through the use of an impermeable berm around the site. This prevents excess water from the PDA entering directly in to the adjoining wetlands and saltmarsh areas. Stormwater from the PDA will be treated onsite prior to discharging into the Hunter River. Further impact evaluation of the proposal on the SEPP 14 wetlands and Ramsar wetlands has been conducted by Ecobiological (2012).

The proposal is unlikely to negatively impact on water quality such that it would detrimentally affect commercial oysters cultured in the Hunter River and the relative contribution of the PDA to food availability (i.e. particulate organic carbon) to detritus/filter feeders in the local aquatic area is considered minimal due to the large catchment area of the Hunter River and the many sources of organic carbon available (both autochthonous and allochthonous).

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13.0 Acknowledgements

This report was written by Dr Kristy McQueen. Field work was conducted by Dr Kristy McQueen and Brendan Alderson and analysis of organic carbon and chlorophyll *a* was performed by ALS Laboratories.

14.0 Figures

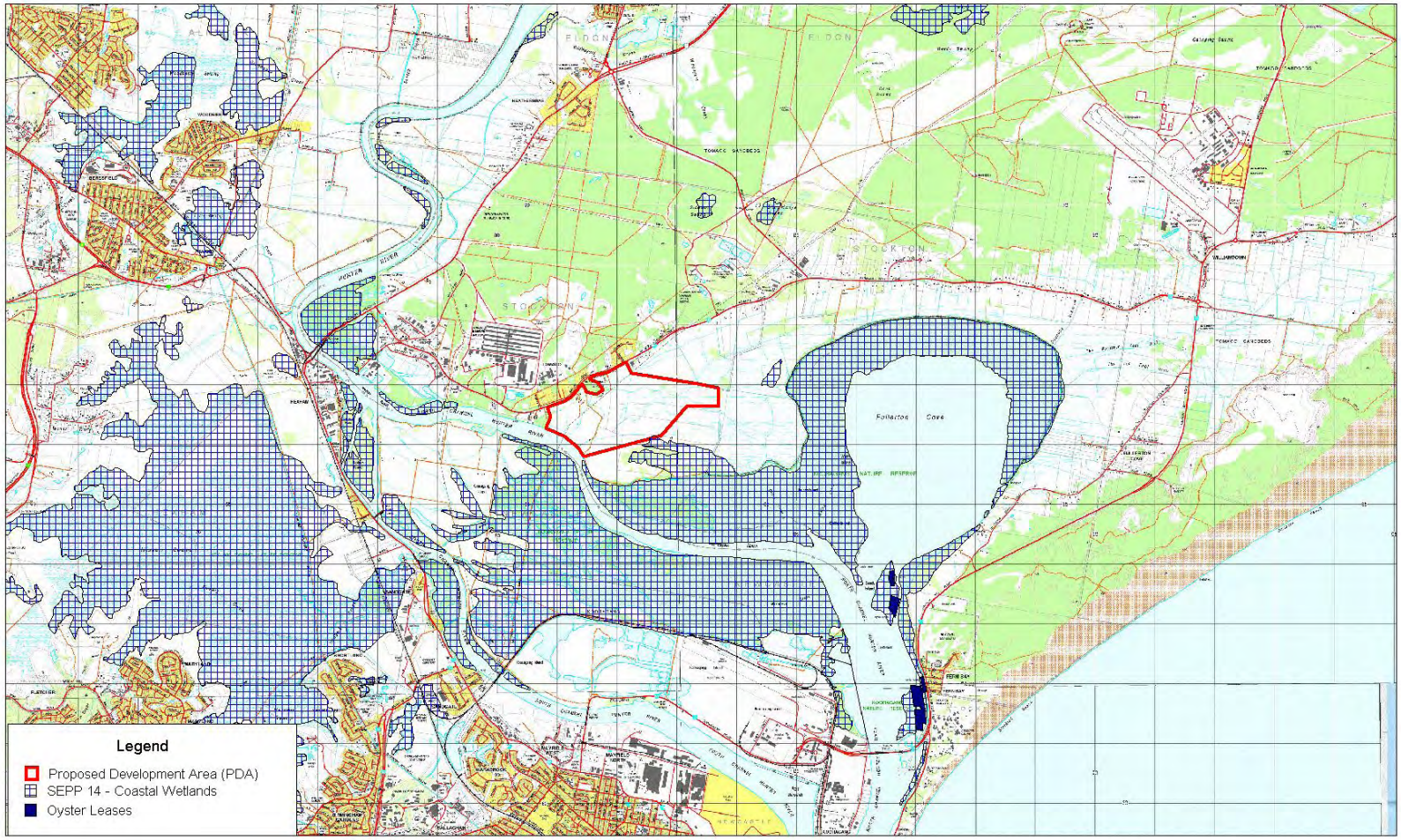


Figure 1. Study Area, SEPP 14 Wetlands, Oyster Leases
Lot 1001 DP 1127780 Tomago Rd, Tomago
Northbank Enterprise Hub Pty Ltd

Date: 19 August 2011 Job No: 100513

Coast Ecology

Figure 2. Proposal
Lot 1001 DP 1127780 Tomago Rd, Tomago
Northbank Enterprise Hub Pty Ltd

Date: 18 July 2012 Job No: 100513

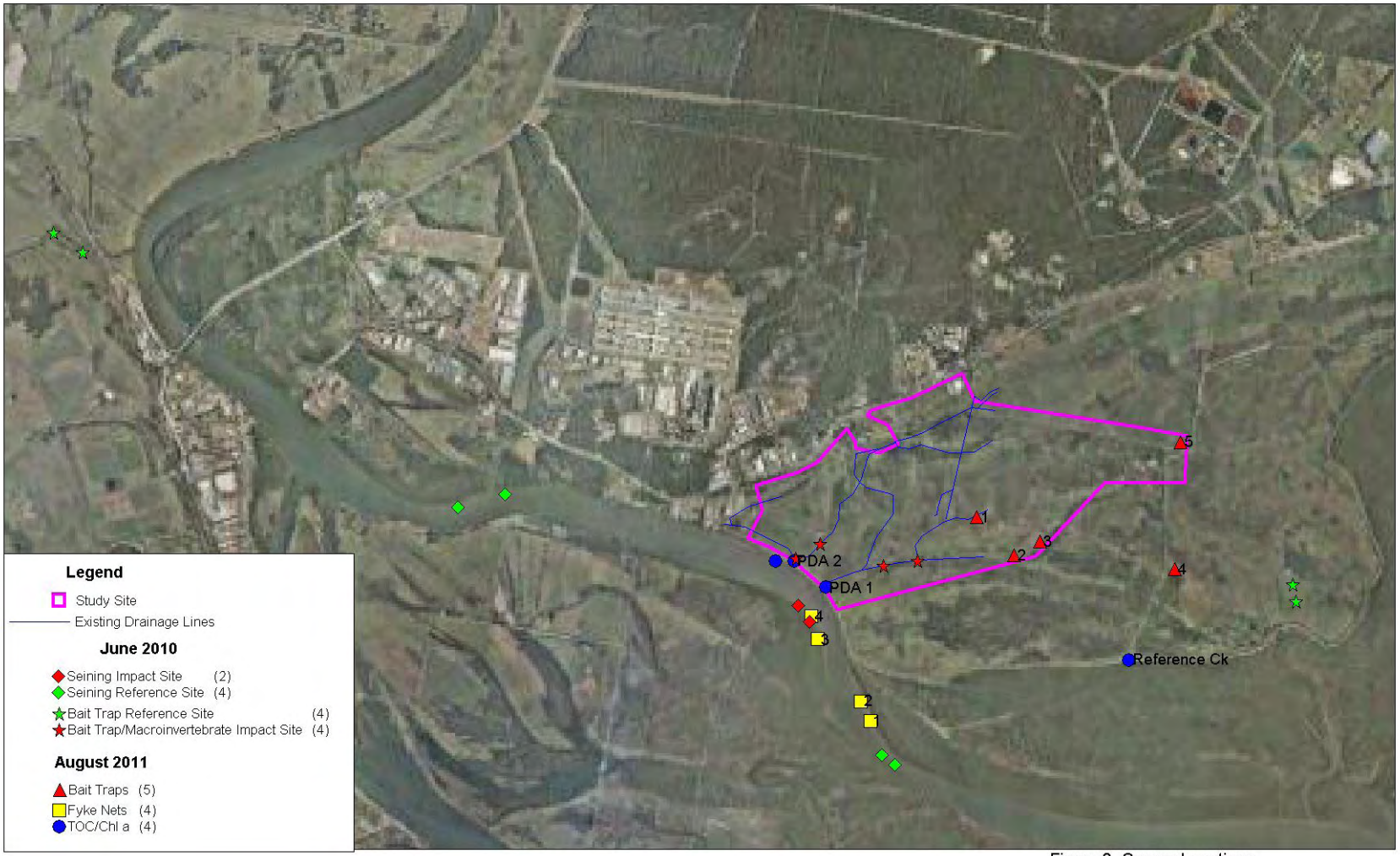
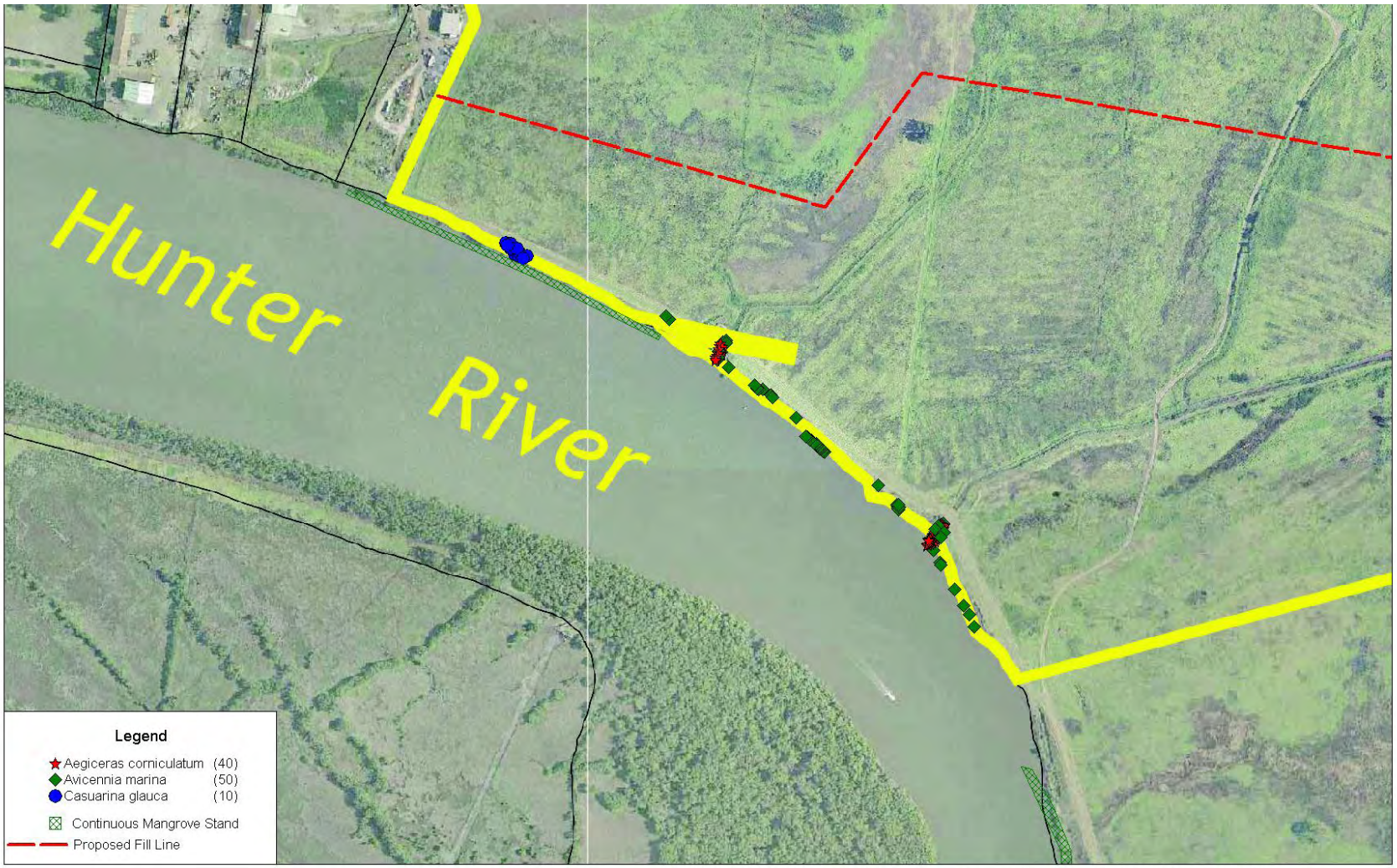


Figure 3. Survey Locations
Lot 1001 DP 1127780 Tomago Rd, Tomago
Northbank Enterprise Hub Pty Ltd

Date: 18 July 2012 Job No: 100513

Coast Ecology



Coast Ecology

Figure 4. Existing Mangrove Habitat
Lot 1001 DP 1127780 Tomago Rd, Tomago
Northbank Enterprise Hub Pty Ltd

Date: 18 July 2012 Job No: 100513

Figure 5. Proposed Fish Friendly Crossings
Lot 1001 DP 1127780 Tomago Rd, Tomago
Northbank Enterprise Hub Pty Ltd

Date: 20 August 2012 Job No: 100513

Coast Ecology

0 250 500
metres

15.0 Appendix 1 Threatened Species Assessment

Table A1 - Threatened species (FM Act) recorded within the Hunter/Central Rivers CMA and their habitat requirements

ScientificName	CommonName	Status	Comments
Carcharius taurus	Grey nurse shark	Critically endangered	Grey nurse sharks are a large shark native to subtropical to cool temperate waters in the Mediterranean Sea and the Atlantic, Indian and western Pacific Oceans. The Study Area does not provide suitable habitat for this species.
Pristis zijsron	Green sawfish	Presumed extinct	Green sawfish were once widely distributed in the northern Indian Ocean, around South and South-East Asia and around northern Australia. Green sawfish live on muddy or sandy-mud soft bottom habitats in inshore areas. They also enter estuaries, where they have been found in very shallow water. The broader Study Area (i.e the Hunter River) may provide suitable habitat for this species. The potential impact of the proposal on this species is provided below.
Carcharadon carcharias	Great white shark	Vulnerable	Great white sharks are found throughout the world in temperate and subtropical oceans, with a preference for cooler waters. This distribution includes the coastal waters of NSW. The Study Area does not provide suitable habitat for this species.
Epinephelus daemelii	Black cod	Vulnerable	Adult black cod are usually found in caves, gutters and beneath bomboras on rocky reefs. They are territorial and often occupy a particular cave for life. Small juveniles are often found in coastal rock pools, and larger juveniles around rocky shores in estuaries The Study Area does not provide suitable habitat for this species.

Table A2 – Assessment of Significance for threatened aquatic species within potential habitat within the Study Area.

The following factors must be taken into account in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats:

Green Sawfish

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Green sawfish live on muddy or sandy-mud soft bottom habitats in inshore areas (NSW DPI, 2007). Thus, while there is no habitat within the drainage lines of the Study Site, there is potential habitat in the broader Study Area and as such, the indirect impacts of the proposal may be relevant to this species.

Green sawfish also enter estuaries, where they have been found in very shallow waters. They feed on slow-moving, shoaling fish such as mullet, which they stun with sideswipes of the snout and are also thought to use their saw to sweep other prey, such as molluscs and small crustaceans, out of the sand and mud. Green sawfish probably don't reach sexual maturity until they are at least 2-3 metres in length. Like all sharks and rays, they have internal fertilisation and give birth to a limited number of live young (NSW DPI, 2007).

The proposal does not involve the removal of food, foraging habitat or breeding habitat for this species and it will not result in an increase in adverse water quality issues. As such, the action proposed us unlikely to have an adverse effect on the life cycle of this species such that a viable local population is likely to be place at risk of extinction.

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

N/A

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> *(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
>
> *(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction*

N/A

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposal will not involve the removal of habitat required for this species.

Stormwater runoff entering the Hunter River will be subject to best practice water quality treatment practices, with proposed mitigation measures applying the principles of Water Sensitive Urban Design (WSUD).

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

N/A

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The most recent sighting of this species was in the Clarence River, Yamba in 1972. There have been no recent sightings of this species in the Hunter River, and as such, the habitat is not considered important to the long-term survival of this species.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

N/A

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The threat abatement strategies listed for the Hunter/Central Rivers are not relevant to the proposed development.

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Key threatening processes listed as adversely affecting threatened species, populations or ecological communities are:

- The current shark meshing program in New South Wales waters
- The introduction of fish to fresh waters within a river catchment outside their natural range
- Removal of large woody debris from New South Wales rivers and streams
- Degradation of native riparian vegetation along New South Wales water courses
- Installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams
- Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales
- Hook and line fishing in areas important for the survival of threatened fish species
- Predation by the plague minnow (*Gambusia holbrooki*).

Gambusia holbrooki were present in drainage lines, however the proposal does not constitute or is likely to increase the impact of this or any of the other listed key threatening process.

16.0 Appendix 2 Interface Strategy (ADW Johnson)

Plan of: Interface Strategy
Tomago Wetland Rehabilitation Project
& Lot 1001 NEH Business & Industrial Park

Location: Tomago Road
Tomago

Council: Port Stephens

Datum:	N/A
Origin:	N/A
Projection:	MGA Zone 56
Origin:	PM 27766
North Direction:	Grid
Contour Interval:	N/A

Date:	25th June 2012
Sheet:	1 of 1
Plan by:	MC
Project Manager:	SD
Office:	Hunter
Plan Purpose:	Report

Version:	A (9/08/2012)
Client:	Northbank Enterprise Hub Pty Ltd
Survey:	N/A
AutoCad:	N:\...\37672-INTERFACE-STRAT.-001-A
Our Ref:	37672

adw johnson

N

adw johnson

SANDBEDS

TOMAGO (FRESHWATER)

Tomago Road

Tomago Road

313 Tomago Road
(N.E.H.)

Existing Part 3A Approval
07-0086 & EPBC Approval
2007/3343

WesTrac Facility

CONSERVATION LOT
(22ha)
TRANSFERRED TO NPWS

380m ①
LEVEE TO RAMSAR BDY

FUTURE LEVEE

TOMAGO WETLAND
REHABILITATION (TWRP)
STAGE 1 LEVEE (EXISTING)

RING DRAIN

EXISTING FLOOD GATES
TO NORTH-SOUTH
DRAIN

FULLERTON
COVE

Tomago
House

Tomago
Church

NEH
DEVELOPMENT
AREA

LOT 1001
D.P. 1127780

DISCHARGE
CONTROL PIT

(LEVEE)

RETAINED
FRESHWATER
WETLAND

③ 'A' ④

LOT 1001 FLOODGATE

TOMAGO
WETLAND
REHABILITATION
PROJECT AREA

BERM

'RICE
PADDY'

BOUNDARY

DISCHARGE
CONTROL PIT

PERIMETER

PERIMETER BERM (LEVEE)

'D'

STAGE 1
(CURRENT)
INUNDATION
SALTMARSH
AREA

Hunter River

⑤ 'B' 'E'

'C'

NORTH
SOUTH DRAIN

RETAINED SWAMP
OAK FOREST

OVERFLOW WETLAND
REHABILITATION
AREA (FRESH WATER)
10ha.

LOT
1002

RAMSAR

NPWS

EXISTING SMART
GATES
STAGE 1 (2006)
TIDE/SALT WATER

FLOOD GATES
INSTALLATION
STAGE 2 WORKS (2012)
TIDE/SALT WATER

0 100 200 300 400 600

Bar Scale 1: 6000 (A1), 1: 12000 (A3)

Ver.	Date	Comment
A	9/8/2012	Intial Plan

adw johnson pty. ltd. unit 7, building 2, 335 hillsborough road, warners bay 2282 ph: (02) 49785100 fax: (02) 49785199 hunter@adwjohnson.com.au abn 62 129 445 398

Plotted By: malc Plot Date: 22/08/12 - 09:01 Cad File: N:\37672 Northbank\Dwg\37672-INTERFACE-STRAT.-001-A.dwg